RystadEnergy

Whitepaper

The evolving energy landscape: A global outlook with offshore opportunities and challenges

Research and Analysis

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Cover photo source: Lizette Bertelsen, Jonny Engelsvoll/ © Equinor

A note from our CEO

Jarand Rystad
CEO

Welcome to Rystad Energy's inaugural whitepaper on the offshore energy industry. In this report, we provide a comprehensive overview of the evolving landscape, offering actionable insights and data-driven expertise to help the industry navigate the complexities of the energy transition while meeting global resource demands. As CEO of Rystad Energy, I am honored to share this analysis and look forward to engaging with industry leaders at the Offshore Technology Conference (OTC) in Houston this May.

The offshore industry currently stands at a critical juncture, facing the intricate challenges of the global energy transition while simultaneously needing to address the world's increasing demand for vital resources. Understanding the forces that have shaped the industry's trajectory is crucial for navigating this complex environment.

Between 2004 and 2012, offshore, particularly deepwater, was projected to dominate future oil production growth. Yet, the US shale oil revolution shifted this, with the unconventional sector driving global growth from 2013 to the present. Consequently, the significant deepwater expansion, potentially requiring up to 500 floating rigs, did not fully materialize. Both the oil market and associated supply chain markets collapsed in 2014, and the focus shifted to cost, performance and drilling efficiency improvements. Today, capital discipline and prioritization of shareholder return trump production growth in shale, with offshore again competitive and will grow going forward. We are seeing a reborn offshore sector, but not at the level it could have been. Thus, instead of an offshore supply tsunami starting in 2012, we are ending up with a breeze wave fifteen years later, at a more moderate finding and development cost level with Brazil, and other basins in the Americas and in Africa growing the most. For gas, East Africa has big potential and will be a new source of LNG.

A note from our CEO

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This whitepaper offers a focused analysis of the offshore energy landscape, examining oil, gas and LNG demand and supply to 2050, with attention to key regions like North America, Asia and Brazil. It further explores the energy transition's impact on the offshore sector, assessing technical readiness, regulatory frameworks and key challenges. Finally, the paper considers the potential of offshore wind, solar, geothermal, and carbon capture, utilization and storage (CCUS).

Rystad Energy's three-year knowledge partnership with the Offshore Technology Conference underscores our commitment to providing cutting-edge research and analysis that helps shape the future of the offshore energy industry. We are eager to share our expertise with the OTC community and collaborate with industry leaders and stakeholders to navigate the evolving challenges and capitalize on emerging opportunities. We trust that this whitepaper offers valuable insights, and we invite you to join us on this ongoing journey of discovery and exploration within the dynamic offshore sector.

Introduction

The global energy landscape is witnessing a rapid pace of transition, shaped by a mix of growing demand, shifting policy priorities and technological change. Population growth – especially in developing economies – along with rapid urbanization and industrial expansion, is driving a steady increase in energy consumption. At the same time, there's an urgency to reduce reliance on fossil fuels and cut emissions, in line with global climate goals such as those outlined in the Paris Agreement.

But moving away from fossil fuels will be far from simple. Oil and gas still make up the bulk of the world's energy supply and remain essential to key sectors like transportation, heavy industry and power generation. The industry faces the dual challenge of reducing its carbon footprint while continuing to feed rising demand. Offshore production is expected to play a key role in bridging this gap.

This white paper takes a closer look at these intersecting pressures. It explores the current state of the energy and climate landscape, trends in supply and demand, and how the energy mix is expected to evolve. We focus especially on the growing role of offshore resources – from traditional oil and gas to renewables like offshore wind and solar energy, and the potential of technologies such as carbon capture and storage. We also examine how broader global events, such as shifts in trade policy, may impact the energy supply chain. Through this analysis, we aim to provide practical insights to help energy stakeholders navigate the path forward.

I. The current global energy and climate context

The offshore energy sector continues to play a vital role in meeting global demand, with a strong performance over the past few years. Offshore oil production reached an impressive 28.4 million barrels per day (bpd), accounting for nearly a third of the world's total output of 102 million bpd. Offshore gas production hit about 115 billion cubic feet per day (Bcfd), also representing about 30% of global supply of approximately 393 Bcfd. These numbers are a testament to the sector's enduring importance, making it clear that offshore energy will remain a critical component of the global mix for years to come, as we show below.

While overall investment in exploration and production (E&P) held steady at around $600 billion since 2023, about $210 billion was in offshore fields. There is a 5% increase in offshore projects investment from 2023’s level. In 2024, a significant $110 billion was allocated to sanctioning oil and gas greenfield projects, marking a 6% increase from the previous year. Within this $110 billion investment, South America is seeing a massive 64% jump to $37 billion. Asian greenfield sanctioning also had a 33% increase, reaching $ 21 billion, North America is experiencing a 33% increase to $14 billion, and Africa is experiencing a 17% rise to $6 billion. What's interesting is that over half of this investment is focused on deepwater projects, particularly in Brazil, Guyana, the US, and Suriname. The strategic shift towards these regions highlights the growing importance of emerging markets like Suriname and Guyana and the continued importance of Brazil and the US in the offshore energy sector.

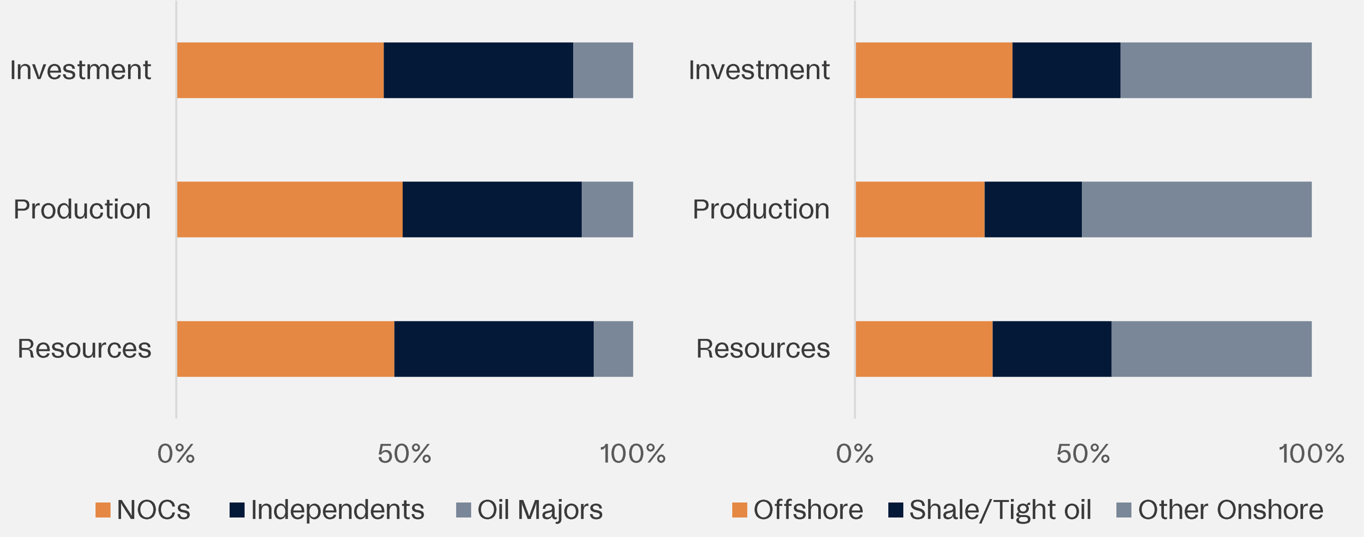
In terms of oilfield services, the global offshore rig market, however, has experienced ups and downs, particularly in the jackup segment, which has been influenced by developments in the Middle East. For 2024, the global average of mobile offshore drilling units (MODU) on contract was 550 units (408 units for jackup, 82 for drillship, and 60 for semisub), resulting in a marketed utilization of 88%. These three rig types combined drilled approximately 2,600 offshore wells. While 2024 was one of the slowest years for new discoveries in two decades, a staggering 80% of those were made offshore, mostly in the deepwater. This is a clear indication that the offshore sector still holds significant potential for growth and exploration.

Where does the current production come from?

When it comes to the oil and gas market, many assume that the supermajors are the dominant players. However, this assumption couldn't be further from the truth. The supermajors accounted for about 11%, 9% and 13% of total production, resources and investment, respectively, in 2024. So, where does most of the production come from?

The answer lies with National Oil Companies (NOCs), which are responsible for more than 50% of global production, resources and investment. But what about offshore? As of 2024, offshore fields accounted for a significant 35% of total investment, produced approximately 28% of global oil and gas, and contributed around 30% of the world's resources.

Investment, production and resources: Company type vs resource type



Source: Rystad Energy UCube, April 2025

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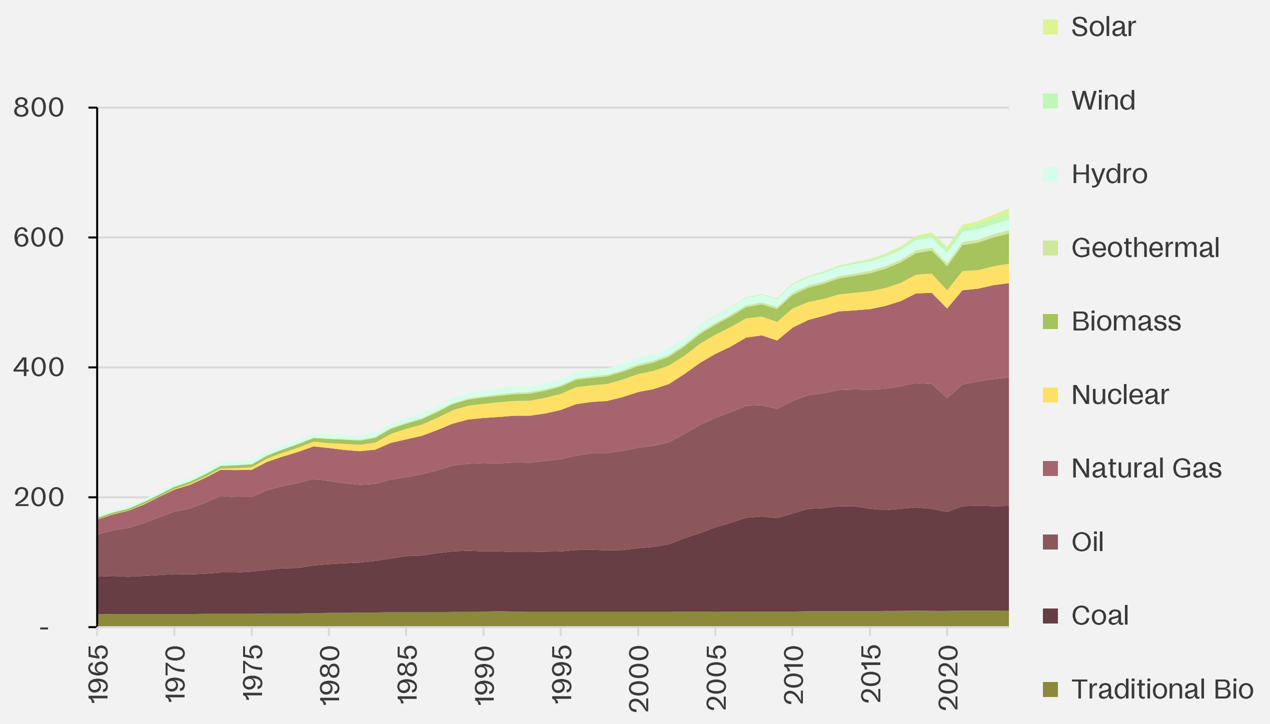
Current energy mix

The global energy mix from 1965 to 2024 is illustrated in the chart below. Notably, the world's total energy consumption in 2024 reached approximately 647 exajoules (EJ). Fossil fuels, including coal, oil, and natural gas, dominated the energy landscape, accounting for about 80% of global energy consumption.

Current energy mix by primary energy source
EJ



Source: Rystad Energy EnergyDemandCube, April 2025

Current energy mix

A closer examination of energy consumption on a per-capita basis reveals a more nuanced picture. In 2024, the average global energy consumption per capita was 76 Gigajoules (GJ or 21,111 kilowatt-hours per capita). However, this figure obscures significant disparities in energy use across countries. In some low-income countries such as South Sudan, Guinea, and The Gambia, energy consumption per capita is strikingly low, falling below 5 GJ per capita (or 1,388 kWh per capita) per year. For context, a typical mid-range refrigerator in a Western country consumes around 1-2 GJ of energy (or 300 – 600 kWh) annually, underscoring the vast difference in energy usage. Aas of 2024, approximately 2.5 billion people worldwide lack access to clean cooking, and around 770 million lack access to electricity, highlighting the pressing need for increased access and more equitable global energy distribution.

Yet, the growing reliance on fossil fuels has had a profound impact on the environment, with a notable increase in greenhouse gas emissions contributing to a global temperature rise of approximately 1.1°C between 1900 and 2020. The primary drivers of these emissions are human activities, including fossil fuel combustion for energy generation, oil and gas production, transportation, and industrial processes. These activities have significantly elevated the concentration of greenhouse gases in the atmosphere, posing a significant threat to the planet's ecosystems and climate.

What does one tonne of emissions mean?

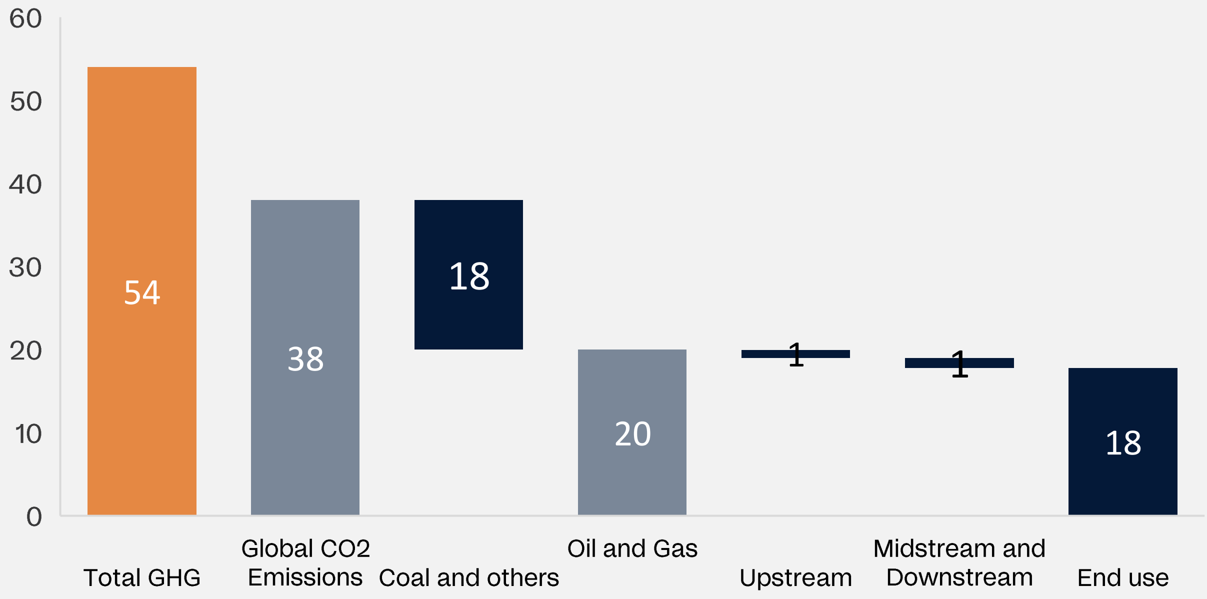
To put the concept of a tonne of CO2 into perspective, consider the following examples: a single tonne of CO2 can be offset by the annual carbon sequestration of 30-46 trees. Alternatively, driving a car from Houston to Denver would emit approximately one tonne of CO2. Similarly, a one-way flight from San Francisco to Tokyo also generates around one tonne of CO2 emissions.

