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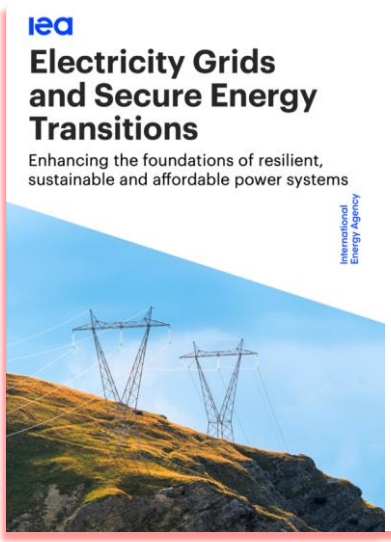

Electricity Grids and Secure Energy Transitions, International Energy Agency

The Electricity Grids and Secure Energy Transitions report provides the first-of-its-kind detailed global stocktake of the power grids. The report shows that the current electricity grid development pace is not in harmony with other supply and demand developments along the power system. Energy security and climate-related implications of sustained delays in grid improvements are quantified. It presents recommendations for timely delivering future-proof electricity grids to serve a more secure and cleaner power system for a more sustainable energy future.

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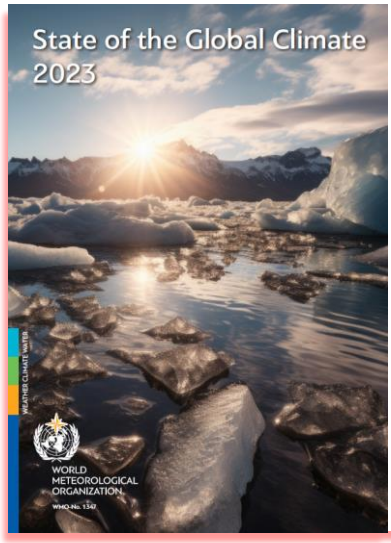

State of the Global Climate 2023, World Meteorological Organization

The WMO report provides a detailed overview of climate change with detailed observations. It shows that the global average near-surface temperature is already at 1.45°C above the pre-industrial baseline. With multifold assessments of the increasing frequency of extreme weather events, it urges for more effective measures including enhanced collaboration as the cost of climate inaction is higher than the cost of coordinated climate action.

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Oil 2024, Analysis and Forecast to 2030, International Energy Agency

This latest edition of the IEA's medium-term market report presents substantial changes in the dynamics of oil supply and demand out to 2030. It shows that global oil demand growth is slowing towards a plateau by 2030 while oil production is ramping up. These new dynamics will increase the spare capacity to levels not seen before, except during the low-demand periods of the COVID-19 outbreak. This major alteration in supply and demand balances will have multifold implications for oil markets, supply chains and investments.

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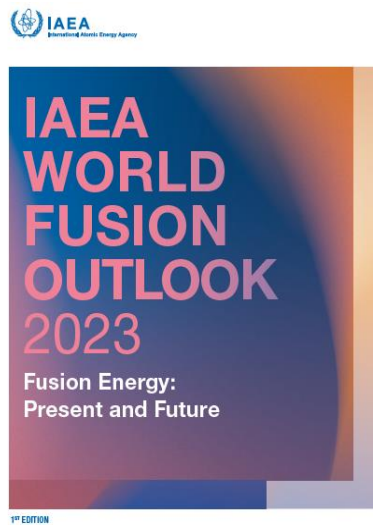

World Fusion Outlook 2023, Fusion Energy: Present and Future, International Atomic Energy Agency

This first-of-its-kind report outlines the recent progress in fusion energy driven by technological advancements, increasing investments, and broader energy and climate objectives toward a more secure, cleaner, and resilient energy future. Avenues for improvement and multiple opportunities are identified for realizing promising outcomes from intensifying fusion energy efforts through scientific progress, technological advancements and enhanced investments and project portfolio.

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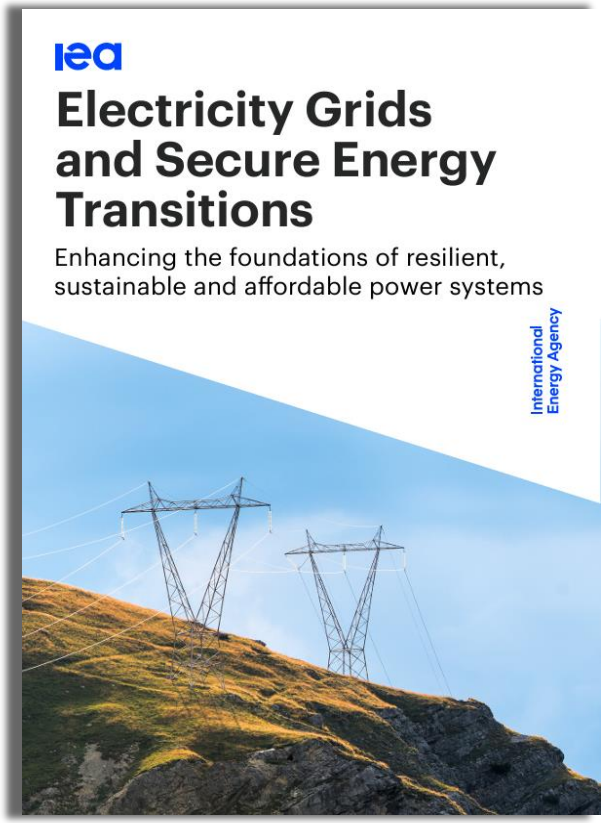


Electricity Grids and Secure Energy Transitions: Enhancing the foundations of resilient, sustainable and affordable power systems, International Energy Agency

Electricity grids have been pivotal to energy systems for over a century. The necessity for advancing the power transmission and distribution grids grows in parallel to rising energy security concerns and clean energy transition objectives, with wider and cleaner electrification targets. The report shows that the current grid development pace is not in harmony with other supply and demand developments along the power system.

On top of that, the report emphasizes demand-side electrification and renewables-based power generation growth while underlining multiple requirements for developing and modernizing the grids. This first-of-its-kind global stocktake provides a comprehensive overview of the current state of the electricity grids based on analyses of country-specific data on grid infrastructures and related investment patterns. It also presents significant assessments of other critical dimensions such as governing regulatory and business models and relevant material supply chains. Timely findings indicate a need to add or replace 80 million km of grids by 2040 to get on track with global energy security and clean energy objectives. In addition, it discusses relevant multifaceted potential risks presented by a Grid Delay Case with the quantitative implications of increased fossil fuel use and GHG emissions. Building upon detailed assessments, the comprehensive study presents critical actions and recommendations for timely delivering future-proof electricity grids to serve a more secure and cleaner power system.

Key Takeaways:

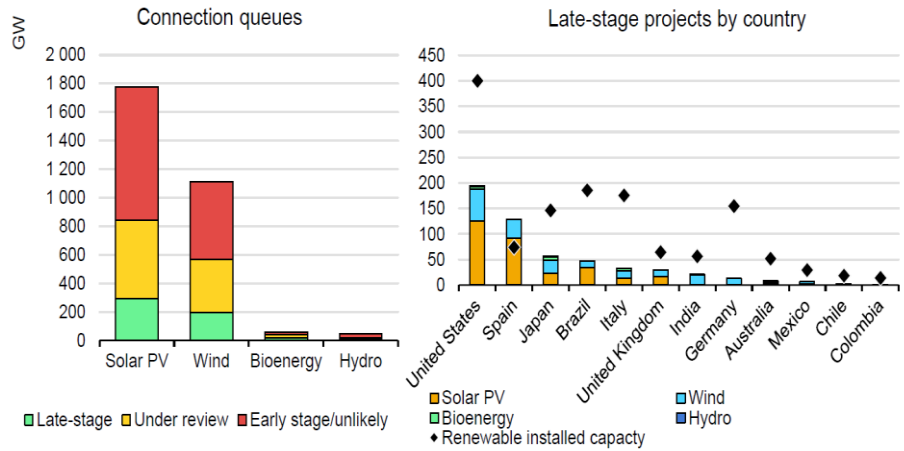
Power grid development is not in harmony with what is needed to secure global energy transition objectives

The assessment of national energy and climate goals indicates a 20% faster growth in global electricity demand over the next decade compared to the realizations over the past decade. Achieving national objectives requires the addition or refurbishment of more than 80 million kilometers of grids by 2040. This is the equivalent of the current worldwide power grid. In a pathway consistent with the net-zero emissions by 2050, the electricity demand growth should even be higher. This faster electrification prospect is driven by clean energy supply growth, mainly backed by solar, wind, and other renewables, and wider use of electricity on the demand side through increasing deployment of electro-mobility, uptake of electrified heating and cooling systems as well as electrolysis-based production of hydrogen to serve the hard-to-abate sectors and industries.

Within these energy transition dynamics, the report shows that the electric grids should play a vital role as the backbone of a modernized and increasingly electrified energy system. However, the current status of electricity grid infrastructures and relevant investment patterns remain short of what is needed to support desired energy transitions. The findings of the "Electricity Grids and Secure Energy Transitions" show that the grids should be rapidly expanded and modernized, including through a further focus on flexibility, interconnections, technology-driven models, and digitalization. The future energy system could be at risk of becoming gridlocked in the absence of increasing policy and industry attention, the report warns.

