



Organization of the Petroleum Exporting Countries

2023 World Oil Outlook 2045

Executive Summary



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2023
**World
Oil
Outlook
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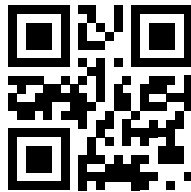
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Foreword

Over the past year, we have witnessed a significant shift in the narrative related to energy transitions and the intertwined issues of energy security, energy availability and the need to reduce emissions.

Governments and political parties are reevaluating their sustainable energy pathways, taking into account the realities on the ground and the views of populations. There has been pushback against the opinion that the world should see the back of fossil fuels, as policies and targets for other energies falter due to costs and a more nuanced understanding of the scale of the energy challenges. Moreover, we are now seeing more focus on the capacities and national circumstances of all countries in the energy transitions agenda, not just a select few.

These were evidently on display at the 8th OPEC International Seminar, held in early July in Vienna, with a focus on the need for all energy sources, all relevant technologies and unprecedented investment, collaboration and support.

At OPEC, we believe that the future needs to see energy transition pathways that strive for an inclusive 'all-peoples, all-fuels and all-technologies' approach. We need to follow sustainable paths that enable economic growth, enhance social mobility, boost energy access, and reduce emissions at the same time.

These issues are part of the thinking and analysis that form the backbone of this year's World Oil Outlook (WOO), as the Organization looks to share its data-driven views on how the future energy landscape may evolve, ones that offer some differing perspectives compared to past editions.

What is clear is that the world will continue to need more energy in the decades to come as populations expand, economies grow, and given the pressing need to bring modern energy services to those who continue to go without.

In this year's WOO, global energy demand is seen expanding by 23% in the period to 2045, or on average by around 3 million barrels of oil equivalent a day every year. The only way this can be realized is through huge investments in all energies.

Recent developments have led the OPEC team to reassess just what each energy can deliver, with a focus on pragmatic and realistic options and solutions. In



this regard, our Reference Case sees oil demand reaching 116 million barrels a day (mb/d) by 2045, around 6 mb/d higher than in the WOO 2022, and with the potential to be even higher.

For this to be achieved, oil sector investment requirements out to 2045 total \$14 trillion, or around \$610 billion on average per year. It is vital that these are made; it is beneficial for both producers and consumers.

Calls to stop investments in new oil projects are misguided and could lead to energy and economic chaos. History is replete with numerous examples of turmoil that should serve as a warning for what occurs when policymakers fail to acknowledge energy's interwoven complexities.

While the world needs more energy, alongside this there is also the need to continually reduce emissions, subscribing to global best practices and cutting edge, best-in-class technologies. For example, carbon capture utilization and storage, direct air capture, clean hydrogen technologies, the circular carbon economy, and others. These form part of the WOO's spotlight on technologies that should play a key role going forward.

The platform for building a sustainable energy future for all also comes from stability in energy markets, which remains the core focus of OPEC and its partners in the Declaration of Cooperation. The continued proactive, preemptive and multilateral approach to balanced and stable markets and the voluntary production adjustments have proven beneficial over the past year. It will continue to be a guiding principle in the years to come.

Nonetheless, the future requires all industry stakeholders to work together, no-one can work alone. Collaboration needs to be based on the realities we see before us, to ensure a long-term investment-friendly climate for all energies.

In putting together this year's WOO, I would like to thank all those involved: management, analysts, editors, designers and all others that played a role. The OPEC team should be proud of this achievement, which is central to the Organization's embrace of transparency through dialogue and cooperation.

We are excited to introduce the WOO 2023 to our valued readership. We believe it offers a forward-thinking approach and a visionary blueprint to help meet energy



security concerns, lessen energy poverty and reduce emissions. We look forward to any feedback you may have.

A handwritten signature in blue ink, appearing to read 'Haitham Al Ghais', enclosed within a faint blue rectangular border.

Haitham Al Ghais
Secretary General

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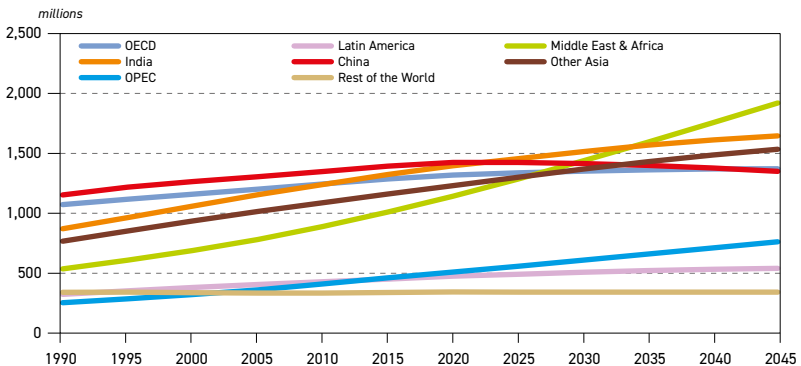
Balanced energy policies and innovative technologies are key to a sustainable future

Sustainable energy and economic prosperity for all requires the use of all sources of energy and the deployment of all relevant technologies with unprecedented levels of investment and collaboration. Recent shifts and the re-consideration of energy transition policies and targets by governments across the world are placing greater emphasis on energy security. This outlook takes all these recent developments into account to provide a forward thinking and realistic outlook, that is based on a scientific approach and hard data. This outlook takes a relatively conservative approach as it assumes that already-enacted, let alone announced energy policies, will be comprehensively implemented.