Where are the emissions coming from?

As indicated in the chart below, the global anthropogenic greenhouse gas (GHG) emissions total approximately 54 Gigatonne of carbon dioxide (GtCO2) equivalent, with 70% of these emissions attributed to CO2. The remaining 30% is comprised of methane, nitrous oxide (N2O) and other GHGs. The total global CO2 emissions are about 38 GtCO2, with 55% of these emissions originating from the oil and gas industry and 45% from coal, primarily for power generation and industrial applications (e.g., steel and cement manufacturing).

A closer examination of the oil and gas sector reveals a more nuanced distribution of CO2 emissions. While upstream activities, such as extraction and flaring, account for approximately 1 Gt of CO2 emissions, midstream and downstream operations contribute an additional 1.2 Gt. Most emissions, around 18 Gt, stem from end-use activities. This challenges the common perception that oil and gas companies are the primary emitters, as they are responsible for only about 10% of total emissions from the oil and gas value chain. Instead, the main contributors to emissions are end-use activities, including transportation, residential and commercial heating and cooking, industrial applications, and feedstock in the petrochemical industry. Electricity generation, which relies heavily on natural gas and fuel oil in power plants, is also a significant source of emissions.

Overview of global man-made GHG emissions*
Gt Co2



*Oil and gas methane emissions is ~2 GtCo2eq
Source: Rystad Energy EmissionsCube, April 2025

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Where are the emissions coming from?

To combat climate change and limit global warming, the Paris Agreement, adopted at COP21 in 2015, sets a shared goal of limiting global temperature rise to well below 2°C, and ideally 1.5°C above pre-industrial levels. To achieve this, countries aim to reach net-zero emissions between 2050 and 2100. The adoption of clean energy technologies is gaining momentum, driven by technological advancements and policy incentives that favor clean energy sources.

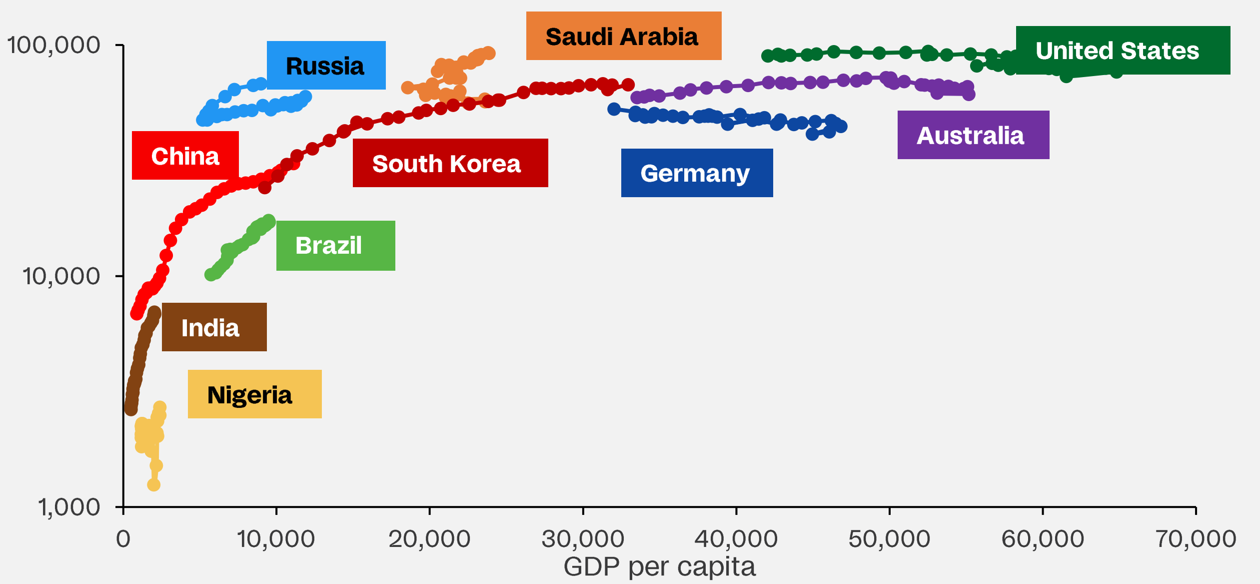
However, despite progress, the energy transition must accelerate further to achieve the emission reduction goals set out in the Paris Agreement. The pace of the transition depends on the actions of leaders in government and industry, highlighting the need for continued cooperation and commitment to a sustainable future.

II. Projecting the future: Population, economic growth and energy demand, generational challenge

Energy demand and economic development are closely intertwined. As nations progress economically, the stages of industrialization and rising personal incomes contribute to amplified GDP and increased energy consumption. There is a strong correlation between GDP per capita and energy consumption per capita, with energy serving as a crucial input for economic activity, powering industries, transportation, and households.

Primary energy consumption per capita, Observations from 1990 to 2021 in selected countries

kWh per capita vs GDP per capita



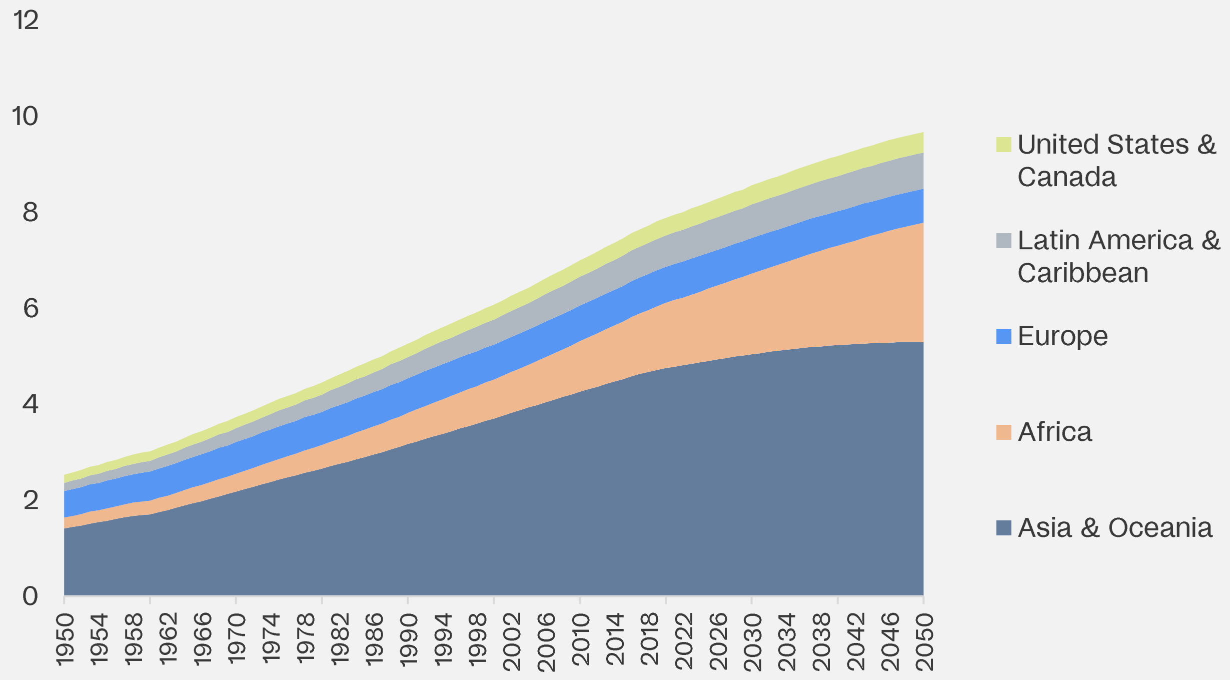
Source: Rystad Energy research and analysis, IMF data, BP Statistical Review of World Energy 2023, April 2025

This correlation is evident in the chart above, which illustrates the relationship between GDP per capita and energy consumption per capita. As GDP per capita increases, energy consumption per capita also tends to rise, indicating a strong link between economic development and energy demand. This is particularly true for countries with lower GDP per capita. On the other hand, in countries like the US and Germany, where GDP per capita is high, oil consumption has plateaued or even declined despite continued economic growth. This shift reflects a broader trend towards energy efficiency, the adoption of advanced technologies, and a stronger focus on environmental sustainability.

Population growth and energy demand

The world population is about 8 billion as of 2024, with projections indicating it will reach about 8.5 billion by 2030 and 9.6 billion by 2050. Developing nations in Africa and Asia are the main drivers of population growth.

World population history and forecast 1950-2050
Billion people



Source: UN World Population Projections 2022

As the population is projected to grow worldwide, especially in non-OCED countries in Asia and Africa, one of the biggest challenges in the future will be to provide energy to accommodate the large population in these countries and meet their basic human needs, from cooking and lighting to industrialization and urbanization. In addition, coupled with the Paris agreement, the need would be to minimize the negative impact of global climate change.

Pathways to net-zero emissions, evaluating three key scenarios

Reaching the goals of the Paris Agreement requires deep decarbonization across all sectors of the economy and a broad range of technologies. While the road ahead may seem complex, there are essentially three tasks for reaching Net-zero:

Task 1: Clean up and grow the power sector. Transitioning to renewable energy sources like solar and wind is essential to reduce emissions from electricity generation. Batteries provide energy storage for intermittent sources, ensuring a stable supply. Hydropower and nuclear energy offer reliable, low-carbon power options to support a cleaner grid.

Task 2: Electrify everything. The next task is electrification across various sectors. Electric vehicles (EVs) are rapidly gaining traction as battery technology improves. In buildings, electric heat pumps can replace fossil fuel heating systems, while industries can adopt electric arc furnaces for steel production.

Task 3: Clean up the residual. Some emissions will persist, necessitating alternative solutions. Carbon capture, utilization, and storage (CCUS) can mitigate emissions from hard-to-abate sectors like cement production. Green hydrogen offers a zero-emission fuel for transportation and industry, while advanced biofuels can serve as low-carbon alternatives in aviation.

III. Fossil fuel supply and demand outlook (with offshore emphasis)

Oil demand: Trends and outlook

In 2024, global oil demand reached 103 million bpd, which is about 30% of the world's energy demand. This is an increase of almost 1 million bpd from 2023, driven mainly by the growth in the aviation and petrochemical sectors, especially from emerging economies.

The breakdown of oil demand by sector reveals that transportation is the largest consumer, using about 60 million bpd. Petrochemicals are the second largest, using around 16 million bpd, followed by energy generation and other sectors.

Despite its ongoing importance, oil demand is expected to be influenced by broader shifts towards cleaner technologies and efficiency improvements in the coming years. While oil will remain a dominant source of energy in 2025 and beyond, these trends are anticipated to moderate the pace of demand growth. The maturity of oil transition technologies varies across sectors, with some making more progress than others in adopting alternatives.

Oil demand: Maturity of oil substitution technologies

The adoption of oil substitution technologies varies across different oil demand sectors. The passenger vehicles and buses sector are further along in its transition, while others such as petrochemical, trucks, shipping, and aviation are still in the early stages of adoption

Challenges and opportunities in the transition to low-carbon technologies

While progress is being made in the transition to low-carbon technologies, the shift remains gradual rather than disruptive across many sectors. In the medium term, efforts to reduce emissions may decelerate, particularly in transportation and industrial sectors where oil continues to offer cost and performance advantages.

Simultaneously, demand for petrochemical feedstocks like naphtha and ethane is expected to grow significantly, fueled by population growth and rapid urbanization, which are driving increased consumption of plastics and other petrochemical products. Oil demand in the industrial sector is also projected to rise in the short to medium term, especially in emerging markets where it remains a cost-effective energy source for industrial expansion.

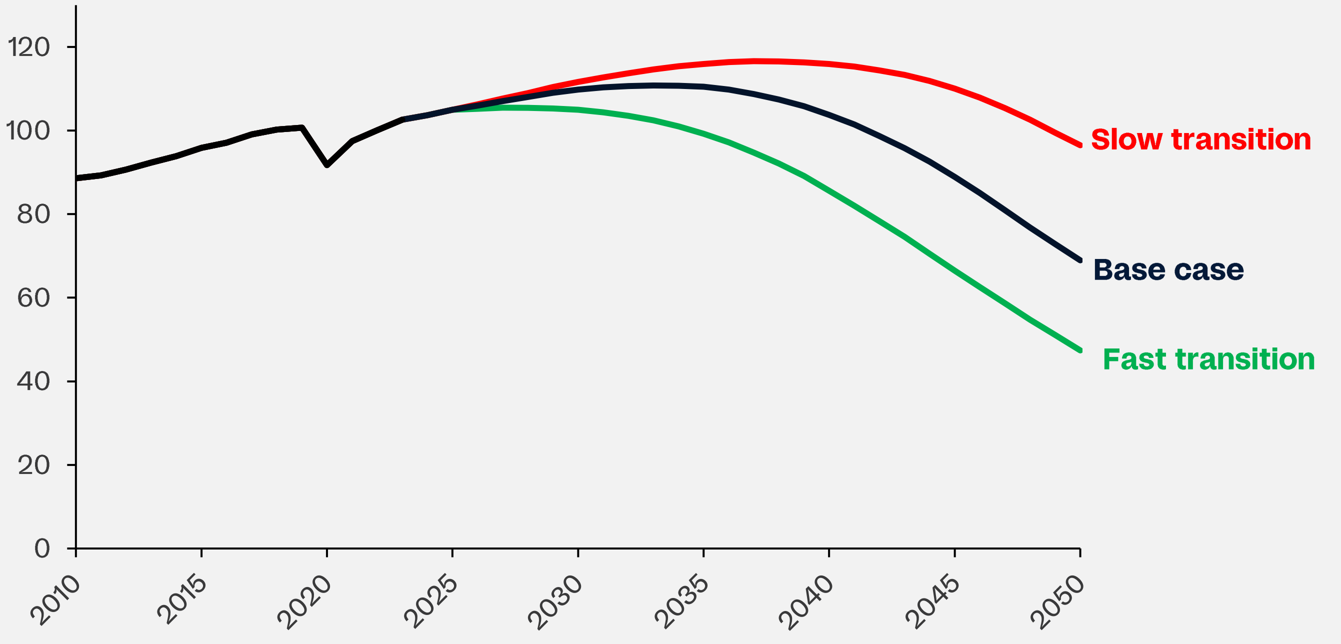
Nevertheless, the long-term outlook points toward an eventual shift. As low-carbon technologies mature and benefit from economies of scale, a more accelerated transition away from oil is expected to unfold in the second half of the next decade. This transformation will reshape the energy landscape, despite near-term headwinds.

Assessing future oil demand: A scenario-based approach

We utilize a scenario-based approach to analyze future oil demand, considering various paths that the energy landscape may take. In this paper, we focus on three main scenarios : the base case, slow transition and fast transition. These scenarios provide a framework for understanding the potential evolution of oil demand and the associated implications for the energy sector.

By analyzing these scenarios, we can gain insights into the potential opportunities and challenges that lie ahead in the transition to low-carbon technologies. This analysis can help inform strategies for reducing emissions and promoting sustainable energy development.