The investment in renewables has almost doubled since 2010, while grid investment has not shown a visible change. In this context, the current annual investment of about 300 billion USD into the power grids should be doubled by 2030 to realize energy and climate objectives. One major bottleneck has already occurred in connecting renewables-based power projects to electricity systems. The report presents a detailed picture of such projects waiting in the queue due to limited connection availability. More than 3,000 GW of renewable power projects are pending due to grid connection-related issues, according to detailed assessments. The number of pending projects is likely higher as the available detailed data covers countries representing half of the worldwide wind and solar capacity. The report notes that 1,500 GW of these assets are in advanced stages of project development, a figure equivalent to five times the solar PV and wind capacity added worldwide in 2023. This problem hinders faster progress in renewables-based power generation, which is a major enabler for a more secure and cleaner global energy system.

Capacity of renewable energy projects in connection queues in selected countries by technology in selected countries (GW)



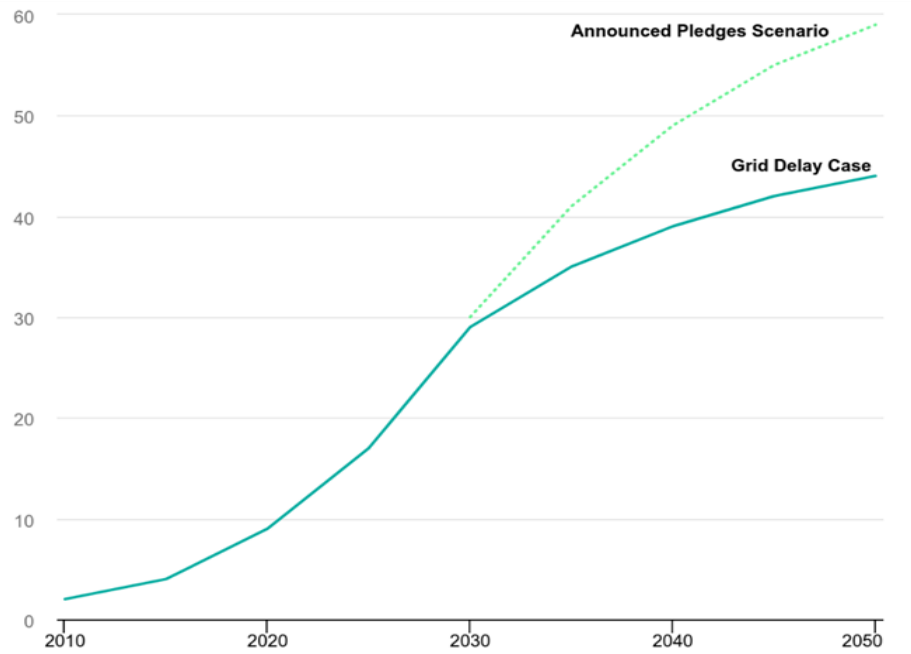
IEA. CC BY 4.0.

The "Grid Delay Case" quantifies implications for energy security and clean energy transitions

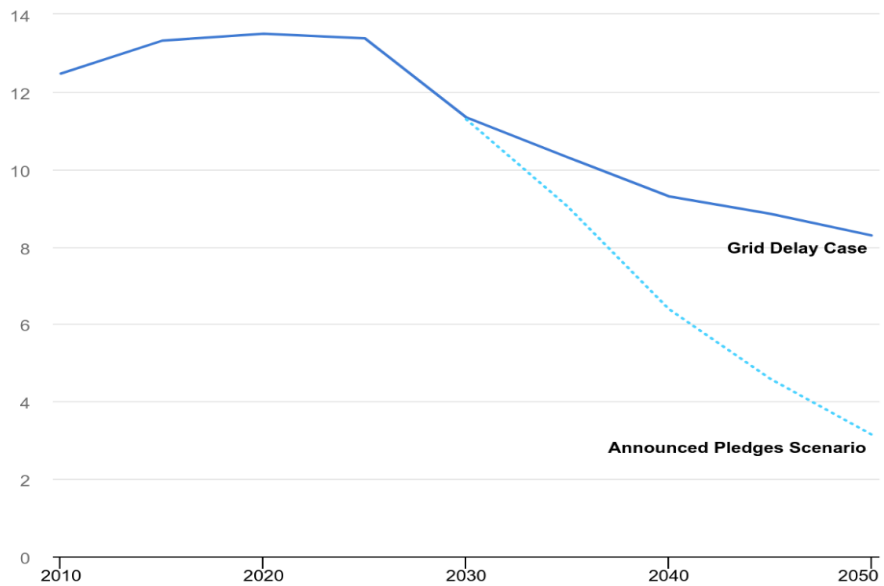
Building upon current trends and the bottlenecks, the "Grid Delay Case" presented in the report investigates the likely negative consequences of limited improvements in grid-related investment and policy patterns. It explores the impacts of more limited investment, modernization, digitalization, and regulatory and operational changes compared to the main scenarios of the IEA. First and foremost, delays in grid development reveal a major risk of slower growth in renewables. This pathway results in increasing natural gas and coal consumption with major implications for energy security, especially for importing countries. Global gas imports are over 80 bcma higher between 2030 and 2050 than in a scenario aligned with national climate targets. This pathway indicates that coal imports would increase by about 50 million tons per year in the same period. As a result, the cumulative CO_2 emissions of the power sector from 2030 to 2050 would be about 60 Gt higher compared to the Announced Pledges Scenario (APS) which is in harmony with national climate targets.

The report notes that this is equivalent to the CO_2 emissions from the power sector during the past four years worldwide. “The Grid Delay Case” would bring global temperature rise well above the crucial 1.5°C, with a 40% chance of exceeding 2°C indicating significant global warming. Possible power outage risks are also underlined, emphasizing potential economic risks including implications on socio-economic development. A greater dependency on fossil fuels due to the limited development of grids would not only boost CO_2 emissions and contribute to a greater long-term global temperature rise but also expose countries that import energy to heightened energy costs and market unpredictability.

Share of Solar PV and Wind in Global Power Generation in the Grid Delay Case and the Announced Pledges Scenario, 2010-2050 (%)



Global Power Sector CO_2 Emissions in the Grid Delay Case and the Announced Pledges Scenario (Gt), 2010-2050 (Gt)



Trends and drivers across power generation and demand necessitate further impetus on developing and modernizing grids

While the current pace of global power grid development is not in harmony with clean electrification developments in power generation and demand, the grid-oriented focus should improve across policies, regulatory frameworks, investment models, and financing mechanisms. In the IEA Net Zero Emissions by 2050 (NZE) Scenario, almost 90% of the power generation expansion will be driven by solar and wind. This rapid deployment of renewable energy necessitates, for example, the modernization of existing distribution grids and the construction of new transmission lines to integrate rather distant renewable energy sources, such as desert solar PV installations and offshore wind farms, with urban and industrial demand centers.

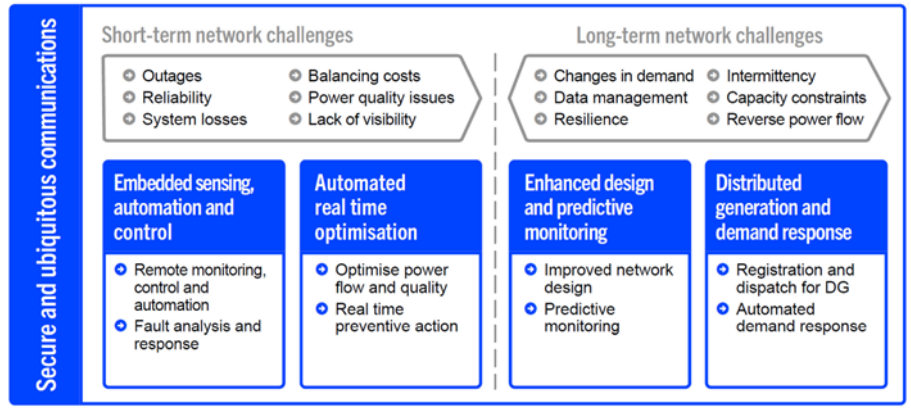
With the increasing share of intermittent renewable resources in the power generation mix, electrical power systems must develop further flexibility in response to the growing variabilities in power production patterns.

On the demand side, strong e-mobility trends as well as the current and anticipated rollout of electric heat pumps, also necessitate improved flexibility from a system perspective. In a trajectory that aligns with the fulfillment of national climate objectives, the requirement for system flexibility is expected to double between 2022 and 2030. Within these major dynamics, power grids must also leverage the advantages of distributed energy sources, including rooftop solar PV panels, while developing measures for flexibility. This involves the adoption of new technologies that improve grid functionality while harnessing demand response and energy storage capabilities, which can be facilitated by advancements in digital technology.