Oil demand under three different scenarios
Million bpd



Source: Rystad Energy Oil Markets Cube, April 2025

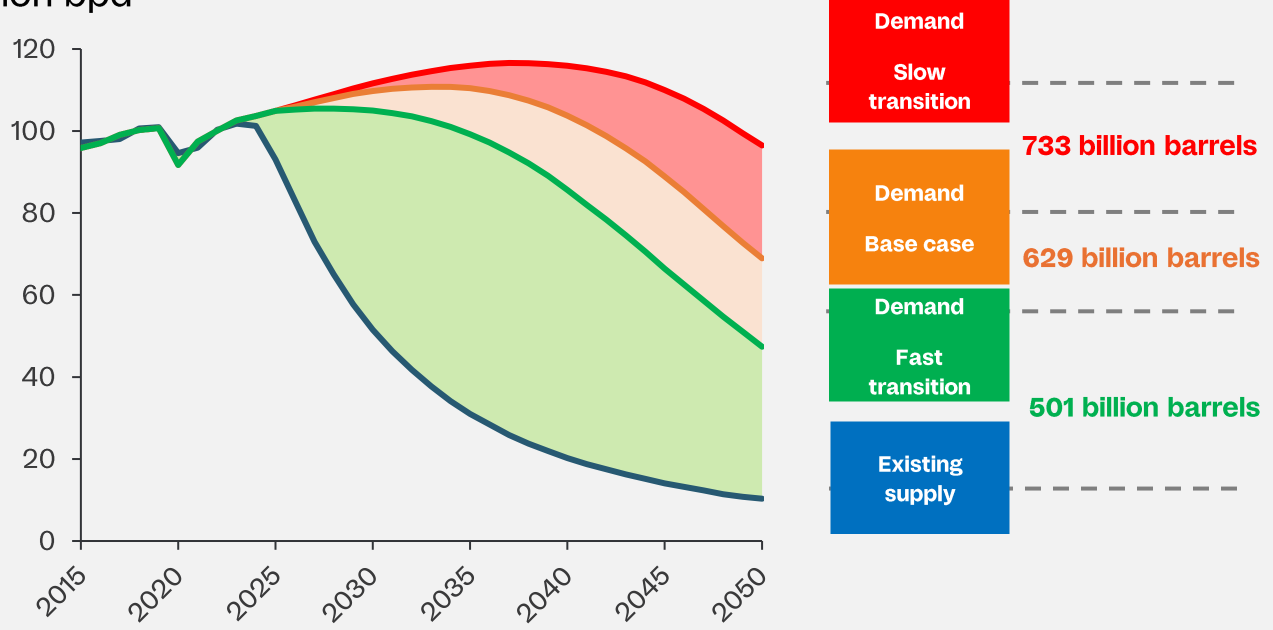
[1]The base case represents the most probable trajectory both in the medium term (predictive until 2030) and long-term (prescriptive until 2050). Oil demand reaches its peak at 110.8 million bpd in 2033. The Slow Transition scenario is a reasonable upside probabilistic range from our base case. Oil demand peaks in 2037 at 116.6 million bpd. The Fast Transition scenario is a reasonable downside probabilistic range from the Base Case. Oil demand reaches its peak at 110.8 million bpd in 2033.

Oil supply: Current composition and future outlook

Global liquids supply in 2024 reached 102 million bpd, with conventional onshore production accounting for over 50% of the total, at approximately 53 million bpd. Shale oil, which has been a significant growth driver in the previous decade, contributes around 18 million bpd, slightly behind offshore shelf production, which accounts for 18.4 million bpd. Offshore deepwater production, which is expected to be one of the main contributors to future production growth, currently accounts for close to 10% of the global supply.

Looking ahead, even in the most aggressive transition scenarios, a substantial amount of oil will still be required to meet demand. This highlights the ongoing importance of oil supply in the energy mix despite the growing momentum behind low-carbon technologies.

Total liquids that must be delivered to the market from 2024 to 2050 under the three demand scenarios
Million bpd



Source: Rystad Energy OilMarketsCube, April 2025

The chart illustrates the significant challenge of meeting future oil demand, particularly in the context of declining production. If no new drilling and completion activities occur, total liquid production would plummet from 100 million bpd to less than 20 million bpd.

Oil supply: Current composition and future outlook

Substantial new discoveries are required to meet demand under the three scenarios. Specifically, under the Base case scenario, approximately 629 billion barrels of oil need to be discovered between 2024 and 2050. In the Slow Transition scenario, the requirement increases to 733 billion barrels, while in the Fast Transition scenario, around 501 billion barrels must be delivered to meet demand.

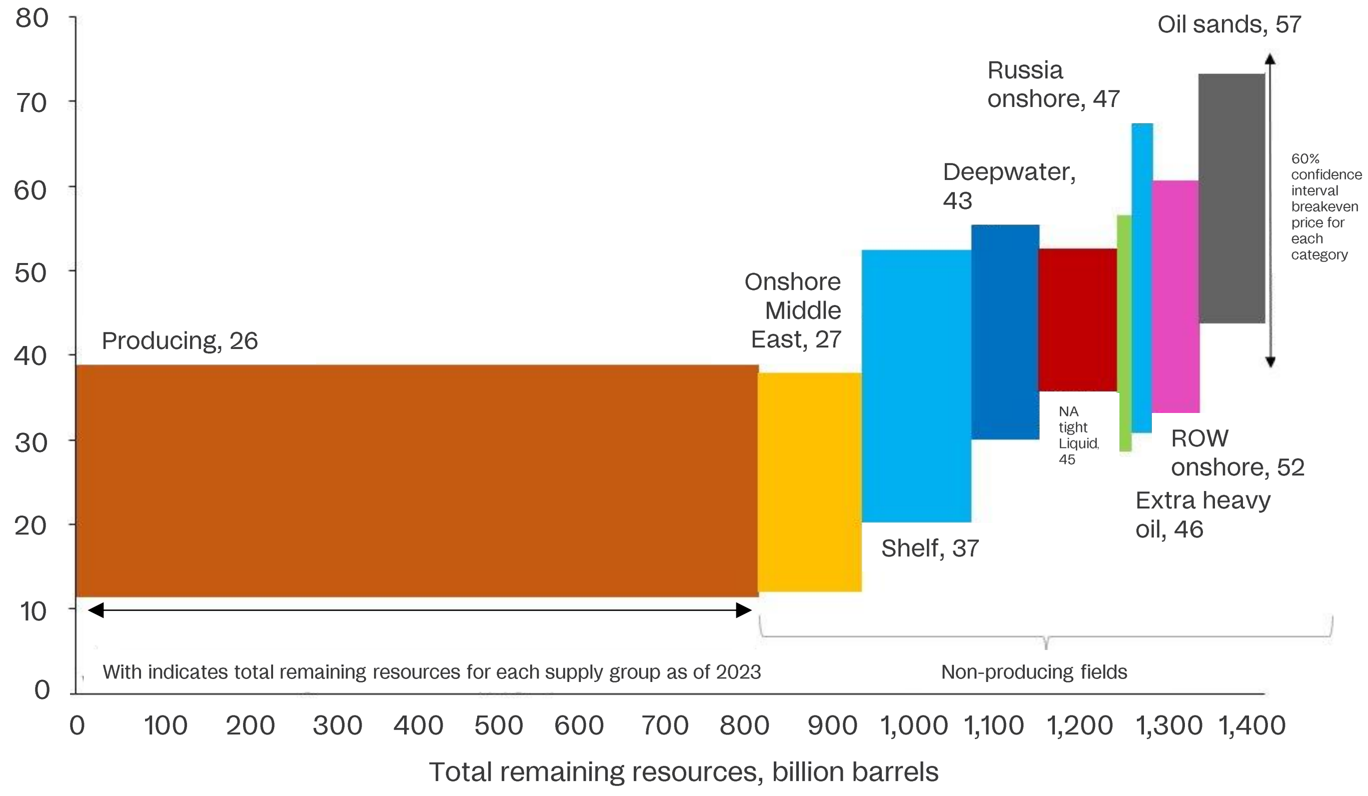
Where are the future supplies coming from?

Over the next few years, especially for crude oil, the growth of shale supply is expected to be outpaced by deepwater supply. Deepwater crude is projected to increase by an average of 400,000 bpd each year from 2025-30, before starting to decline in the mid-2030s. OPEC has the potential to expand by around 850,000 bpd, while shale expands by around 350,000 bpd over the next five to six years. However, both OPEC and shale supplies are expected to decline in the 2030s.

Cost of supply curve

The cost of supply curve for 2030 can help us better understand the cost competitiveness of the different supply sources.

Global liquid cost of supply curve for remaining resources for 2030
Brent breakeven price, USD per barrel



Source: Rystad Energy UCube, April 2025

This chart shows that offshore supply will play a significant role in meeting future demand, followed by other supply sources. The chart also highlights that, for future projects, offshore projects have one of the most competitive breakeven prices compared to other supply sources.

Comparing supply sources: Breakeven prices, IRR and emission intensity

A more detailed comparison of the different supply sources is presented in the table below.

Comparing supply sources: Breakeven prices, IRR and emission intensity

Supply segment	**Undeveloped liquids resources*** (Billion barrels)	**Average Brent breakeven price** (USD per barrel)	**Average payback time @ $70 per barrel** (Years)	**Average IRR @ $70 per barrel** (Percentage)	**Average CO_2 intensity**** (Kg/boe)
Other onshore OPEC	138	30	8	27	25
Offshore shelf	111	37	9	20	19
Tight oil	101	45	2	35	14
Offshore deepwater	68	43	8	24	15
Other onshore non-OPEC	59	50	17	15	27
Oil sands	50	57	13	12	69

*Includes the discovery life cycle **Average values for the years 2020 to 2023
Source: Rystad Energy UCube, April 2025

This table shows that shale tight oil and offshore sources have a lower carbon footprint than conventional onshore and oil sands from an emission intensity standpoint. However, from a breakeven standpoint, conventional onshore, tight oil, and offshore shelf have an advantage over deepwater.

Key offshore regions for future supply

Several offshore regions are poised to play a crucial role in meeting future global oil demand. The three key regions to watch are:

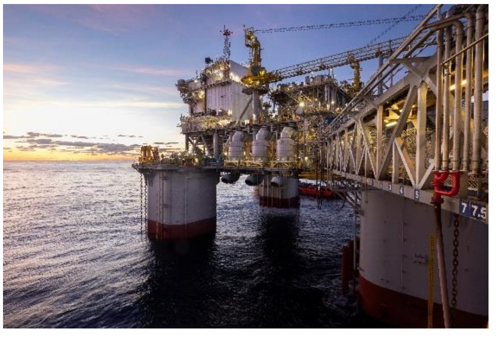
Gulf of America (Gulf of Mexico)

The Gulf of America remains a global leader in deepwater oil exploration, with recent developments pushing the boundaries of what's technically possible. Advanced drilling technologies, high-spec rigs and improved seismic imaging have enabled operators to access ultra-deep, high-pressure reservoirs once thought unreachable. The following key discoveries highlight the region's ongoing innovation and potential.

•**Anchor:** Operated by Chevron, Anchor marks a major industry milestone as the first deepwater project to deploy 20,000 psi-rated technology at full scale. With production starting in 2024 from reservoirs located 34,000 feet below sea level, Anchor demonstrates the successful application of next-generation HPHT drilling and completions in one of the world's most challenging offshore environments.

•**Kaskida:** Kaskida is BP's first Gulf development requiring 20,000 psi-rated well equipment. Enabled by cutting-edge 20K drilling technology and advanced seismic imaging, the project sets a new benchmark for safe and efficient development of ultra-deep reservoirs and opens the door for additional Lower Tertiary developments such as Tiber.

•**Sparta:** A deepwater development by Shell and Equinor, Sparta is one of the latest fields in the Gulf to incorporate 20,000 psi well design. The project reflects growing confidence in 20K systems as a standard for unlocking complex, high-pressure reservoirs in the Lower Tertiary trend.



Anchor at dusk
Source: Chevron

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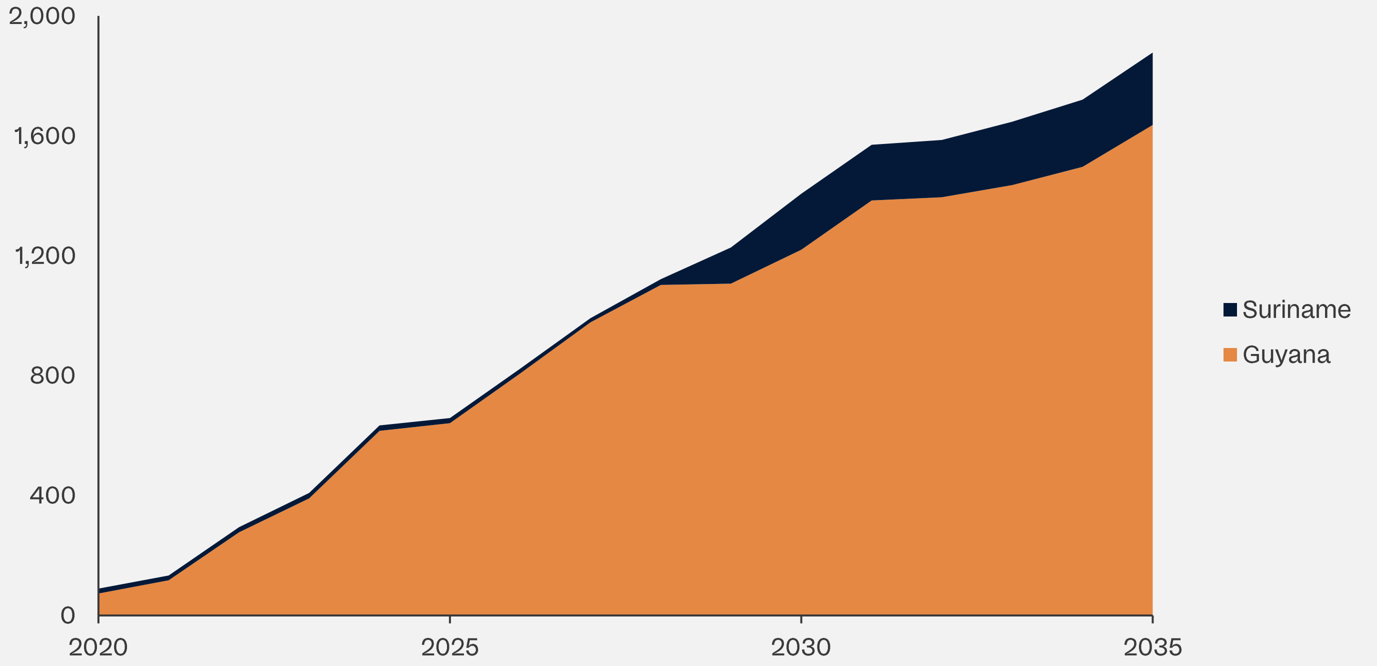
Key offshore regions for future supply

The Guyana-Suriname Basin

This region is rapidly emerging as a world-class offshore area, with massive discoveries of high productivity and profitable fields. Recent investment from supermajors like ExxonMobil, TotalEnergies, and also Hess have been substantial. For example, the Stabroek Block, operated by ExxonMobil, has delivered the Liza and Payara fields, which are world-class with significant reserves and low production costs.

Crude oil production from Suriname and Guyana 2020-2035
Thousand bpd



Source: Rystad Energy UCube, April 2025

Key offshore regions for future supply

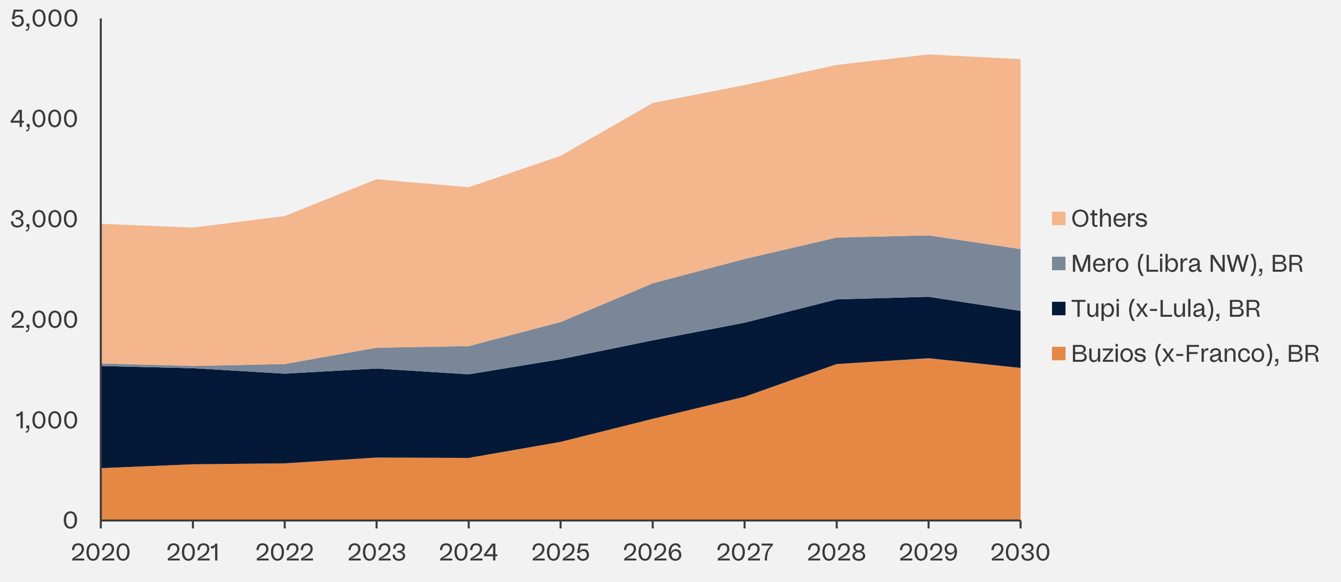
Brazil Pre-Salt (Santos and Campos Basins)

Brazil's pre-salt region is characterized by proven reserves, established production and highly prolific fields. Ongoing exploration and technology advancements are expected to drive reliable production growth, making Brazil a significant contributor to global oil supply stability through 2030 and beyond. Key fields in this region include:

•Búzios: The largest producing field in Brazil's pre-salt region, known for its high productivity and central role in Petrobras' strategy.

•Tupi (formerly Lula): A pioneering, prolific pre-salt field with sustained high productivity and major reserves.

Crude oil production from Brazil 2020-2030
Thousand bpd



Source: Rystad Energy UCube, April 2025

Brazil has the potential to add 2 million bpd of new production by 2030, offset by 1 million bpd of decline in producing fields. The main drivers of this growth are the Buzios, Tupi and Mero projects.

Key offshore regions for future supply

West Africa (Namibia and Angola)

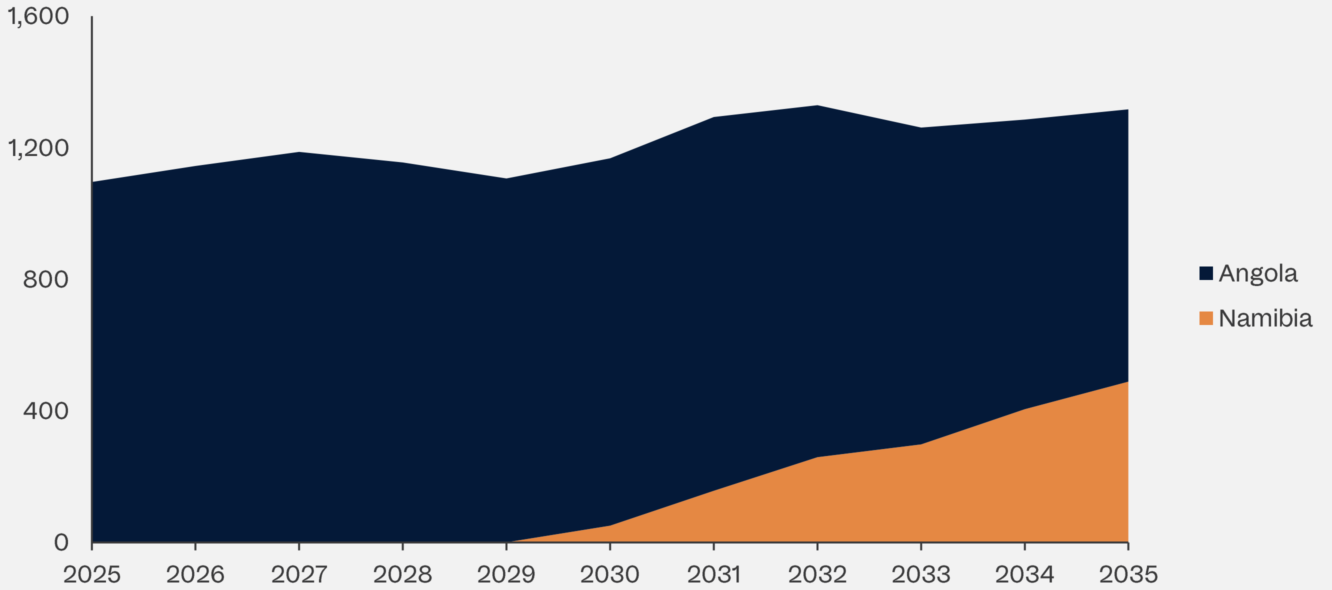
Recent significant discoveries offshore Namibia, such as the Venus and Graff fields, have opened a new frontier in the region. Ongoing deepwater investment offshore Angola is also expected to drive long-term growth and further discoveries, making West Africa strategically important well past 2030. Key fields in this region include:

•Venus (Namibia): A major discovery by TotalEnergies, with significant potential to transform Namibia into an oil-producing nation.

•Mopane (Namibia): A significant oil discovery by Galp Energia, confirming substantial hydrocarbon potential in the Orange Basin and strengthening Namibia's emergence as a key frontier for offshore exploration.

•Block 17 (Angola): An established cornerstone of Angolan offshore production, with continued exploration and production activity.

Crude oil production from Angola and Namibia 2025-2035
Thousand bpd



Source: Rystad Energy UCube, April 2025

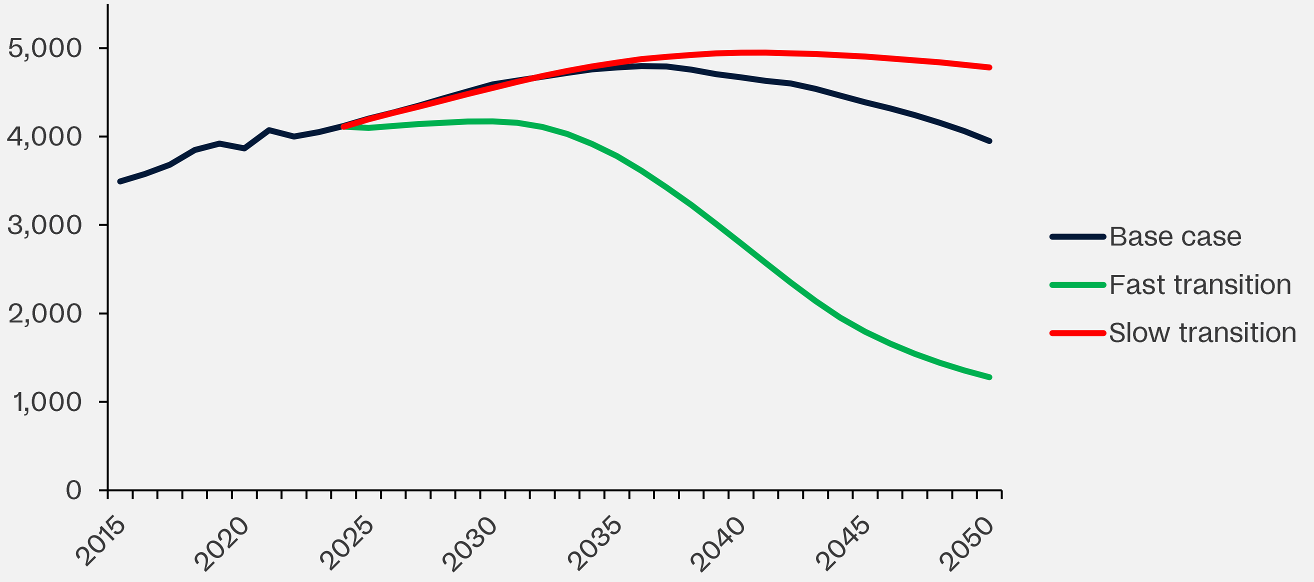
Gas demand

Global gas demand in 2024 reached approximately 4,119 billion cubic meters (Bcm), a slight increase from the 2023 level. The power sector accounted for roughly one-third of demand in 2024, followed by industry and buildings at 28% and 20%, respectively.

Gas demand scenarios

Let us also look at gas demand using these three different demand scenarios : Rystad Energy models a range of scenarios corresponding to specific degree levels (DG), measuring the increase in temperatures between pre-industrial levels in 1850 and 2100. In this paper, we will focus on the base case, fast transition, and slow transition scenarios.

Gas demand under three different scenarios
Billion cubic meters (Bcm)



Source: Rystad Energy GasMarketCube, April 2025

[2]Base Case: The RE base case closely tracks the 1.9 DG scenario in the medium term and converges with the 2.0 DG scenario towards 2050. Fast Transition: in line with the 1.6 DG scenario. Slow transition: in line with the 2.2 DG scenario

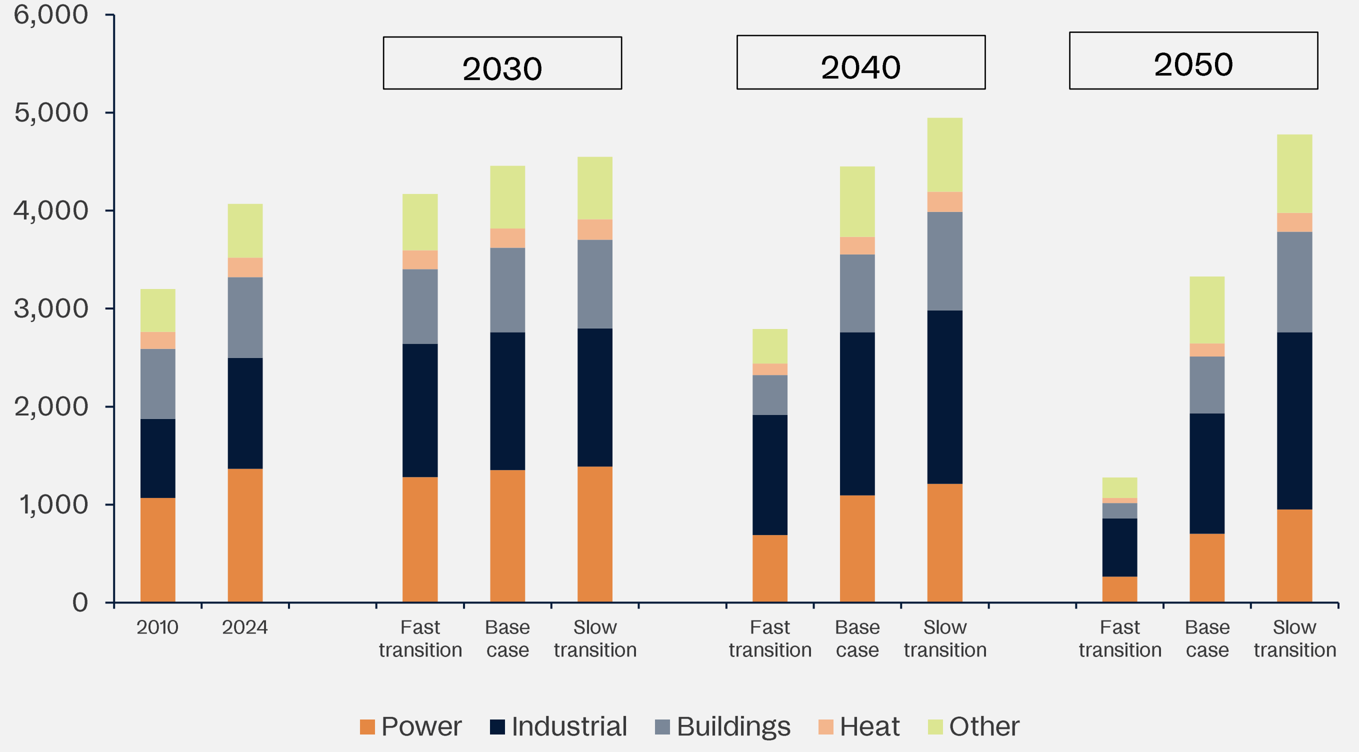
Gas demand scenarios

By 2030, the industry is expected to supplant power as the largest demand sector, with a growth of over 20% expected across scenarios, while gas-for-power is flatlining at best. The pace of renewables rollout and electrification of heating in buildings are the main determinants of gas demand in the 2030s. In a fast scenario, gas-for-power and building demand could be reduced by as much as half, shedding a combined 950 Bcm. In the base case and slow transition scenarios, the slower decline in power is offset, or even surpassed, by other sectors, especially industry, with a growth of up to 26%.

Long-term outlook (2030-2050)

While global gas demand is expected to decline across all scenarios and most sectors towards 2050, the scenarios diverge dramatically. In the fast scenario, decarbonization pressures lead to reductions of over 40% in all sectors, resulting in total demand of only 1,277 Bcm or a 54% decline compared to 2040. In the base case, demand is expected to decline by 25% to 3,329 Bcm – a whopping 2,050 Bcm higher than the fast transition case. From 2040 to 2050, the power sector is set to decline particularly fast at 36%, while other sectors decline more slowly.