Digitalization presents remarkable opportunities for grids

According to the findings in the report, investment in digital solutions across power grids increased from about 12% of total grid investment in 2016 to about 20% in 2022. This figure can further escalate by implementing new digital solutions while addressing the increasing number of electric vehicles, electric heat pumps and small-scale renewable projects. For example, with the emergence of prosumers and aggregators, new synergies can be captured by embracing data and innovative digital technologies. The report notes that about three-quarters of digital investments were allocated to real-time monitoring and control of power flows, especially across power distribution grids. This first-of-its-kind report introduces multiple avenues of enhanced digitalization of power grids to address challenges while realizing opportunities for a more flexible, resilient and cleaner power system.

Digital solutions to tackle short- and long-term grid challenges



IEA. CC BY 4.0.

Note: DG = distributed generation.

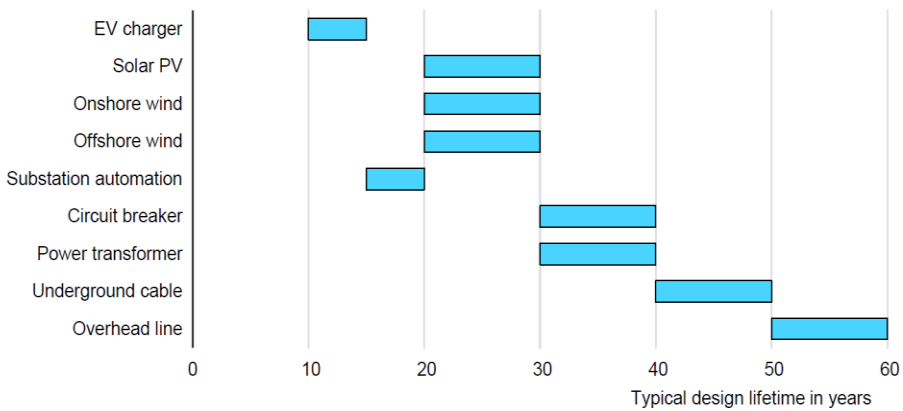
Sources: IEA analysis based on 3DEN, Unlocking Smart Grid Opportunities in Emerging Markets and Developing Economies (2023), World Economic Forum, Accelerating Smart grid Investments (2010).

A suite of recommendations to enable future-proof power grids to deliver energy security and clean energy transition objectives

"Electricity Grids and Secure Energy Transitions" assesses the regulatory aspects in detail, recommending that the relevant regulatory frameworks be reviewed and updated with a view to support deployment of new infrastructures while also improving the use of existing assets. The regulatory efforts should incentivize grids to keep pace with the growth and shifts in electricity demand and supply. This requires addressing administrative barriers, rewarding high performance and reliability, and spurring innovation. Regulatory risk assessments also need to be improved to enable the accelerated buildup and efficient use of grid infrastructure.

Planning for power transmission and distribution grids needs to be further aligned and integrated with broader long-term planning processes of policy-makers, the report notes. New grid infrastructure often takes five to fifteen years to plan, permit, and complete, compared to, for example, one to five years for new renewables projects and less than two years for new EV charging infrastructure. Therefore, grid plans should integrate relevant inputs from long-term energy transition plans across many other sectors. The relevant planning elements include anticipating and enabling the growth of distributed resources, connecting resource-rich regions with demand centers, and reflecting links with other major demand sectors such as transport, buildings, and industry, as well as new vectors such as hydrogen. Future flexibility opportunities can further be developed by ensuring interoperability within a system perspective. The report findings also emphasize that robust stakeholder and public engagement is key to informing long-term scenario development. The public needs to be aware and well-informed about the crucial links between grid developments and successful energy transitions.

Typical design lifetimes for high-voltage equipment, solar PV, wind and EV charging stations



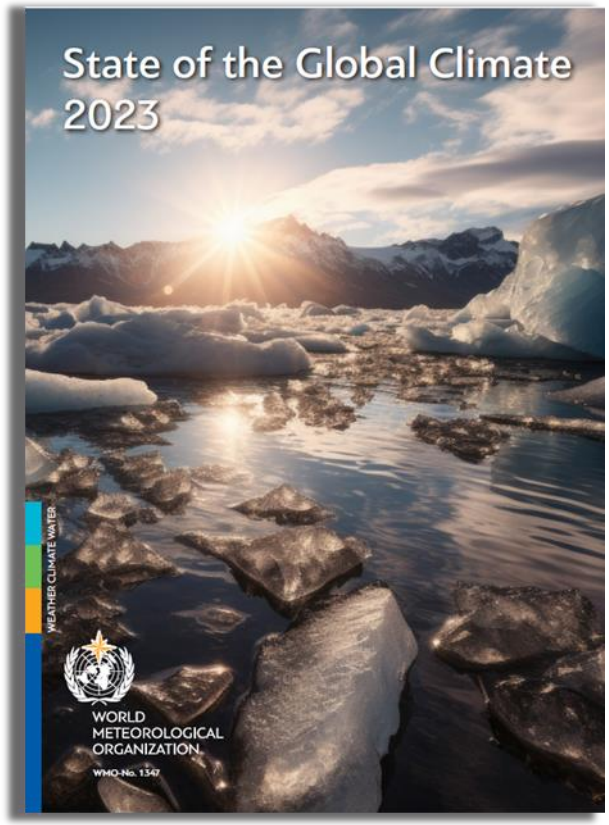
The current investment pace is a major bottleneck, as grid investment needs to nearly double by 2030 to over USD 600 billion per year after more than a decade of stagnation at the global level. The report presents regional assessments in detail. Although electricity demand continues to grow sharply and energy access needs are increasing rapidly, emerging and developing economies, excluding China, have experienced a decline in grid investment in recent years. On the other hand, advanced economies have seen steady growth in grid investment, but their pace needs to be accelerated to facilitate faster clean energy transitions. In that regard, investment should continue to rise in all regions beyond 2030.

The most important barriers to grid development vary by region. For instance, the financial health of the utility sector is a key challenge in some countries, including India, Indonesia, and South Korea. On the other hand, improved access to finance and the high cost of capital are among the central barriers in many emerging markets and developing economies, especially in Sub-Saharan Africa. Therefore, financial barriers can be addressed by improving the mechanisms in which the grid companies are remunerated. Improvements can include driving target-based grid funding and increasing cost transparency. The public acceptance of new projects and a need for regulatory reform remain the main hurdles in some jurisdictions such as Europe, the United States, Japan and Chile. In these regions, policymakers can ramp up the progress on grid development by streamlining administrative processes, enhancing planning, and ensuring regulatory risk assessments. In turn, these efforts can prepare the sector for upcoming power generation and demand developments within energy transitions in advance.

The report also highlights the critical importance of supply chains. Governments can support the expansion of supply chains by creating firm and transparent project pipelines while standardizing procurement and technical installations. Grid development requires both commodity components, such as wires and distribution transformers, and niche components, such as subsea cables and transmission transformers. These elements pose different supply chain characteristics. The findings show that increased demand with growing grids will put pressure on raw material supply chains while further diversification in the complete supply chain is essential to address growing supply chain risks effectively. According to the findings in the report, there is also a substantial need for a skilled workforce including system operators and regulatory institutions. The report recommends building pipelines of talent by ensuring digital skills are integrated into power industry curricula while managing the impacts of the energy transition and increased automation on workers through mechanisms for reskilling and on-the-job training.

“Electricity Grids and Secure Energy Transitions”, providing a first-of-its-kind global stocktake, identifies several strategic cooperation actions. These include expanding and strengthening grid interconnections within countries, between countries, and across regions to make electricity systems more resilient and allow them to better integrate the rising contributions of solar and wind power. The report recommends that governments back large-scale transmission projects to ensure grids are accommodating a strong growth in renewables-based power. It also urges grid developers and operators to benefit from digitalization in their efforts to achieve more resilient and flexible power grids. Improving and expanding grid infrastructure worldwide will require stronger international collaboration. The report suggests a major role for advanced economies by mobilizing financing, providing access to technology, and sharing best practices on advancing relevant policies.

Link to Report: https://www.iea.org/reports/electricity-grids-and-secure-energy-transitions



State of the Global Climate 2023, World Meteorological Organization, 2024

This latest World Meteorological Organization (WMO) report provides a comprehensive overview of numerous climate indicators and trends, signaling critical shifts and implications for the planet. It presents up-to-date data and historical analyses, including a detailed presentation of major climate and weather events during 2023. The study shows that the year 2023 broke nearly every climate record. The increasing frequency and scope of extreme weather events, with major implications across regions, including wildfires, floods, air pollution, and population displacement are discussed.

Besides the oceans, the cryosphere, ice sheets, sea ice, snow, and permafrost are all adversely affected by major shifts in the climate. For example, Arctic and Antarctic sea-ice extent levels have reached extreme lows, the report states. Sea ice extent was at a record low from June until early November across the Antarctic in 2023. Moreover, the report's findings include an extreme melt season observed in the glaciers of Western North America and the European Alps. This led to the largest loss of ice on record since 1950.The report presents the multifaceted consequences of a changing climate and extreme weather events while emphasizing socio-economic impacts. The crucial role of increased collaboration, such as through early warning systems, is underlined to address certain challenges. The trend and target-based analysis emphasized the critical role of enhanced climate finance in mitigating and adapting to the adverse effects of worsening climate change, especially for developing and climate-vulnerable countries and regions.