Natural gas demand by sector
Billion cubic meters (Bcm)

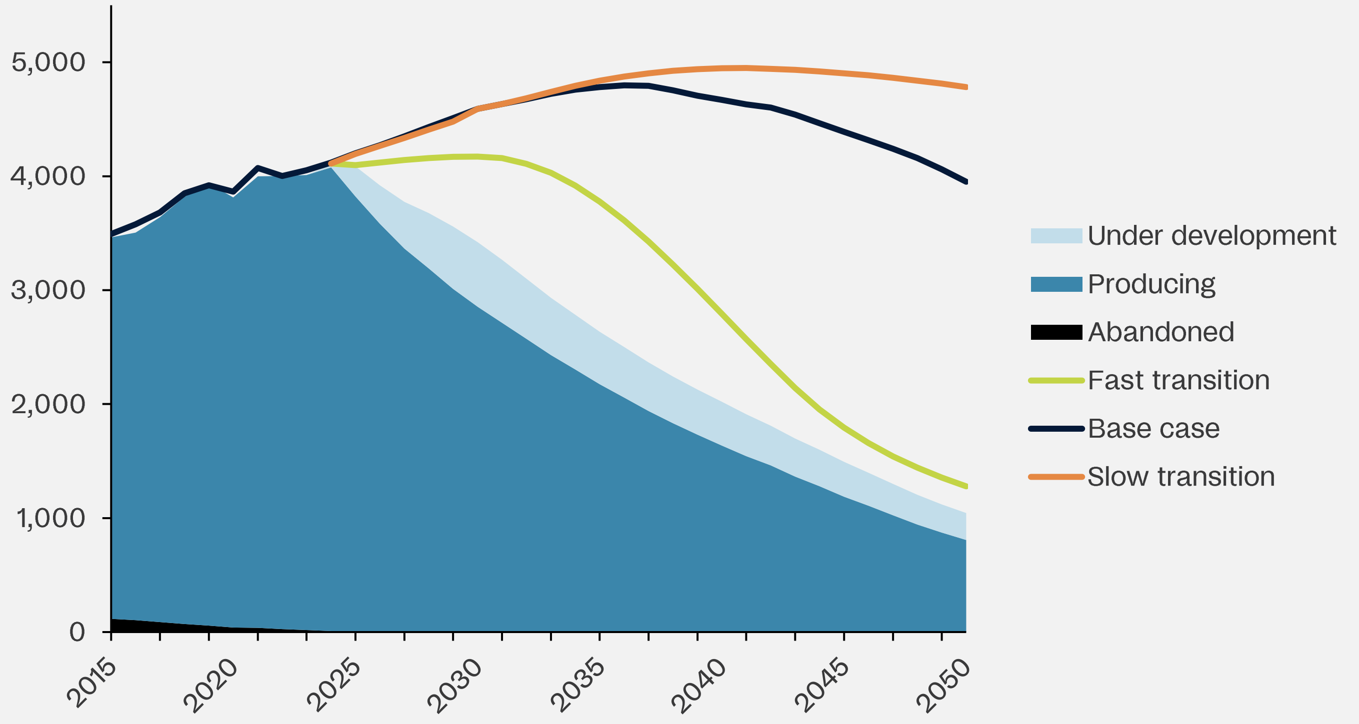


Source: Rystad Energy GasMarketCube; Rystad Energy research and analysis, April 2025

Global gas production

Global gas production reached about 4,100 Bcm in 2024. Despite increased output from Russia, China, and the Middle East, production from currently producing and underdeveloped fields is forecast to drop by 16.6% by 2030, resulting in a significant deficit. By 2035, the deficit is expected to range from 1,150 to 2,200 Bcm. By 2050, demand is projected to exceed currently sanctioned supply by 2,300 to 3,700 Bcm. Even in a scenario with an accelerated global energy transition, significant upstream investments are required to meet demand, indicating that natural gas will remain a key component of global energy mixes.

Producing and under development natural gas supply vs demand scenarios
Billion cubic meters (Bcm)

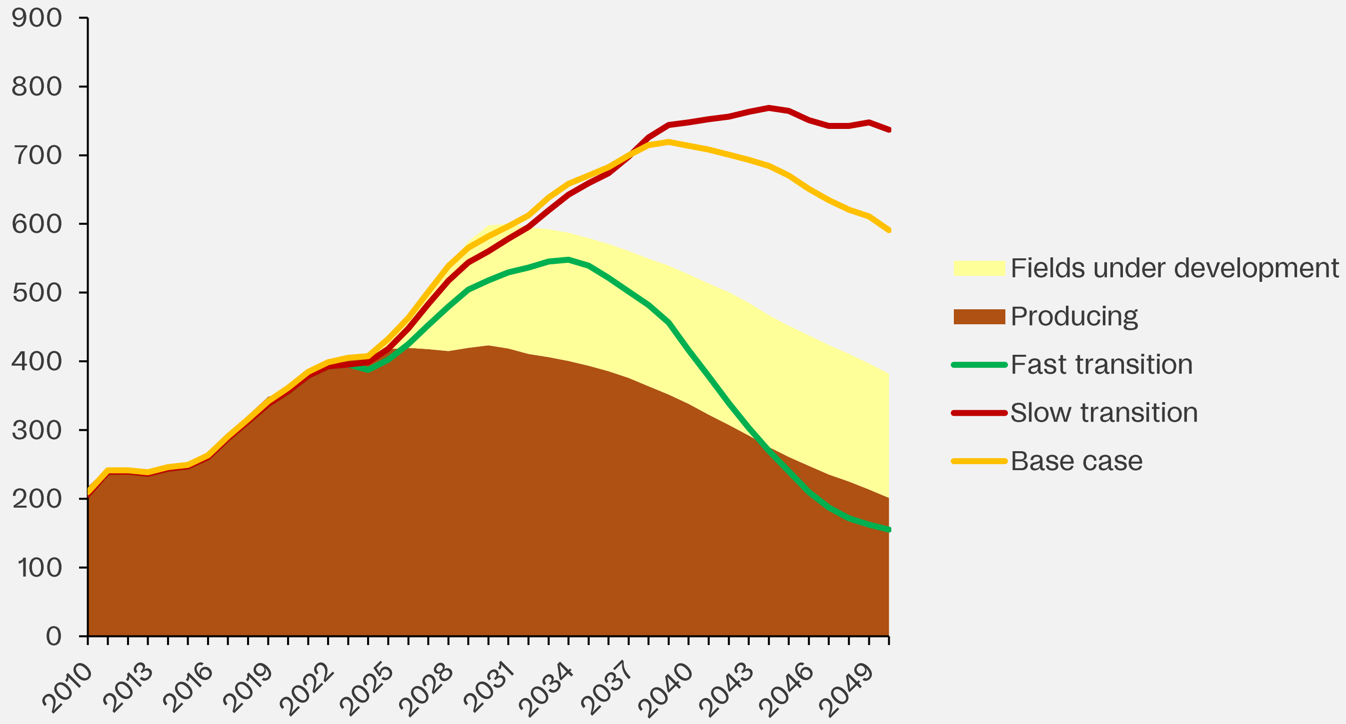


Source: Rystad Energy GasMarketCube; Rystad Energy research and analysis, April 2025

Global LNG demand scenario analysis

According to the base case scenario, the world would need approximately 170 million tonnes of additional liquefied natural gas (LNG) supply from newly approved projects (FIDs) by 2040. Conversely, under the fast transition scenario, existing and already approved projects are considered sufficient to meet global LNG demand through 2050.

Producing and under development LNG supply vs demand scenarios
Million tonnes

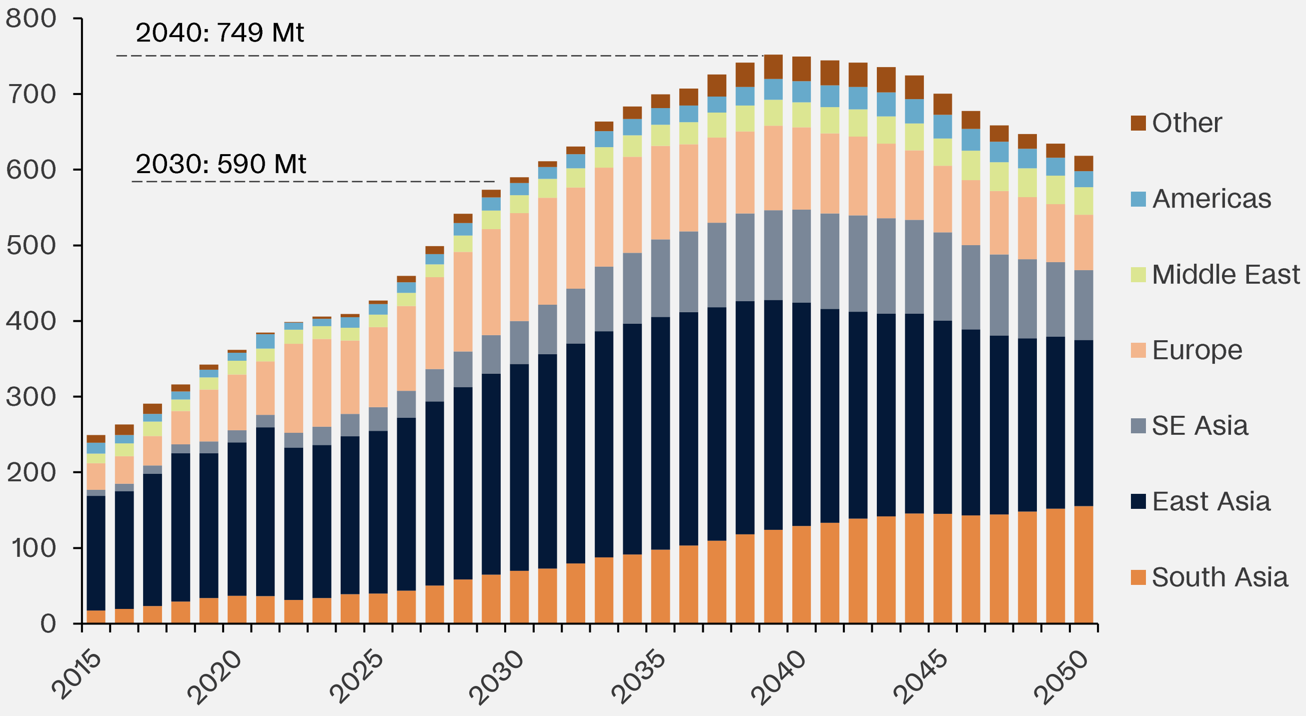


Source: Rystad Energy GasMarketCube, April 2025

Regional trends and outlook

Europe has become the premium market for LNG due to its government-backed energy security and willingness to pay a premium. Although the long-term LNG demand forecast for Europe has been reduced, it is still expected to reach 140 Mtpa by 2031 and decline to 73 Mt by 2050. The market has seen a shift towards long-term, destination-fixed LNG contracts to secure stable supply and reduce price variability. The development of new LNG projects, particularly in North America and the Middle East, is expected to add 200 Mt of export capacity by 2030, enhancing supply security for Europe. Global LNG demand is forecast to reach 576 Mt by 2030, driven by demand in OECD Asia and emerging markets, although the energy transition is expected to slow demand growth in East Asia from the 2030s onwards, with South and Southeast Asia continuing to drive demand growth through the 2040s.

LNG demand by region, Rystad Energy base case
Million tonnes per annum (Mtpa)

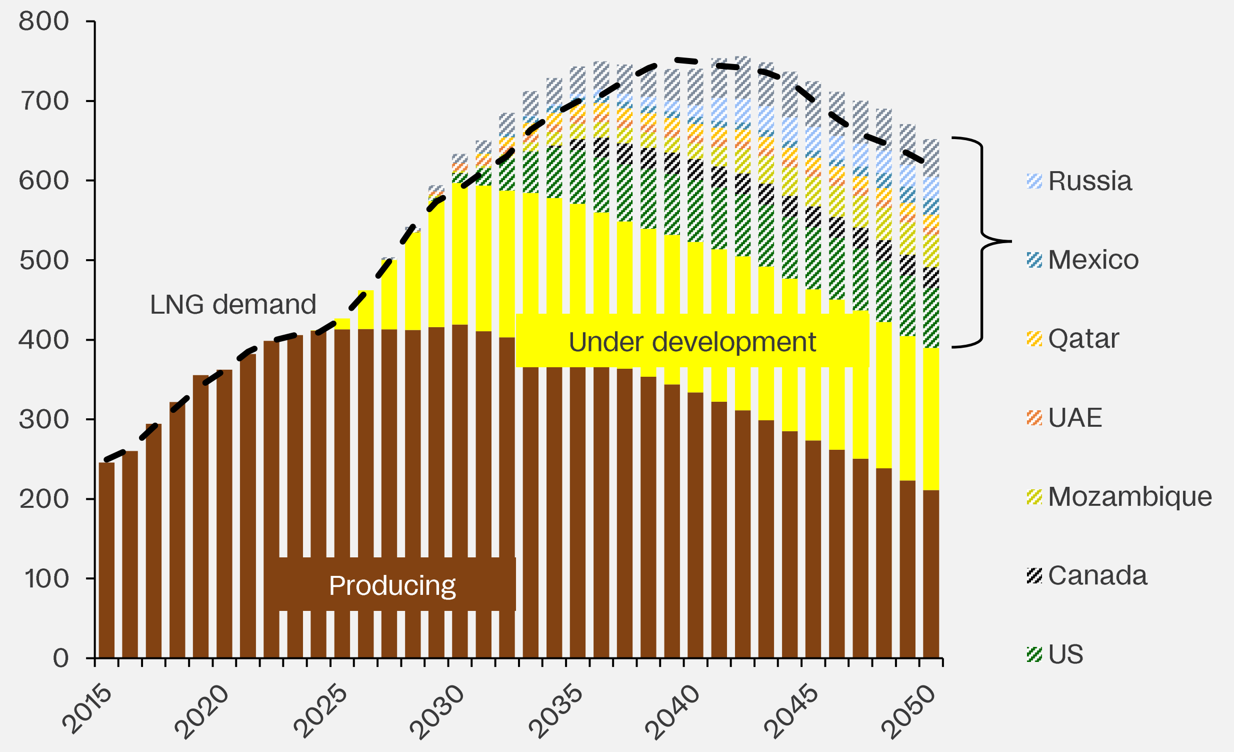


Source: Rystad Energy GasMarketCube, April 2025

Long-term outlook and regional trends

The global LNG market is facing challenges, including demand inflation, labor shortages, and environmental concerns, which may impact project development, particularly in price-sensitive regions. Despite these challenges, an impending oversupply in the late 2020s is expected to accelerate LNG demand. The oversupply risk is balanced by EPC inflation and higher return expectations by project developers, which have delayed FIDs. By 2040, a supply requirement of over 200 Mt is expected, with nearly 38% of this coming from US-origin LNG, driven by declining domestic gas demand in the US. However, regional projects in Asia will also be crucial for maintaining price competitiveness in the long term.

LNG supply by life cycle and demand base (Rystad Energy base scenario*)
Million tonnes per annum (Mtpa)

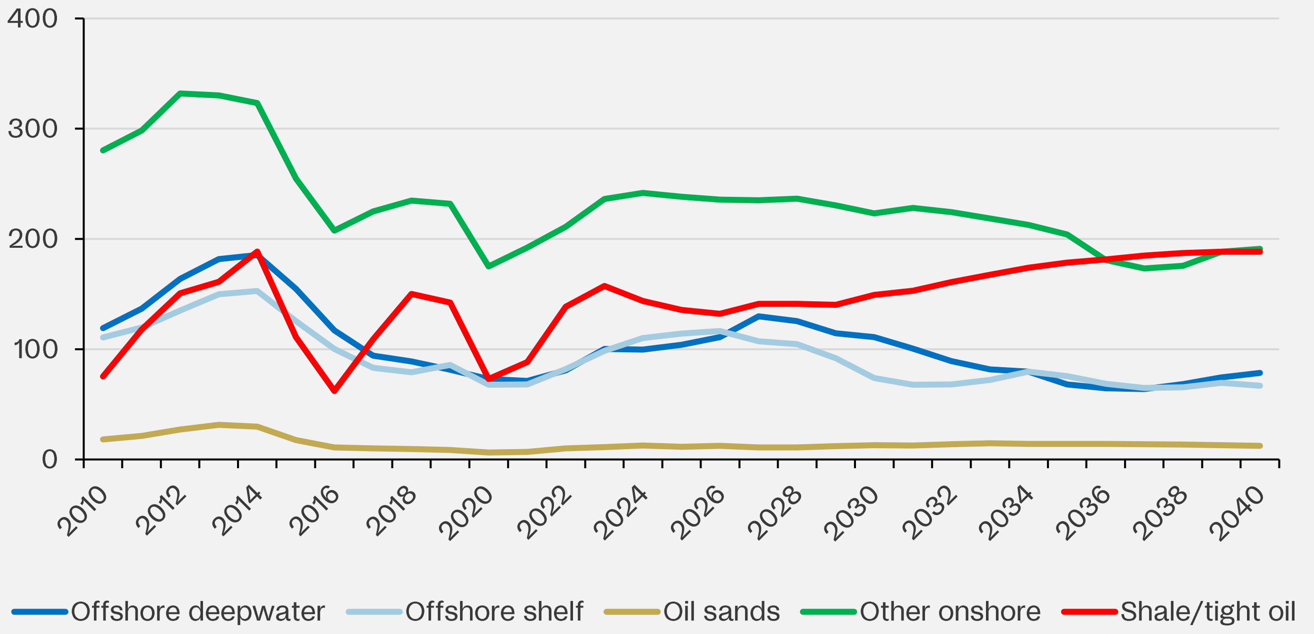


Source: Rystad Energy GasMarketCube, April 2025

IV. Oil and gas investment and drilling outlook

We expect global capital expenditures (capex) on developing and maintaining upstream oil assets to reach around $600 billion per year in 2025. However, this amount is expected to decline to under $570 billion per year by 2030. Offshore investment will peak around 2027, then gradually decline through 2030 to 2040.