Key Takeaways:

Greenhouse gas emissions are on a constant rise

The concentrations of the three main greenhouse gases (GHGs) —carbon dioxide, methane, and nitrous oxide— reached record-high levels in 2022. The report states that the real-time data from specific locations showed a continued rise in 2023. Reflecting a balance among emissions from human activities, natural sources, and sinks, limiting these concentrations will be decisive for a sustainable future of the planet. The report shows that CO_2 levels are 50% higher than pre-industrial era.

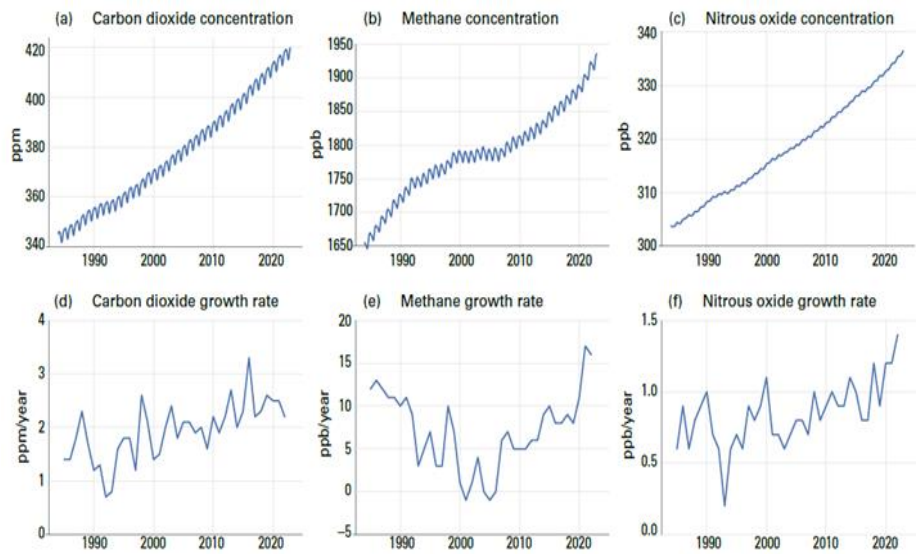


Figure 1. Top row: Monthly globally averaged mole fraction (measure of atmospheric concentration), from 1984 to 2022, of (a) CO_2 in ppm, (b) CH_4 in ppb and (c) N_2O in ppb. Bottom row: Growth rates representing increases in successive annual means of mole fractions for (d) CO_2 in ppm per year, (e) CH_4 in ppb per year and (f) N_2O in ppb per year.

Source: World Data Centre for Greenhouse Gases (WDCGG)

The global mean near-surface temperature is already around 1.4 °C above pre-industrial levels

According to the report's findings, the global average temperature in 2023 was 1.45 ± 0.12 °C above the 1850–1900 average. This shows a narrowing gap between the 1.5 °C target set by the Paris Agreement and the observed temperature rise. Additionally, the report notes that 2023 was recorded as the warmest year in the 174-year observational history. Furthermore, the average rise of the past ten years is estimated at 1.20 ± 0.12 °C above the 1850–1900 average. This makes it the warmest ten-year period on record. Record-high monthly global near-surface temperatures were observed for the ocean between April and December 2023, while record temperature levels were recorded for the land from July through November 2023. Overall, a significant number of months showed high temperatures.

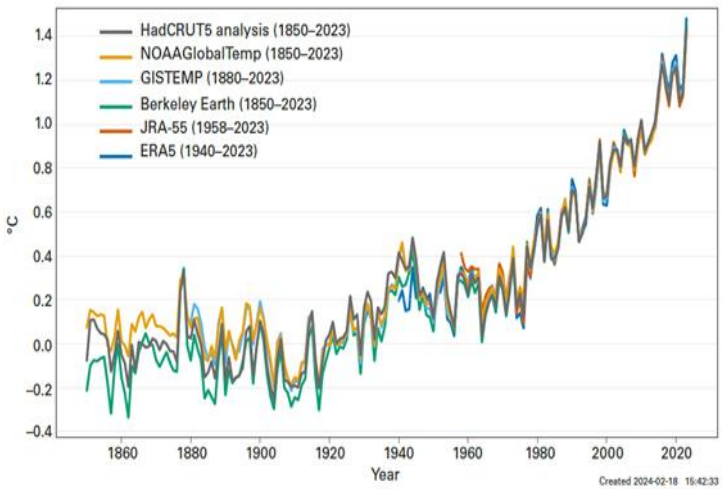


Figure 2. Annual global mean temperature anomalies (relative to 1850–1900)

Source: Data are from the six datasets indicated in the legend. See Data set and methods for details.

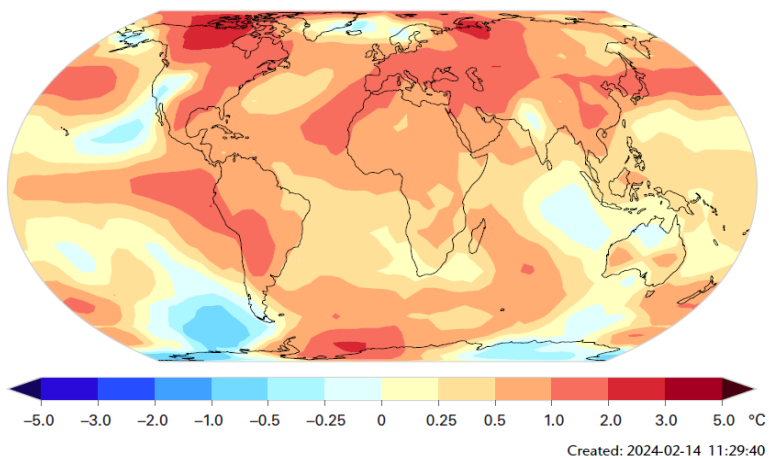


Figure 3. Mean near-surface temperature anomalies (difference from the 1991–2020 average) for 2023.

Source: Data are the median of the six datasets indicated in the legend. See Data set and methods for more details

Periods of high-intensity precipitation were on the rise in 2023

The report points out that accumulated precipitation in 2023 was above the long-term average in several regions. These mainly include East and Central Asia, parts of Northern Asia, the western Indian summer monsoon region, parts of the Maritime Continent, Western, Central, and Southeast Europe, the Western Middle East, North-West, South-West, and South-East of North America. Some regions experienced low precipitation. Numerous short-term climate drivers play a prominent role in weather and climate events, ranging from days to several months or even years-long periods. The El Niño–Southern Oscillation (ENSO), the Indian Ocean Dipole (IOD), and the North Atlantic Oscillation (NAO), contributed to major weather and climate events, including precipitation and rainfall changes across large areas in 2023. On the other hand, long-term drought persisted in certain regions such as northwestern Africa, parts of the Iberian Peninsula, some regions of central and southwest Asia, and Central America, and South America.

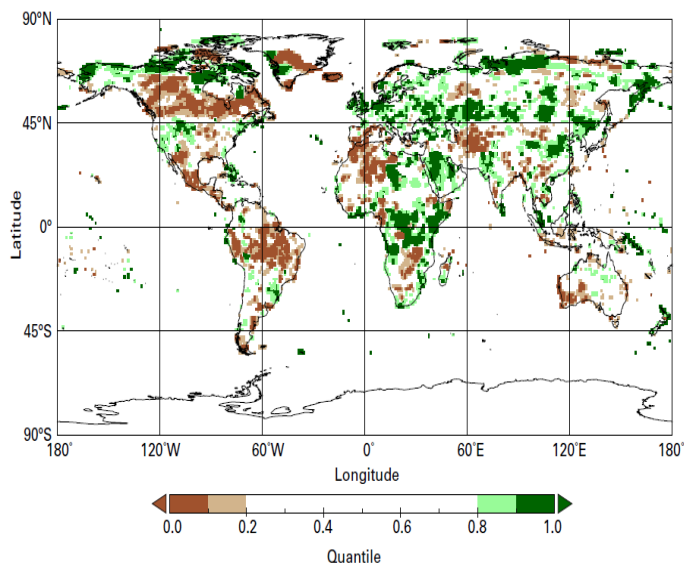


Figure 23. TTotal precipitation in 2023, expressed as a quantile of the 1991–2020 reference period, for areas that would have been in the driest 20% (brown) and wettest 20% (green) of years during the reference period, with darker shades of brown and green indicating the driest and wettest 10%, respectively.

Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst (DWD), Germany. For more details, see Data set and methods

Other major findings include observations and detailed assessments of oceans, land and ice

In addition to up-to-date information on GHG concentrations, temperature, and precipitation changes, the report also discusses the multiple implications for oceans, land, and ice. The oceans absorb heat and CO_2, slowing the increase of CO_2 concentration and warming in the atmosphere. However, the heat absorbed by the oceans leads to ocean warming. This eventually results in the melting of ice on land, rising sea levels, and ocean acidification with negative implications for ocean life, plants, and animals. The report notes that ocean heat content reached its highest level in the 65-year observational record. Additionally, the science-based analysis highlights rising global sea levels, reaching a record high based on the satellite record from 1993. This is a consequence of ocean warming combined with melting glaciers and ice sheets. The rate of increase in global mean sea levels during the past ten years is more than twice the rate in the first decade of the satellite record, 1993–2002. The report highlights more frequent, intense, and long-lasting marine heatwaves and decreasing marine cold spells.

Besides the oceans, the cryosphere, ice sheets, sea ice, snow, and permafrost are all adversely affected by major shifts in the climate. For example, Arctic and Antarctic sea-ice extent levels have reached extreme lows, the report states. Sea ice extent was at a record low from June until early November across the Antarctic in 2023. Moreover, the report's findings include an extreme melt season observed in the glaciers of Western North America and the European Alps. This led to the largest loss of ice on record since 1950.

Periods of extreme weather are becoming a major hazard, including population displacement and environmental degradation

This latest edition of "The State of the Global Climate" report examines the multifaceted impacts of recent extreme weather and climate events. The science-based analyses highlight that extreme weather and climate events had impacts across all inhabited continents throughout 2023. Reportedly, extreme heat affected many parts of the world. It caused wildfires in Canada, Europe, and Hawaii, which led to the destruction of homes, loss of life, and large-scale air pollution. Additionally, drought, extreme heat waves, and devastating floods affected many regions. The Mediterranean Cyclone is referred to as one of the most impactful weather-related events of 2023.

Under the shadow of increasing climate variability across regions, extreme weather and climate events could jeopardize water and food security and trigger more climate-related population displacement, the report discusses. It notes that extreme weather and climate conditions continued to trigger new displacement in 2023 while putting vulnerable populations at risk in life-threatening conditions. As climate change tightens its grip on vulnerable populations, acute food security concerns should be addressed. According to the report, the acutely food insecure population has increased more than two-fold over the past few years, from 149 million before the Covid-19 pandemic to 333 million in 2023. Extreme weather conditions and climate change are cited among the major factors behind the drastic growth, the report underlines.

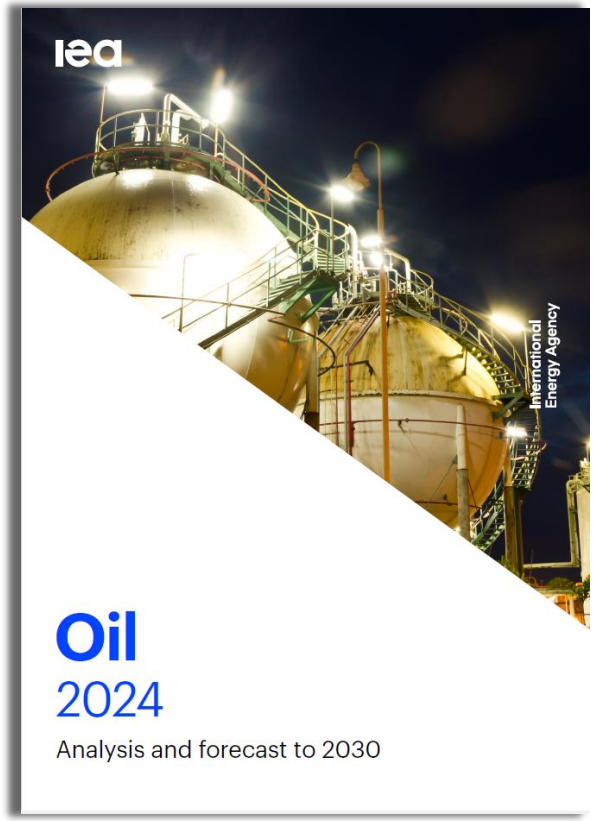
Given worsening extreme weather events and the enormity of socioeconomic losses, the report discusses areas for improvement with increasing focus

The importance of multi-hazard early warning systems as one of the key components for reducing the impact of disasters is emphasized. The WMO is positioned to increase collaboration with the international community while humankind faces unprecedented challenges regarding climate change and extreme weather events. The report presents the "Early Warnings for All" initiative. Moreover, it informs that a new "Global Greenhouse Gas Watch (GGGW)" is poised to provide science-based information to contribute to efforts for climate change mitigation.

The report also acknowledges the key role of clean energy and climate finance. The findings emphasize the interlinkages between climate variability and renewable energy, while the energy transition and renewables-based technology deployment are gaining significant momentum. It discusses why climate monitoring is crucial and how it would help enhance the planning, operation, and management of future energy systems, which are anticipated to be increasingly driven by intermittent and weather-dependent renewable energy sources.

Similar to other emerging studies and reports, the findings also shed light on the state of climate finance, underscoring a large financial gap between tracked climate finance flows and climate finance requirements to keep the 1.5˚C goal within reach. The analysis notes, in particular, that many climate-vulnerable and developing countries are receiving limited climate finance. The WMO report warns that the cost of climate inaction is higher than the cost of coordinated climate action.

Link to report: https://wmo.int/publication-series/state-of-global-climate-2023



Oil 2024, Analysis and Forecast to 2030, International Energy Agency

The Oil 2024 report presents substantial changes in the dynamics of oil supply and demand out to 2030. This latest edition of the IEA's medium-term market report shows that global oil demand growth is slowing towards a plateau by 2030 while oil production is ramping up. Major factors driving oil demand are the aviation and petrochemical sectors worldwide. However, new trends such as the increasing uptake of electric vehicles, fuel economy improvements in road transportation, and decreased oil product utilization for power generation in the Middle East are increasingly offsetting this growth.

Together with the impact of structural shifts, the forecasted global oil demand in 2030 will be about 106 million barrels per day (mb/d), slightly up from 102 mb/d in 2023. On the other hand, supply capacity is forecasted to reach almost 114 million b/d by 2030, backed by production increases in the U.S. and several other non-OPEC+ regions. These new dynamics will increase the spare capacity to levels not seen before, except during the low-demand periods of the COVID-19 outbreak. This major alteration in supply and demand balances will have multifold implications for oil markets, supply chains and investments.

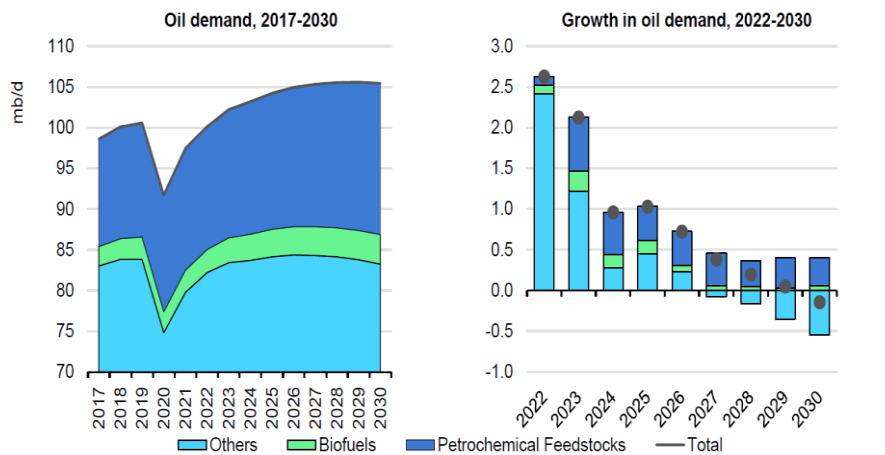
Key Takeaways:

World oil demand is slowing towards a plateau while energy transitions are advancing

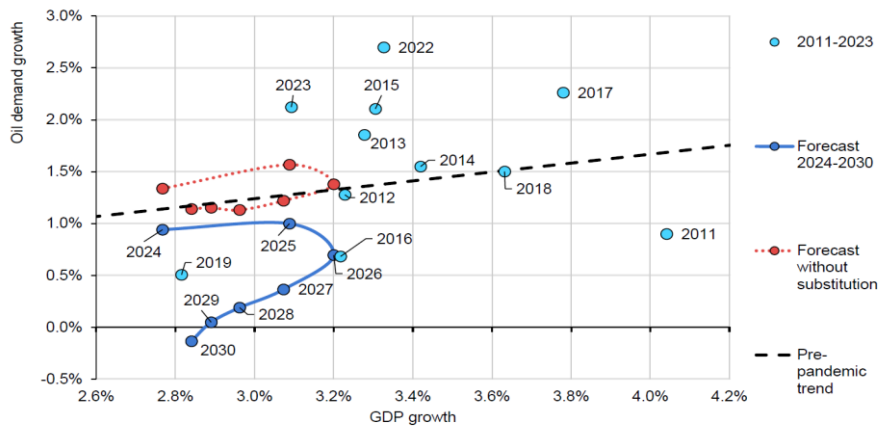
Oil 2024 forecasts global oil demand to flatten at 105.4 mb/d towards 2030 with notable transitions to clean energy solutions and technologies. The transportation sector has long been the major driver of oil demand worldwide. The key factors limiting oil consumption growth are the recent developments in electric vehicles (EVs) with surging sales and market penetration, and fuel economy improvements in road vehicles. Another major development easing demand is the continued switching from oil-based power generation to other sources such as natural gas and renewables, especially in the Middle East. The projected 3.2 mb/d increase until the end of this decade stems from jet fuel demand and a growing petrochemical market. Demand for naphtha, LPG and ethane is set to grow by 3.7 mb/d until 2030, including an increased utilization of LPG for clean cooking purposes.