Global E&P upstream investments by segment for base case
Billion USD

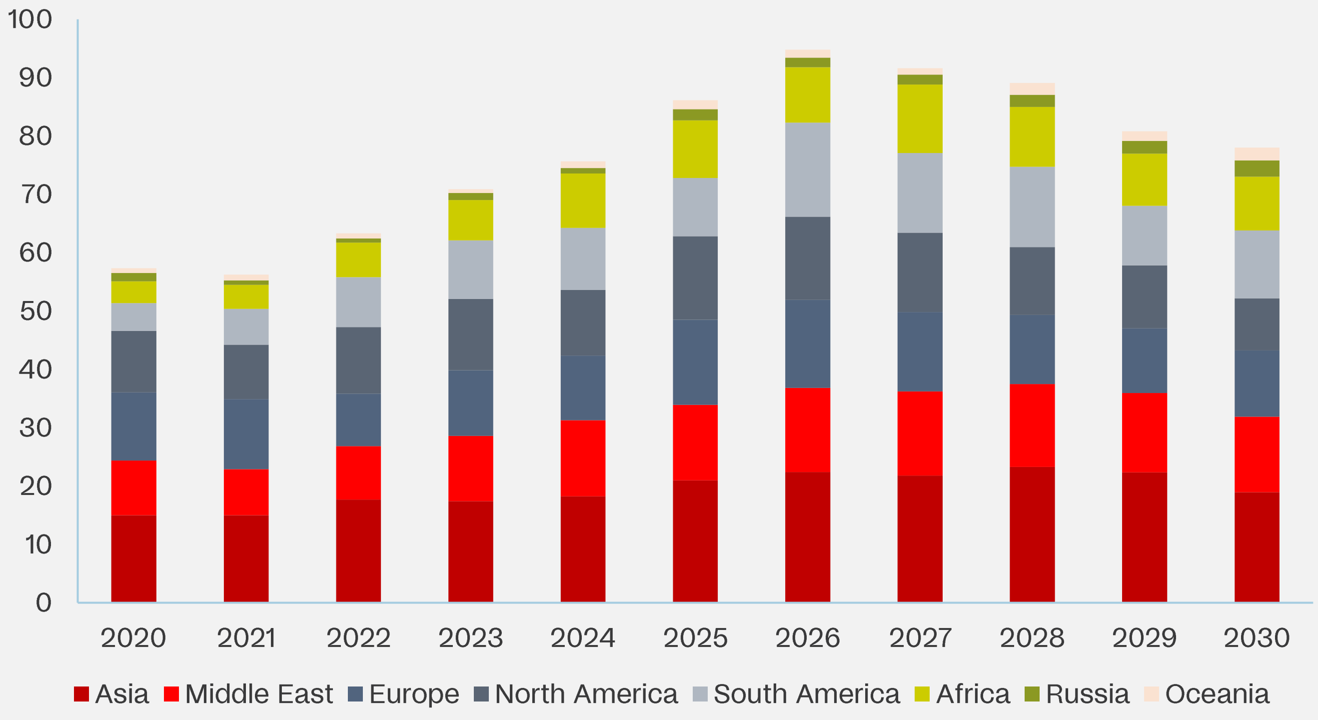


Source: Rystad Energy UCube, April 2025

Offshore well and exploration well investment by region

As shown in the chart below, the primary regions driving offshore well and exploration well investment from now to 2030 are Asia, Europe, North America, and South America. In terms of well capex, the main drivers are Norway, China, the US, and Brazil. On the exploration side, Brazil and Guyana are also expected to see continued activity, building on their existing investments. Additionally, Africa is poised to witness significant exploration well drilling activities in the coming years.

Global offshore well and exploration well investment base case
Billion USD

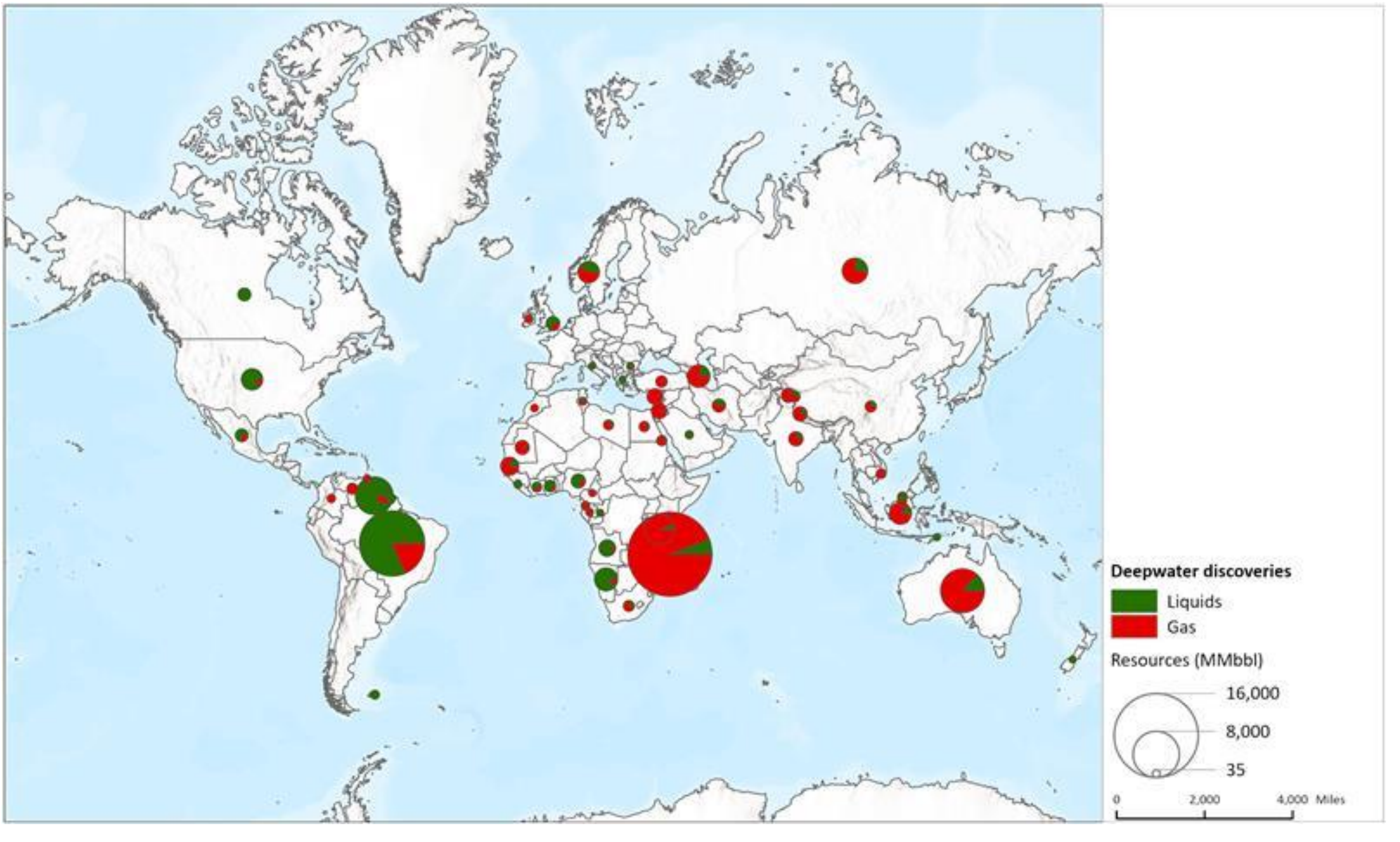


Source: Rystad Energy UCube, April 2025

Offshore well and exploration well investment by region

The map below illustrates the distribution of discovered and underdeveloped deepwater resources by country, highlighting the discovered and underdeveloped deep water field resources in Africa by oil and gas.

Discovered and underdeveloped offshore deepwater resources



Source: Rystad Energy UCube, April 2025

V. New US tariffs: Immediate and long-term supply chain ripples

The global energy supply chain is undergoing significant changes due to the aggressive tariff policies introduced in 2025. New US trade restrictions across trading partners and those focused on steel, aluminum and energy equipment are causing cost escalations and shifts in sourcing strategies. The market currently faces great uncertainty due to unclear tariff timelines and rollout plans.

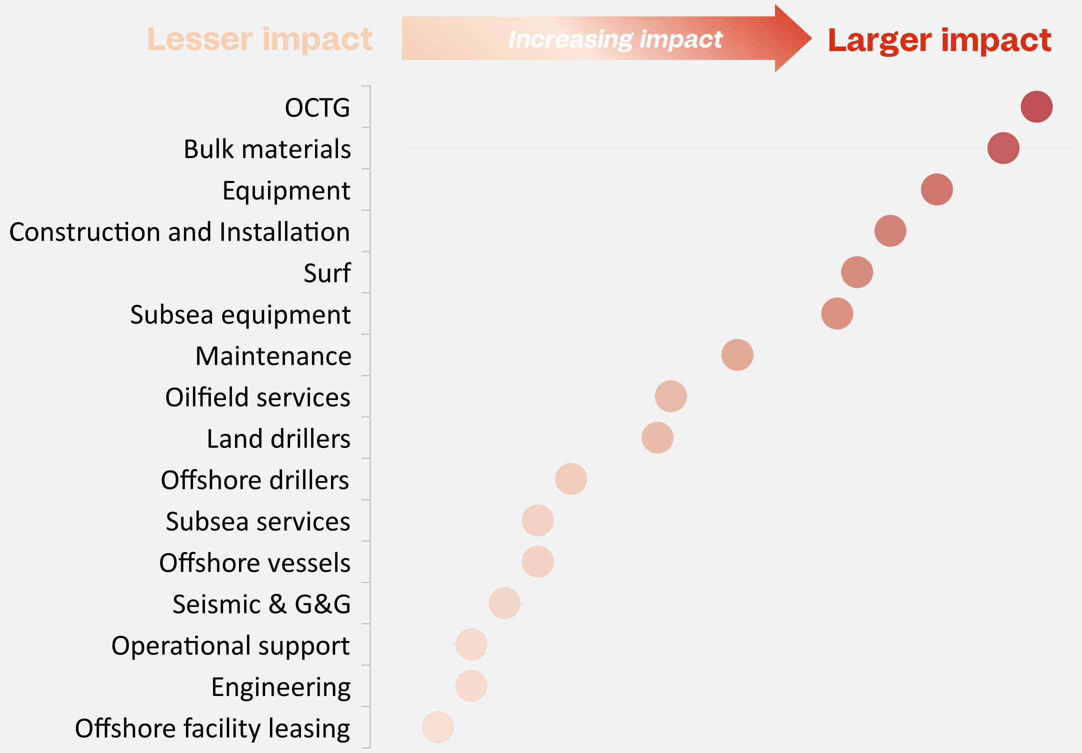
These tariffs are having a ripple effect across various aspects of supply chain management. The direct impact of tariffs is most evident in the increased cost of raw materials like steel and aluminum, which in turn raises project costs. Companies are having to find new suppliers, leading to short-term supply gaps and increased lead times. In some cases, logistics networks need to be reconfigured, causing disruptions across various industries.

The oil and gas industry is particularly vulnerable to the effects of tariffs. The sector most affected is oil country tubular goods (OCTG), with tariffs on imports from Canada and Mexico disrupting supply chains and increasing price volatility. Other traded equipment, such as Christmas trees, gas turbines, compressors, and spare parts, are also expected to experience significant price increases.

According to our analysis, on a scale of 1 to 10, the oil and gas category likely to be most impacted by tariffs is oil-country tubular goods (OCTG), followed by bulk materials and equipment. Tubular goods and linepipe are seen as the most affected because they are directly subject to tariffs, while bulk materials and equipment experience both direct and indirect effects. The categories expected to be least affected are primarily services, such as rigs, vessels, and seismic operations. Our estimates of the impact on various oil and gas categories consider potential price changes, lead times, and other trade-related challenges. The potential cost implications for oil and gas projects remain subject to a range of variables, including retaliatory tariffs.

New US tariffs

Oil and gas categories tariff impact analysis
Rated on a scale of 1 to 10



Note: impact is based on price changes, lead times and trade challenges from currently announced tariffs; tariffs included: 25% steel, aluminum, likely 25% tariffs imports on EU
Source: Rystad Energy research and analysis, March 2025

Strategies for mitigating the impact of tariffs on the energy supply chain are crucial in the current market environment. One such strategy is diversification, which involves broadening the supplier base to reduce reliance on tariffed regions and exploring domestic production options. By doing so, companies can minimize their exposure to tariffs and maintain a stable supply of essential materials.

Another approach is to focus on inventory and logistics planning. Companies should consider stockpiling essential parts and using data analytics to better forecast demand and optimize procurement schedules. This proactive approach can help mitigate the effects of tariffs by ensuring a steady supply of critical components and reducing lead times.

New US tariffs: Immediate and long-term supply chain ripples

Financial and contractual adjustments can also play a key role in mitigating tariffs' impact. Strategies like hedging and negotiating cost pass-through agreements can help mitigate financial risks from tariffs. By taking a proactive approach to managing financial risks, companies can reduce the uncertainty and volatility associated with tariffs.

Finally, technology and digitalization can also be leveraged to mitigate the impact of tariffs. Using AI and blockchain can improve supplier selection, risk management, and supply chain visibility. By embracing digital technologies, companies can gain a deeper understanding of their supply chains and make more informed decisions to navigate the complexities of tariffs.

Mitigating actions for procurement resilience

Tactical → longer term → Strategic

Actions	Risks and rewards	Example segments
Stockpiling	• Ties up capital • Mitigate tariff exposure	OCTG
Seek alternative technologies with existing suppliers	• Performance and price risk • Protection from tariffs	Equip.
(Re)-negotiate contracts with indexation & other financial safeguards	• Supplier pushback • Risk hedging	All
Seek alternative suppliers	• Qualification delays • Diversified supply base	Materials
Drive homeshoring of value chain	• High setup cost • Long-term supply security	Yards
Leverage new technologies & digital tools	• Adoption challenges • Procurement traceability	All

Risks
Rewards

Source: Rystad Energy research and analysis, March 2025

VI. Offshore clean tech: Diversifying energy sources

CCUS and offshore

Carbon Capture, Utilization, and Storage (CCUS) is a versatile emissions reduction technology that can be applied across various sectors of the energy system. It captures CO2 from fuel combustion or industrial processes, transports it via ship or pipeline, and then utilizes or stores it.

Role of CCUS in decarbonization

CCUS plays a multifaceted role in decarbonization, with a range of key applications. One of the primary uses of captured CO2 is Enhanced Oil Recovery (EOR), which accounts for over 65% of the global captured capacity. Beyond EOR, CCUS is also used for geological storage, where CO2 is permanently stored in deep geological formations, such as saline aquifers or depleted oil and gas reservoirs.

Advantages of offshore CCUS

Offshore CCUS presents several advantages, including:

•Vast pore space availability in offshore geological formations, particularly saline aquifers.

•Reduced NIMBYism (Not-In-My-Back-Yard opposition) as storage sites are located away from densely populated areas.