"Oil 2024" assesses differing regional patterns in demand development. Herein, China and India are the main engines of growth, each with different characteristics. Accordingly, major oil product demand drivers are the transport sector demand in India and jet fuel and petrochemical feedstock demand in China, whereas China is advancing in the electrification of road and rail transportation. On another front, advanced economies continue to show a decline, with demand decreasing by 3 mb/d in the forecasting horizon, from almost 46 mb/d in 2023 to 43 mb/d by 2030. The report notes that, except for the COVID-19 pandemic years, such levels were last seen in 1991. Emerging economies in Asia represent the total worldwide demand growth projected until 2030. In addition to shifts in regional oil demand patterns, structural economic shifts are also analyzed in detail. Within the short term, demand increases by about 1mb/d. This is largely parallel to the figure implied by the GDP growth. However, the historically strong demand-GDP correlation is set to break starting in 2026, the report presents. This new paradigm, with notable implications for future oil demand growth, is mainly a result of switching from oil to other fuels and cleaner technologies, such as clean electricity and natural gas, in the transport and power sectors.

World oil demand forecast to plateau this decade



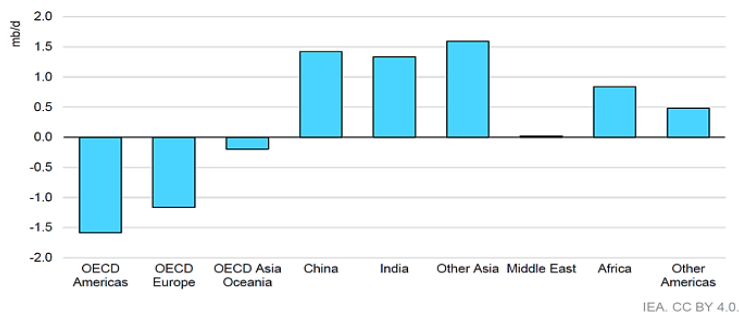
Growth in global oil demand and GDP, 2011-2030



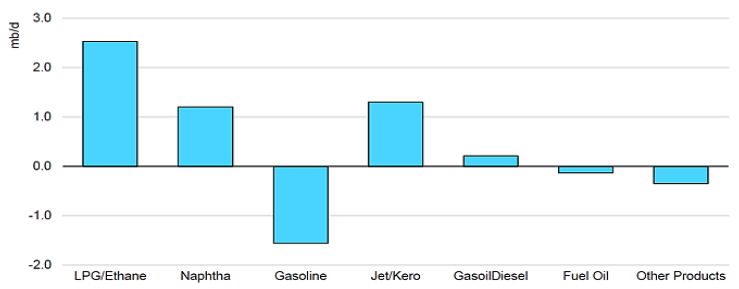
Note: Excludes 2020 and 2021 due to Covid-19 distortions.

Demand growth is dominated by Asia, aviation and petrochemicals

Growth in oil demand by region, 2023-2030



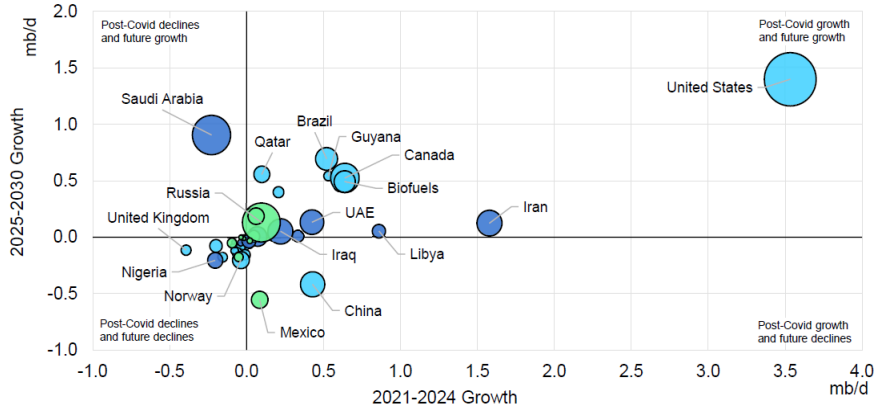
Growth in world oil demand by product, 2023-2030



Oil supplies are increasing, led by non-OPEC+ producers

Rising world oil supplies, led by non-OPEC+ producers, are projected to surpass forecasted demand starting in 2025. The increase in supply reflects a consistent growth in upstream investment. Global upstream capital expenditures reached an eight-year high of USD 538 billion in 2023, and are expected to rise by 7% in 2024. Non-OPEC+ producers will continue to lead the supply growth. They account for a 4.6 mb/d increase. This represents about three-quarters of the net increase until 2030. The U.S. supply shows an increase of 2.1 mb/d, while other countries in the region, including Argentina, Brazil, Canada, and Guyana combined contribute 2.7 mb/d. Within OPEC+, Iraq, Saudi Arabia, and the United Arab Emirates lead a 1.4 mb/d increase. OPEC+ members in Africa and Asia show declines. Supply capacity in Russia is expected to see a marginal decline.

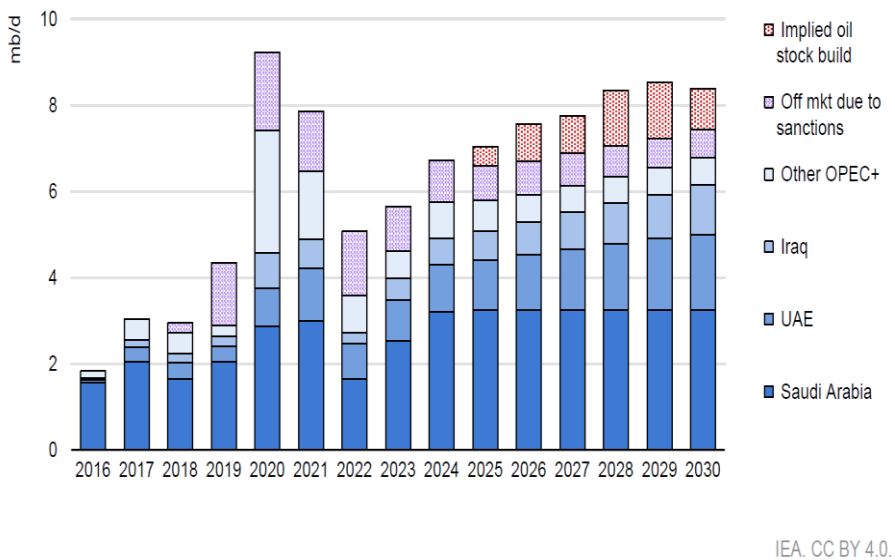
Oil supply changes for select countries in 2025-2030 compared to 2021-2024



Notes: Based on current OPEC+ supply deal. Assumes Russia and Iran remain under sanctions. Sized to 2024 total liquids production.

During the 2023–2030 forecast period, a notable increase in global oil production capacity, spearheaded by the U.S. and other non-OPEC+ producers, is forecasted to outpace the growth in demand. This will push the global spare capacity to unseen highs, except for the COVID-19 outbreak period. Until 2030, total global supply capacity will increase by 6 mb/d to about 113.8 mb/d, an astounding 8 mb/d beyond the estimated world demand of 105.4 mb/d, the report shows. Spare capacity at such levels could have unprecedented impacts on oil markets, especially producer economies in OPEC and beyond, as well as the U.S. shale industry. This major change will have consequences for the oil industry's future strategies. The report notes several uncertainties that may arise from macroeconomic developments or new policies to accelerate energy transitions and efficient technologies.

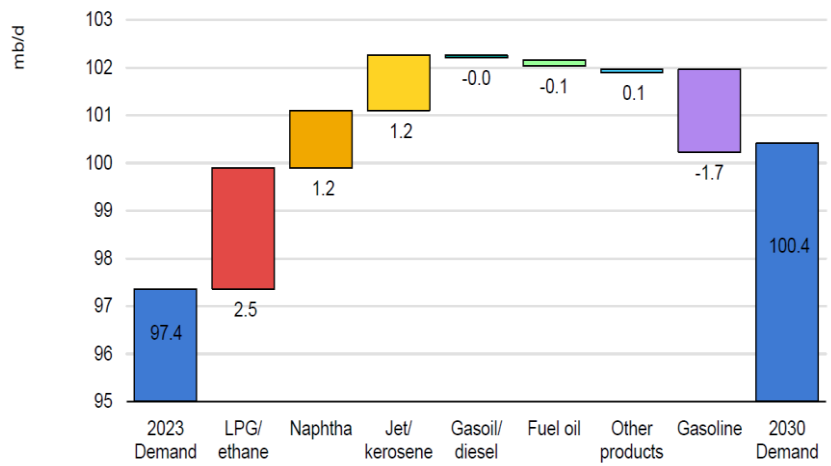
Surplus supply capacity may reach unprecedented levels



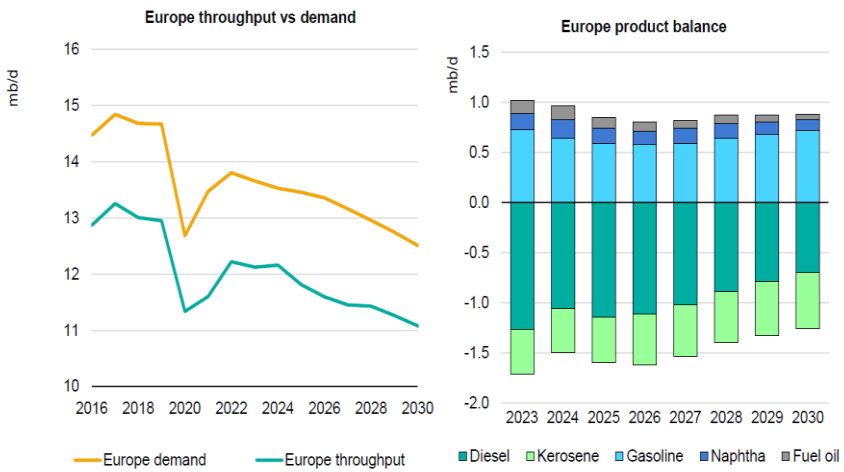
Refineries' adaptation to changing demand patterns

Global oil markets must navigate numerous changes in the medium term as fundamental changes are starting to alter oil demand, supply, and trade dynamics. Worldwide refining capacity is set to increase by 3.3 mb/d during 2023-2030. This is significantly lower than historical trends. Nonetheless, the report notes that this is sufficient to match the forecasted oil product demand as the supply of non-refined fuels, such as biofuels and natural gas liquids, is soaring. In turn, this may have multiple implications for refineries to adjust to slowing demand for refined fuels. Major trends shaping the refinery industry include increasing EV penetration and jet fuel utilization, as well as rising contributions from NGLs and biofuels, in demand sectors. Within differing regional supply, demand, and trade patterns, refinery capacity growth will continue to be concentrated in Asia, especially in China and India. The report shows continued substantial diesel and jet fuel supply shortfalls in Europe. Together with jet fuel demand in North America, global competition in the middle distillate markets will intensify.

Product demand growth, 2023-2030



European throughput versus product balances



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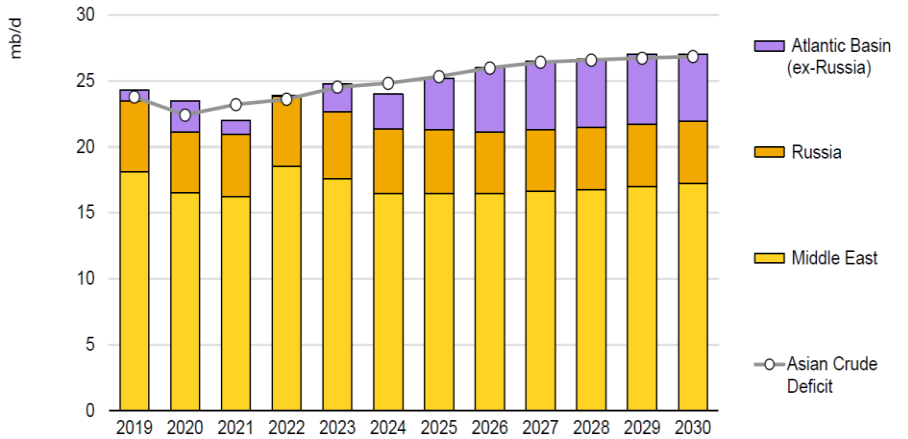
Net crude oil exports versus Asian import requirement, 2019-2030



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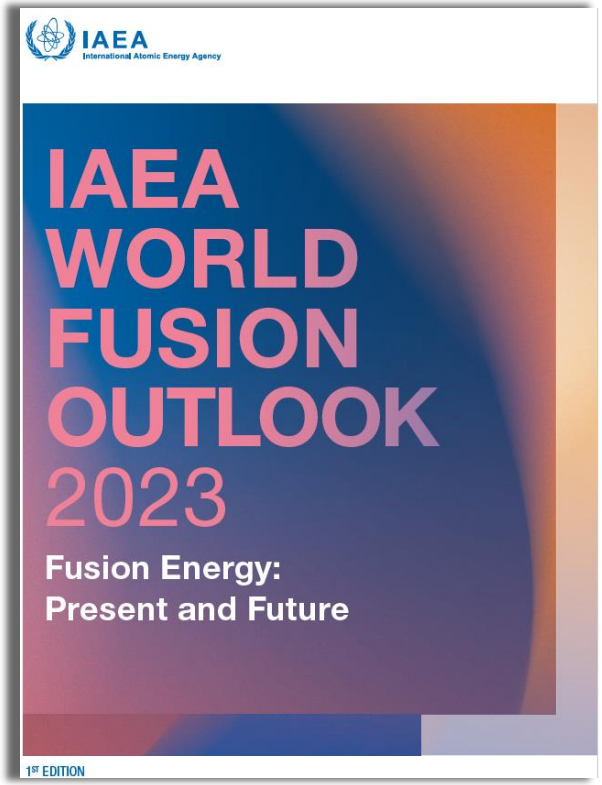
Link to Report: https://www.iea.org/reports/oil-2024

Oil trade flows shift to the East

Asia is the main demand center with increasing shortfalls in both crude and oil product supplies. On the other side, the surplus of crude oil and oil products in the Atlantic Basin is expanding. The report shows that those volumes from the Atlantic Basin to eastern regions will increase in the period out to 2030, especially with rising non-OPEC+ supplies and sanctions on Russian exports. Asia's increasing demand will also attract product supplies from the Middle East. The divergence between the East and West will further stimulate global trade flows in the future, the Oil 2024 report notes.



World Fusion Outlook 2023, Fusion Energy: Present and Future, International Atomic Energy Agency

This first-of-its-kind report outlines the recent progress in fusion energy, an emerging science and technology field driven by technological advancements, increasing investments, and broader energy and climate objectives toward a more secure, cleaner, and resilient energy system of the future. The report presents current challenges and recent global and regional efforts to spur advancement and wider deployment of fusion technology. Several avenues for improvement and multiple opportunities are identified for realizing promising outcomes from intensifying fusion energy efforts.

It sheds light on scientific progress, technological advancements, growing investments, and project portfolios while underlining that fusion could be part of solutions for climate-related challenges, supporting electricity supply, and strengthening energy security.

Key Takeaways:

Multi-faceted drivers push an increasing focus on fusion energy

The report assesses that heightening concerns over the adverse impacts of climate change and emerging policies and strategies to tackle energy security challenges are the critical drivers supporting the recent efforts in fusion energy technology development and deployment. Fusion energy is now pronounced in future solution perspectives in several new policy initiatives and documents addressing climate change and energy security issues. These include the Mid-century Long-Term Low- Greenhouse Gas Development Strategy of Canada, the United Kingdom's Net Zero Strategy: Powering Up Britain, and The Long-Term Strategy under the Paris Agreement of Japan. The report also takes note of many other recent initiatives oriented towards technology advancements, such as the emerging U.S. policy and technology framework and the EU Net-Zero Industry Act that lists fusion as one of the promotional areas of technology investments.

Multiple challenges still exist; however, technological advancements constantly support a reliable fusion energy future

World Fusion Outlook outlines up-to-date fusion-oriented scientific and technological achievements through multiple disciplines. These developments are the key contributors to the growing promise in fusion energy perspectives. Recent trends showing substantial growth in the investment portfolio, especially through private funding and government support, are another key enabler in the quest to utilize fusion energy, the report highlights.

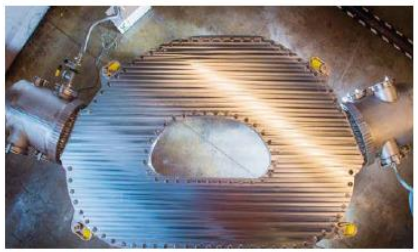
It describes the basics of fusion reactions and the associated requirements for achieving sustainable energy yields that could enable stable electricity supplies and profound decarbonization. Fusion challenges, corresponding efforts, and scientific breakthroughs are mainly centered around the successful integration of physics with a wide array of developing technologies, especially advanced fuels and materials. The challenges primarily stem from two particular technical considerations. First and foremost, the technology requires extremely high temperatures (over 100 million ˚C) for plasma heating. Enduring stable confinement of the hot plasma inside the fusion reactor core is required. Ultimately, the fusion assets should provide effective technical solutions to ensure the extraction and conversion of the significant energy production for desired use cases such as providing stable power generation or offering high-temperature heat services. A holistic perspective incorporates many other dimensions such as fuel cycle management, nuclear safety, institutional development, as well as consideration of overall economics for integration into future energy systems.