•Reduced subsurface risks such as pore space trespass and contamination of underground sources of drinking water.

•Existing infrastructure, expertise, and supply chains can be leveraged to reduce project costs.

Challenges of offshore CCUS

However, offshore CCUS projects also come with several challenges, including:

•Higher development costs compared to onshore projects.

•Logistical complexity of offshore reservoirs, often located in deep waters.

•Regulatory frameworks for offshore CO2 storage are still evolving in some regions.

•Environmental concerns such as potential impacts on marine biodiversity and endangered species in deeper waters.

Regional projects

Offshore CCUS projects are underway in various regions, including the US Gulf Coast, Europe and Asia. This section provides an overview of notable projects in each region, starting with the US Gulf Coast.

Offshore CCUS projects underway

•Sleipner Field (Norway): Permanent geological storage of CO_2 in the Utsira formation, a saline aquifer beneath the North Sea.

•Northern Lights Project (Norway, Denmark, Netherlands): A pioneering cross-border "open-source" CCS infrastructure project, led by Equinor, Shell, and TotalEnergies.

•US Gulf Coast: Several offshore CCUS projects are in development, including the Bayou Bend Projects and the Aves CCS Hub.

Challenges and opportunities

Despite the challenges, offshore CCUS projects offer significant opportunities for emissions reduction. The key is to navigate the complexities and challenges of offshore storage while leveraging existing infrastructure and expertise to reduce project costs.

Offshore wind

Offshore wind energy is a rapidly expanding renewable energy source, enabling large-scale utility generation near populated areas where land is scarce. By locating wind farms offshore, conflicts with wildlife and human activities are reduced, and stronger, more predictable winds can be harnessed.

Global offshore wind industry

The global offshore wind industry is experiencing rapid growth, driven by government targets and increased developer confidence. Many countries are committed to meeting installation targets by 2030, resulting in high installation activity. While bottom-fixed installations will account for over 90% of installed capacity by 2030, floating wind is gaining popularity.

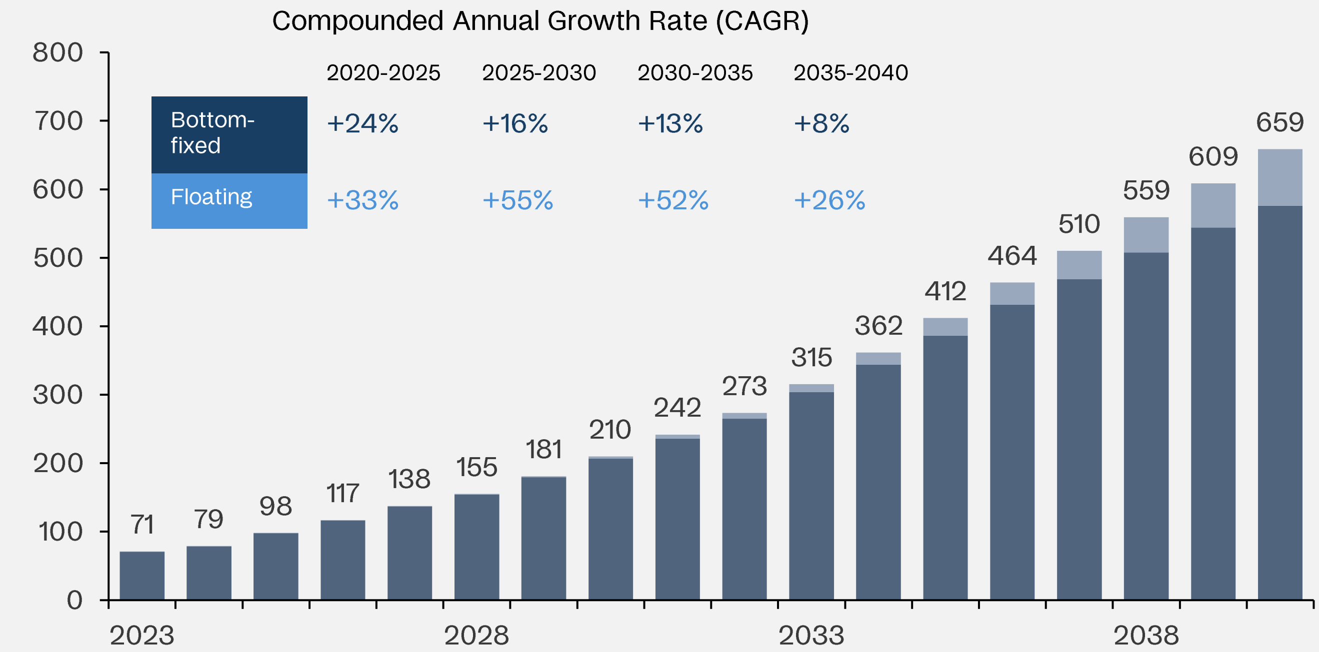
Challenges and advancements

Despite the growth, several challenges remain for the floating offshore wind sector, including technical readiness, policy support and cost. However, advancements are occurring, with over 100 unique floating wind concepts, primarily semisubmersible floaters. The levelized cost of electricity (LCOE) for floating offshore wind is expected to decrease significantly by 2040.

Regional opportunities

Regional opportunities for floating wind are vast. Europe is expected to lead floating wind installations, driven by aggressive targets. Asia is predicted to follow, with South Korea emerging as a major market. The UK is projected to be the global leader, with substantial planned capacity driven by recent auctions. By 2040, installations are projected to exceed 658 GW, with floating wind accounting for roughly one-eighth of this total.

Global offshore wind forecast, 2023-2040
Gigawatts (GW)



Source: Rystad Energy Offshore Wind Cube, April 2025

Floating PV and onshore PV

Solar energy is a versatile and renewable energy source that can be harnessed for various purposes, including heating, electricity generation, and powering other processes. Solar panels, also known as photovoltaic (PV) cells, convert sunlight directly into electricity through the photovoltaic effect.

Floating PV

Floating PV consists of solar PV farms installed on bodies of water, including freshwater and saltwater. PV modules are mounted on floating structures, such as pontoons or platforms, which are typically located on ponds, lakes, and hydroelectric dams. This method of installation offers several advantages, including reduced land usage and increased yields due to the cooling effect of the surrounding environment. In some cases, floating PV farms can generate up to 10% more electricity than ground-mounted systems. Additionally, combining floating PV with hydroelectric dam installations can provide existing connection infrastructure and enable hybridization, improving the generation profile. In reservoir applications, floating PV installations can also contribute to water conservation by minimizing evaporation losses.

Offshore PV

Offshore photovoltaic (PV) systems utilize specialized floating solar panels engineered for buoyancy and durability in marine conditions. These panels are coupled with robust anchoring systems to maintain stability against wind, waves and currents. Essential electrical infrastructure is integrated to transmit generated power to the onshore grid efficiently. Offshore PV systems offer significant advantages, including optimized space utilization and preservation of valuable land resources.

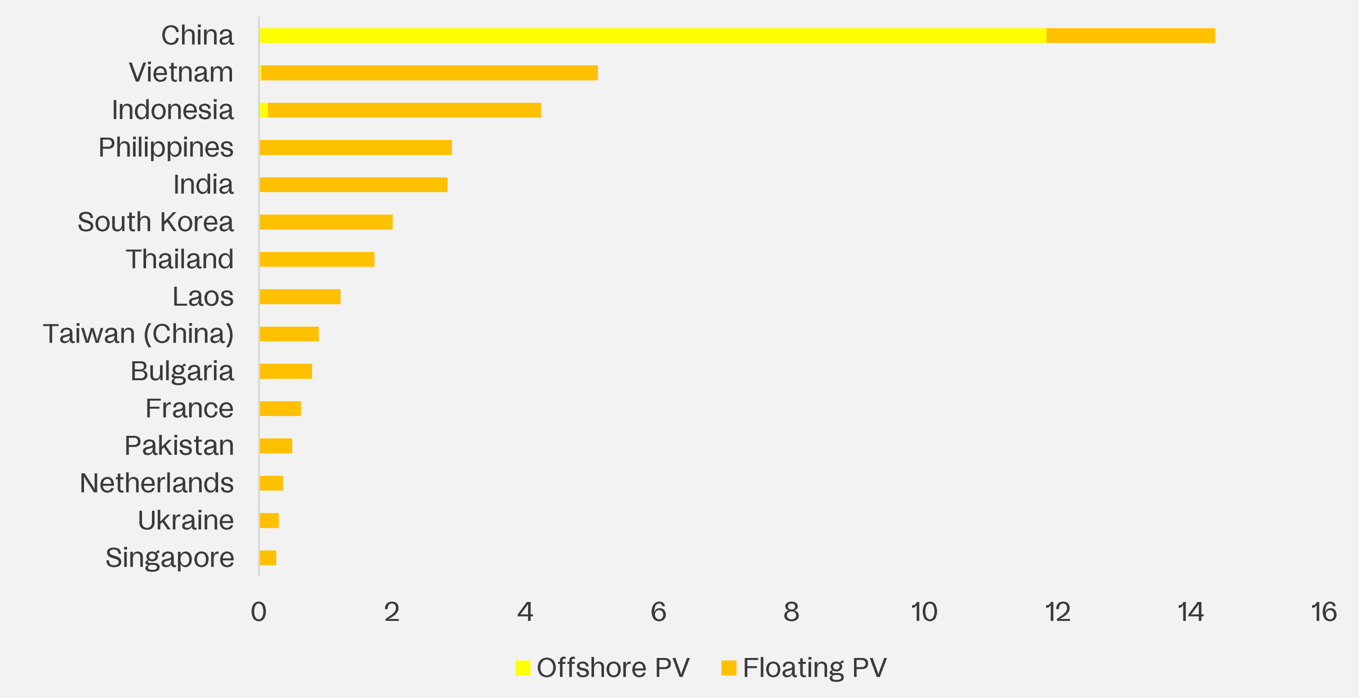
Market overview and challenges

The offshore PV market is still in its early stages, with most activity limited to pilot projects and research initiatives. However, the sector has seen some growth, reaching a cumulative installed capacity of 1.1 GW in 2024, primarily driven by China. China also leads the development pipeline, with 13 GW of projects under various stages of development. Other countries, including Japan, Singapore, the Netherlands, and Norway, have deployed small-scale pilot projects.

Despite its potential, the offshore PV market faces several challenges, including high development costs, the need for further research on the technology's effects on underwater ecosystems, and ensuring the structures can withstand harsh offshore conditions. Additionally, the lack of regulatory frameworks hinders the market's growth.

The following chart provide a visual representation of the global floating PV and offshore PV market.

Global floating PV and offshore PV capacity by 2040
Gigawatts (GW_{AC})

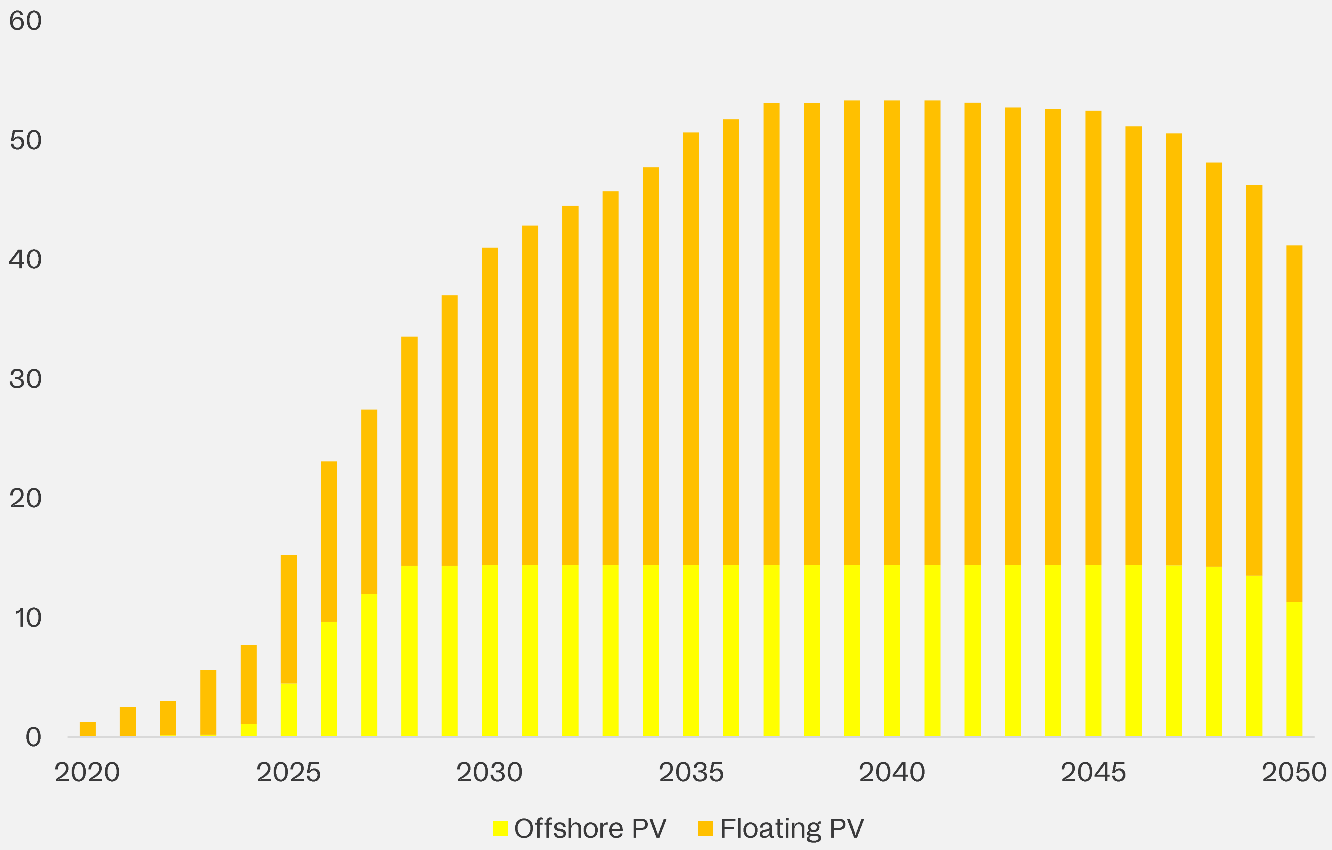


Sources: Rystad Energy PowerCube, April 2025

Market overview and challenges

The following chart provide a visual representation of the global floating PV and offshore PV market.

Global floating PV and offshore solar PV outlook, 2015-2400
Gigawatts (GW_{AC})



Sources: Rystad Energy PowerCube, April 2025

Geothermal energy: A growing market driven by drilling advancements

Geothermal energy harnesses the heat from the Earth, accessed by extracting hot water or steam from underground reservoirs. This heat can be utilized for electricity generation or direct heating applications. The geothermal market is gaining traction due to its baseload capabilities, minimal land footprint, and dual applications for power and heating.

Olkaria geothermal field

Geysers geothermal field

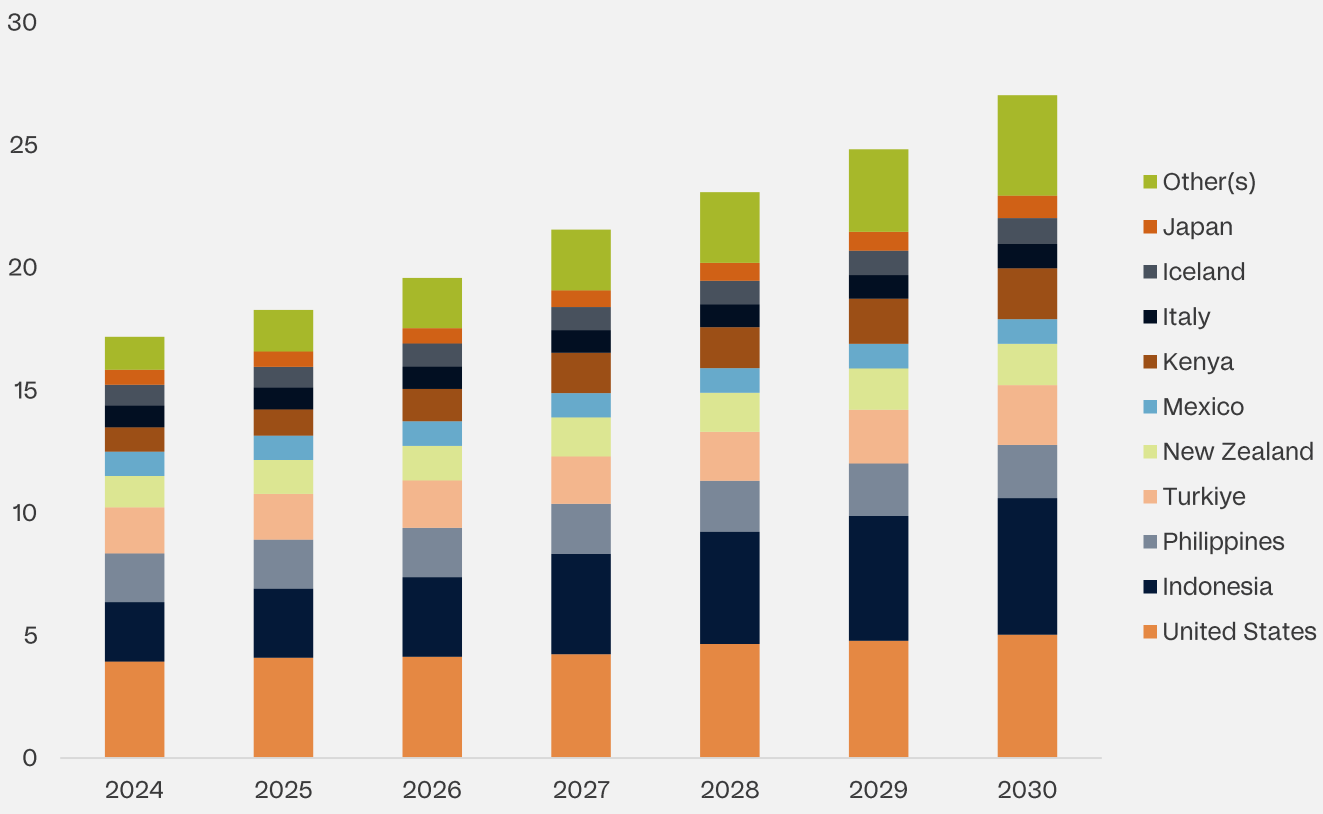
Geothermal power

Geothermal power generation initiatives are typically established in locations with high thermal gradients. These projects are often located in areas with significant tectonic and volcanic activity, leading to the creation of high-enthalpy regions. Historically, the geothermal power market has been led by activity along the Ring of Fire.

Market growth and regional hotspots

Rystad Energy forecasts that global installed geothermal power capacity will increase by 56% to 27 gigawatt-electric (GWe) by 2030, up from the current 17.2 GWe. The US, Indonesia, the Philippines, and Türkiye are expected to remain key drilling hotspots.

Geothermal installed capacity
Gigawatts electrical (GWe)

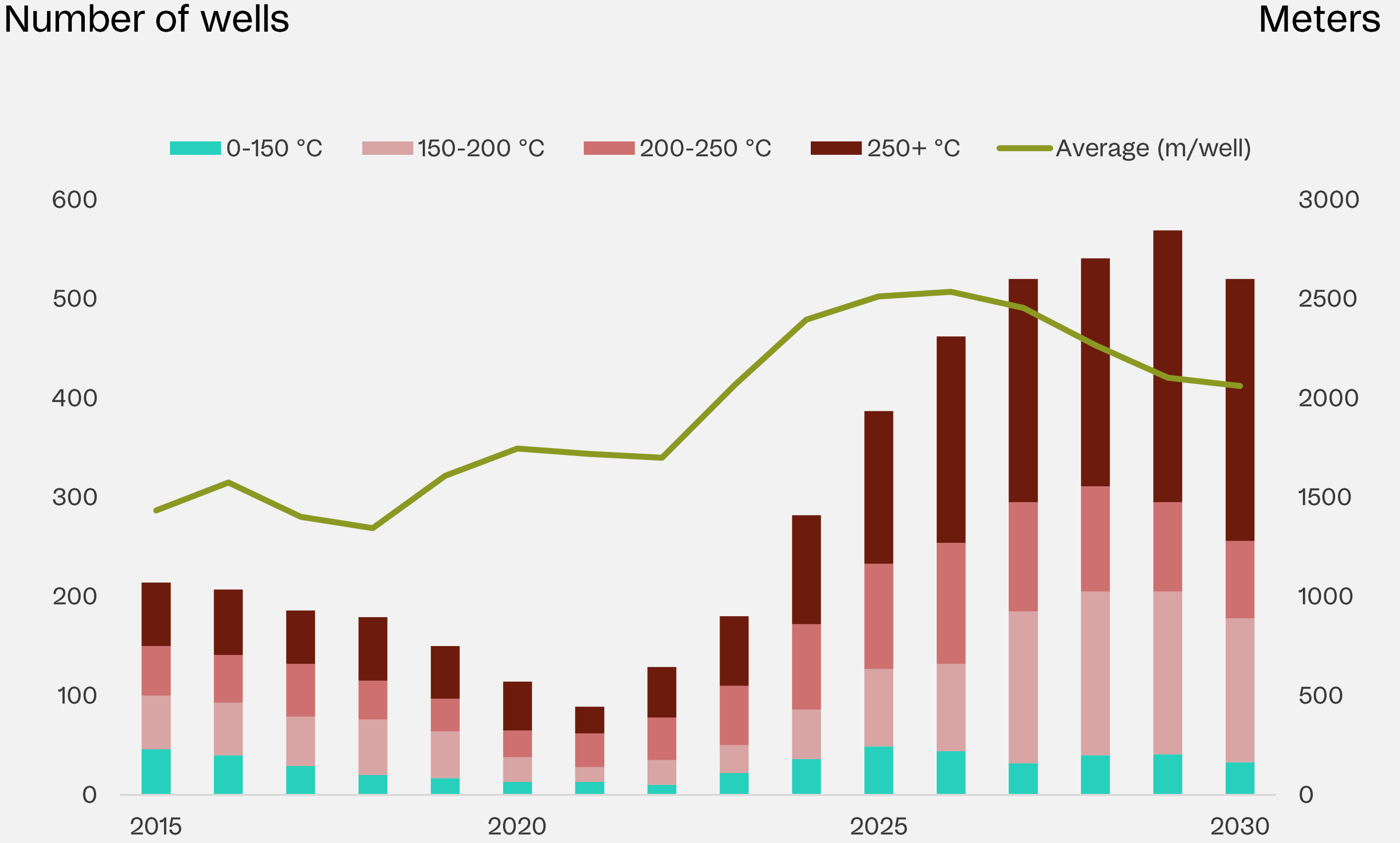


Source: Rystad Energy Geothermal Analysis Dashboard, April 2025

Drilling: The foundation of geothermal development

The global leaders in the geothermal power generation market are the US, Indonesia, the Philippines, and Türkiye, with a total installed capacity of around 10.2 GWe and 3,800 active wells as of the end of 2024. These countries are expected to remain drilling hotspots, with a cumulative annual growth of more than 15% in drilling activity between 2024 and 2030. This growth will provide opportunities for drilling contractors and well service companies, with an expected increase from around 280 wells drilled in 2024 to close to 520 in 2030.

Wells drilled globally for geothermal power generation



Source: Rystad Energy Geothermal Analysis Dashboard, April 2025

Geothermal heating

Geothermal energy has been utilized for thousands of years, with heat extracted from hot springs. The most widespread use of deep/medium-deep geothermal energy is district heating. The global installed capacity for geothermal heating stood at approximately 26.4 GWt at the end of 2024.

Leveraging oil and gas expertise

The oil and gas (O&G) industry's experience and technology offer significant opportunities for geothermal development. The transfer of technology and workforce from the O&G sector can accelerate geothermal projects. Existing O&G wells can be repurposed for geothermal production, reducing costs and infrastructure requirements. The US shale industry's experience in horizontal drilling and hydraulic fracturing is crucial for enabling EGS technologies. Growing interest from O&G service companies is driving innovation and efficiency in geothermal drilling.

A selection of North American land drilling contractors involved in geothermal start-ups

Contractor	Share of the number of rigs[3]	Involved in geothermal	Invested in geothermal start-ups
NABORS	12%	✓	✓
H&P	31%	✓	✓
ENSIGN	5%	✓	⊘
[illegible]	6%	✓	✓
PATTERSON-UTI	22%	⊘	✓

Source: Rystad Energy Geothermal Analysis Dashboard, April 2025

[3]The percentage of rigs shown in the table represents the share of total US land rigs as of 2024. Data reflects activity through October 2024.

Offshore geothermal potential and challenges

Offshore geothermal resources offer significant potential, particularly in the Gulf of America. However, offshore geothermal development faces several challenges, including high costs, technological challenges, and environmental concerns.

Wave and kinetic energy

Extracting energy from tidal and wave energy has been discussed for quite some time, as these two energy sources bring something to the table that other renewable sources cannot: predictability. Solar and wind power are intermittent and prone to rapid fluctuations, causing more blackout risks for transmission system operators (TSO) and distribution system operators (DSO) to maintain grid operations. Tidal range is the difference in potential energy of the water between high and low tides. Tidal streams, on the other hand, use direct water flow in the ocean, which is induced by the potential difference between the moon and the sun to a large extent, in addition to temperature variations in the ocean. As the movement pattern of the moon is predictable, so are the tidal range and tidal stream. This advantage of predictability can complement other renewable sources such as solar and wind, increasing overall grid stability.

There are currently only two utility-scale tidal barrage projects in the world, with a total capacity of almost 500 Megawatt (MW): the 240 MW La Rance in France, built in 1966, and South Korea's 254 MW Sihwa power station, commissioned in 2011. Many countries are exploring tidal power, including the UK, China, the US, Japan, and Australia. Tidal and wave power offer predictability, which is not available with solar and wind power.

Advantages of tidal barrages and tidal stream

Tidal barrages have a long project lifetime of up to 120 years, but research has shown that they can affect the environment as they change the water circulation pattern. Tidal streams, on the other hand, have a simpler installation process and can generate power three times that of offshore wind turbines for the same turbine size.

Wave power: Utilizing kinetic energy

Wave power utilizes kinetic energy transfer when the wind blows across the water's surface. Many concepts have been proposed for wave energy generator devices, but there is no convergence on technology yet.

Subsidies and industrialization

Government subsidies are still necessary to industrialize these new ocean energies. The UK is the frontrunner in tidal stream development, providing subsidies to demonstration projects. The UK government awarded a strike price of almost 198 GBP/Mwhfor most tidal stream projects, which is still higher than other nascent offshore technologies such as floating wind.

VII. Key enablers of offshore decarbonization

As the offshore energy sector evolves to meet global decarbonization goals, a range of innovative technologies and strategies are emerging to reduce emissions, enhance efficiency, and support clean energy integration. From carbon capture systems and digitalization to advanced grid infrastructure, critical mineral sourcing, and alternative fuels, these developments play a crucial role in shaping a more sustainable offshore future.

Continued radical and incremental innovation is paramount for the whole offshore sector. It enables cost and emissions reductions, improves safety and enhances operational efficiencies.

Offshore carbon capture: Mitigating emissions directly at the source

Offshore carbon capture technologies, specifically those deployed on floating production storage and offloading (FPSO) units, are becoming increasingly prominent. This approach captures CO2 directly from offshore facility emissions, offering a significant avenue for reducing the carbon footprint of existing operations.

Digitalization: Enhancing sustainability and operational insight

Digitization plays a supporting role in enhancing sustainability and operational insight in offshore operations. While not a direct driver of efficiency itself, it provides the data and tools necessary for optimization. The electrification of offshore assets, facilitated by digital technologies, remains a key aspect of reducing CO2 emissions.

Electric grid infrastructure: Enabling offshore energy integration

Robust grid infrastructure and advanced transmission technologies are essential for the efficient integration of offshore energy resources. High-Voltage Direct Current (HVDC) transmission is crucial for long-distance power transfer from offshore wind farms, enabling the distribution of clean energy to onshore grids.

Critical minerals: The foundation of offshore renewable energy

Rare earth elements (REEs) are essential for producing high-strength permanent magnets used in offshore wind turbines. As demand for offshore wind energy rises, so does the need for REEs—placing critical minerals at the heart of the energy transition.

To meet this growing demand, countries are exploring deep-sea mining, especially as high-grade land-based deposits decline. Projects are advancing in the exclusive economic zones (EEZs) of Japan, Norway, and Papua New Guinea.

However, the main challenge is environmental. Deep-sea mining poses significant risks to marine ecosystems, including habitat destruction, sediment plumes, and biodiversity loss. Some ecosystems affected by past test mining haven't recovered even after decades. In response, companies like BMW, Samsung SDI, Volvo, and Google have backed a moratorium until the environmental impacts are fully understood.

While pilot projects like Japan's 2017 trial show promise, further technological innovation is needed to make the process both viable and sustainable. The International Seabed Authority (ISA) is currently developing regulations to balance mineral extraction with environmental protection.

Battery storage: Enabling grid stability and operational efficiency

Battery energy storage systems (BESS) are vital for grid stabilization and enhancing operational efficiency in offshore environments. Falling battery costs and a focus on stationary storage are driving the growth of BESS installations, enabling smoother integration of intermittent renewable energy sources.

Hydrogen and fuel substitutions: Decarbonizing offshore maritime operations

Hydrogen, particularly green hydrogen produced from renewable energy, is emerging as a key fuel in offshore decarbonization efforts, including the maritime and aviation sectors that support offshore operations. Hydrogen-derived fuels and biofuels are being piloted and increasingly adopted to power vessels and, to a lesser extent, helicopters. While biofuels like sustainable aviation fuel (SAF) are already in use for offshore helicopter transport, hydrogen-derived fuels remain in the early stages of testing, particularly in maritime applications. These cleaner fuel alternatives offer a viable pathway to reduce emissions across offshore and maritime supply chains significantly.

Closing: Looking forward

As highlighted above in detail, the energy transition is indeed complex, and this white paper highlights just how many moving parts are involved. While the need to cut emissions is widely recognized, the path forward must strike a balance – keeping energy affordable and reliable while steadily shifting toward cleaner sources. Oil and gas will continue to play a key role in the global energy mix for years to come, even as renewables scale up. In this context, offshore energy will be essential – not only for traditional oil and gas production, but also as a growing hub for clean technologies like offshore wind and carbon capture.

That said, the road to a more sustainable energy system comes with real challenges. Building out renewable infrastructure at scale, making carbon capture affordable, and reducing supply chain risks – especially those driven by geopolitics and trade disruptions – are just a few of the hurdles. In addition, minimizing the environmental impact of energy operations and making sure the transition is equitable and accessible to all are critical priorities.

In the end, the way forward isn't just about swapping one set of technologies for another – it's a full-scale transformation of how the world produces and consumes energy. Getting it right will take cooperation between governments, industry players and researchers – all working together to drive innovation, shape smart policies and unlock the investment needed. A successful transition will depend on seeing the big picture: one that connects energy security, economic growth and climate action in a way that's both practical and sustainable.

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