Fusion reactions have been successfully achieved in numerous experiments. Nevertheless, they have not generated usable energy yet, the report underlines. However, one of the critical findings presented in the report is that advances achieved across different disciplines constantly underpin a promising fusion energy future. These include achievements in physics, materials science, computational science, and engineering. The report presents key developments in R&D and technology while underlining technology gaps. These gaps need to be addressed for transforming present R&D efforts into tangible fusion energy technology deployment. The modeling and mitigation of any plasma-related instabilities stand at the core of the present research activities. From the materials science perspective, the development of suitable materials for the construction of a commercial fusion power plant is a key challenge with ongoing research activities. The fusion reactor components should be enhanced for commercially viable operations.

The project pipeline is growing across a wide spectrum of fusion technologies and facilities

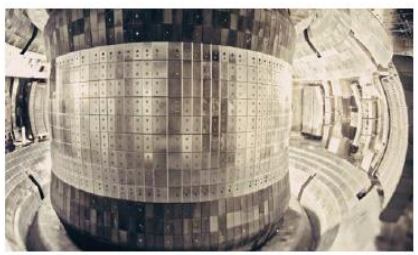
The report provides up-to-date information about ongoing fusion energy projects across different regions and facilities. According to the findings, nuclear fusion and plasma physics-related research continue in over fifty countries. The designs and relevant concepts are mostly based on magnet-based machines in which fusion takes place, including stellarators and tokamaks. Technologies that benefit from lasers, linear devices, and advanced fuels are also within the spectrum. Large-scale international fusion projects and national projects driven by governments are both supporting technological advancements. For example, new designs and materials can be employed even during the construction of the experimental systems. Complementing these promises, considerable private sector involvement has recently emerged in many countries where private funding is effectively allocated to fusion facilities. This rather new angle can facilitate the diversification of funding sources and the implementation of novel commercial design concepts and strategies.

In addition, the report provides information about ITER, the largest international experimental fusion facility that is located in Cadarache in France, as well as advanced demonstration (DEMO) and pilot facilities. The report notes that the most advanced examples of such DEMO and pilot units are based in the countries that are part of ITER.



USA
In September 2021 the Massachusetts Institute of Technology (MIT) Plasma Science and Fusion Center and Commonwealth Fusion Systems (CFS) announced the successful demonstration of a record breaking 20 tesla magnetic field in their first of a kind high temperature superconducting magnet [23], a major breakthrough in the design of their SPARC tokamak project[5]. Courtesy of CFS.

EUROPE
In December 2021 the Joint European Torus (JET) tokamak reached the highest sustained energy pulse ever[6], a record breaking 59 megajoules of sustained fusion energy over a fusion pulse of 5 seconds — more than double the 21.7 megajoules released over around 4 seconds in 1997. Courtesy of EUROfusion.



CHINA
In December 2021 China's experimental advanced superconducting tokamak (known as EAST) achieved the longest steady state high temperature plasma operation (1056 seconds or 17.6 minutes), i.e. long-pulse high-performance operation with an ITER-like configuration and heating schemes[7]. Courtesy of ITER Organization.

REPUBLIC OF KOREA
A study in September 2022 reported that experiments at the Korea Superconducting Tokamak Advanced Research facility in the Republic of Korea had produced a plasma with a high temperature above 100 million kelvin and sufficient control of instabilities to ensure steady state operation for up to 20 seconds [24]. These results raise confidence in the tokamak design as a promising path towards commercial fusion. Courtesy of ITER Organization.

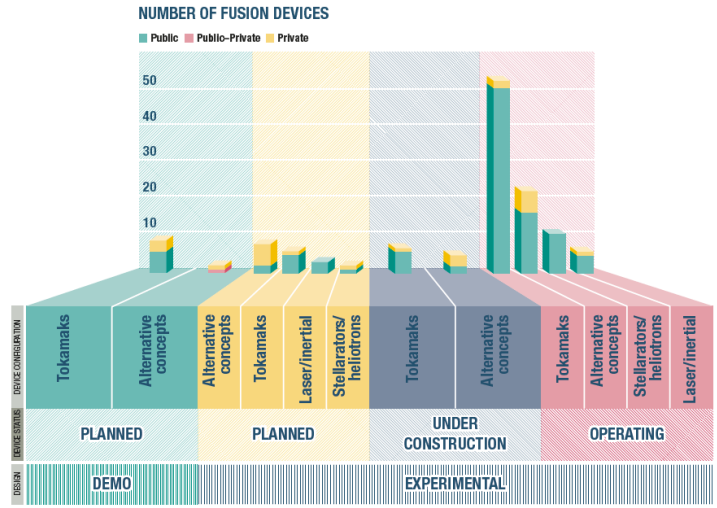


TABLE 2: LIST OF PLANNED DEMO DEVICES

Country	Organization	Name	Type	Ownership
Canada	General Fusion Inc.	FDP	Magnetized target fusion	Public–private
China	Chinese Consortium	CFETR	Conventional tokamak	Public
EU	EUROfusion	EU-DEMO	Conventional tokamak	Public
Japan	Japanese Consortium	JA-DEMO	Conventional tokamak	Public
Republic of Korea	Korea Institute of Fusion Energy	K-DEMO	Conventional tokamak	Public
Russian Federation	Russian Consortium	DEMO-RF	Conventional tokamak	Public
UK	Tokamak Energy	ST-E1	Spherical tokamak	Private
	UKAEA	STEP	Spherical tokamak	Public
USA	Commonwealth Fusion Systems	ARC	Conventional tokamak	Private
	General Atomics	GA FPP	Conventional tokamak	Private
	Longview Fusion Energy Systems, Inc.	Longview Fusion Pilot Plant	Laser/inertial	Private
	TAE Technologies	Da Vinci	Field reversed configuration	Private

Funding is a critical enabler for emerging fusion technologies and new projects

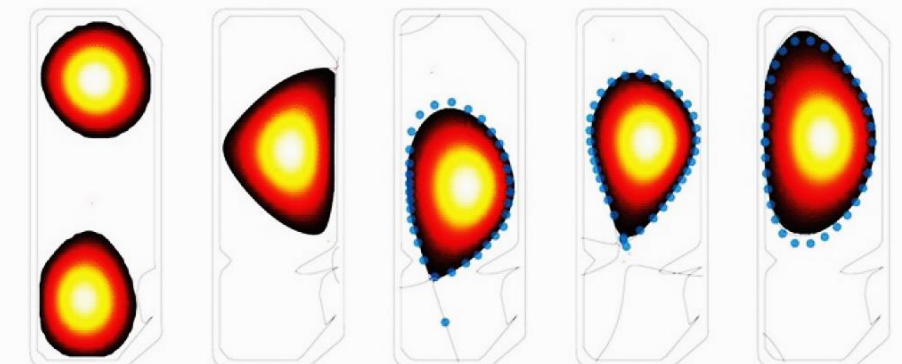
The report refers to recent findings of the Fusion Industry Association to highlight how private fusion companies have increased their investment over the past couple of years. These private firms attracted more than 6.2 billion USD in investment in 2023, representing an annual increase of around 1.5 billion USD, or about 30%. There are 43 private companies in Australia, Canada, China, France, Germany, Israel, Italy, Japan, New Zealand, the UK, and the U.S. It is important to note that more than half of these companies are based in a single region: the U.S. Enhanced private funding and government support can expand the project portfolios to facilitate fusion energy development, the WFO notes.

Legal and regulatory frameworks should be formulated

The report also details the legal and regulatory frameworks necessary for sustainable achievements in fusion energy. Within the scope of responsible and peaceful use of nuclear energy technologies, fusion energy technology is also no exception. Every new nuclear technology requires an assessment of the adequacy and comprehensiveness of the existing legal frameworks, which should effectively ensure public safety and health. There is an obvious need to assess the current international legal frameworks for safe and secure operations and determine if the existing frameworks are applicable and fully fit for emerging fusion energy technologies. Although both fission and fusion produce energy, there are fundamental differences in terms of distinct technological requirements and characteristics. These could lead to significant differences in legal and regulatory formulations.

AI use is expanding in fusion science and research

The WFO report also points out that artificial intelligence (AI) applications are emerging for achieving plasma stability. AI-based approaches could enable real-time control of fusion experiments. One example illustrates that AI-based systems can create and maintain a wide range of plasma shapes and configurations in the variable configuration tokamak in Switzerland. The report outlines a five-year coordinated research project (2022-2027) tailored to develop and testing AI models on a global scale. The work packages include tasks for system behavior optimization using machine learning and AI methods, as well as the development and use of energy image databases.



“Making fusion energy accessible to all”

The report provides information on the IAEA’s current work on fusion R&D and technology development, including scientific collaborations with partners. It also underscores that the IAEA's efforts aim to enhance the knowledge base by briefing relevant institutions about partnership details. The WFO complements the IAEA Fusion Portal, which intends to provide news and publications around fusion projects and events globally.

Link to report: https://www.iaea.org/publications/15524/iaea-world-fusion-outlook-2023

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For any questions and additional information, please contact:

Bora Şekip Güray
Dr. Mehmet Doğan Üçok
Ufuk Sezer
iicec@sabanciuniv.edu

CONTACT

Address:

IICEC, Sabancı University Minerva Palace, Bankalar Cad. No: 2, Karaköy, 34420, Istanbul Turkey

Phone: *+90 (212) 292 49 39 / 1114*

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