Population growth drives energy demand requirements

Global population is expected to expand by around 1.5 billion from nearly eight billion in 2022 to about 9.5 billion by 2045. This will be driven by strong population growth in the Middle East & Africa and Other Asia. The global working-age population (aged between 15–64) is set to increase globally by 826 million over the forecast period, while the global urbanization rate is anticipated to rise from 57% in 2022 to 66% by 2045.

World population trends, 1990–2045



Source: OPEC.



Average global economic growth is seen at 3% p.a. over the long-term

Global economic growth is expected to average 3% per annum (p.a.) over the forecast period. Thus, over the entire outlook, global GDP is set to almost double from \$138 trillion in 2022 to \$270 trillion in 2045 (on a 2017 PPP basis). With average long-term growth of 6.1% p.a., India is expected to remain the fastest-growing major developing country. China and India alone are set to account for more than a third of the global economy in 2045.

Long-term annual real GDP growth rate

% p.a.

	2022-2028	2028-2035	2035-2045	2022-2045
OECD Americas	1.5	2.2	2.2	2.0
OECD Europe	1.4	1.5	1.1	1.3
OECD Asia-Pacific	1.3	1.3	1.1	1.2
OECD	1.5	1.8	1.6	1.6
Latin America	1.9	2.2	1.8	1.9
Middle East & Africa	3.1	3.9	4.5	4.0
India	6.1	6.3	5.9	6.1
China	4.9	4.2	3.0	3.8
Other Asia	4.3	4.1	3.0	3.7
OPEC	3.0	3.1	3.2	3.1
Russia	1.0	1.4	1.2	1.2
Other Eurasia	2.5	2.5	2.3	2.4
Non-OECD	4.1	4.1	3.5	3.8
World	3.0	3.1	2.8	3.0

Source: OPEC.

Global primary energy demand to increase by 23% to 2045, driven by non-OECD

Global primary energy demand is set to increase from around 291 million barrels of oil equivalent per day (mboe/d) in 2022 to close to 359 mboe/d in 2045, an increase of 68.3 mboe/d, or 23% over the outlook period. Growth is expected to slow gradually from the relatively high short-term rates to more modest long-term increments, in line with moderating population and economic growth. Energy demand growth will be driven by the non-OECD region, which is set to increase by 69 mboe/d over the outlook period. Around 28% of non-OECD growth is expected to come from India alone. At the same time, energy demand in OECD countries is set to marginally decline in the outlook period.

Total primary energy demand by region, 2022–2045

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2022	2025	2030	2035	2040	2045	2022– 2045	2022– 2045	2022	2045
	OECD Americas	55.4	55.4	56.4	56.6	56.4	55.9	0.5	0.0	19.0
OECD Europe	33.7	34.0	33.9	33.4	32.7	32.0	-1.7	-0.2	11.6	8.9
OECD Asia-Pacific	17.5	17.7	17.9	18.0	18.0	18.0	0.5	0.1	6.0	5.0
OECD	106.6	107.1	108.2	108.0	107.1	105.9	-0.7	0.0	36.7	29.5
China	71.3	75.2	78.1	78.7	78.1	77.4	6.1	0.4	24.5	21.6
India	19.2	21.3	25.4	29.7	34.1	38.5	19.3	3.1	6.6	10.7
OPEC	20.3	22.8	26.4	29.6	32.6	34.7	14.4	2.4	7.0	9.7
Other DCs	50.3	54.2	61.1	68.2	75.0	77.1	26.8	1.9	17.3	21.5
Russia	15.7	15.5	15.4	15.3	15.2	15.2	-0.5	-0.1	5.4	4.2
Other Eurasia	7.5	7.8	8.3	8.9	9.5	10.4	2.9	1.4	2.6	2.9
Non-OECD	184.3	196.8	214.7	230.3	244.5	253.3	69.0	1.4	63.3	70.5
World	290.9	303.9	322.9	338.3	351.6	359.2	68.3	0.9	100.0	100.0

Source: OPEC.

Wind and solar grow at the fastest rate; oil retains the largest share in the energy mix

Demand for all primary fuels is set to increase in the long-term, with the exception of coal due to energy policy and climate commitments. The strongest growth

World primary energy demand by fuel type, 2022–2045

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Fuel share %	
	2022	2025	2030	2035	2040	2045	2022–2045	2022–2045	2022	2045
	Oil	90.7	96.4	102.0	104.3	105.3	106.1	15.4	0.7	31.2
Coal	75.9	74.6	71.1	65.9	60.0	54.4	-21.5	-1.4	26.1	15.1
Gas	67.1	69.6	75.0	80.2	84.4	87.0	20.0	1.1	23.1	24.2
Nuclear	15.0	15.9	17.4	19.4	21.7	23.8	8.8	2.0	5.2	6.6
Hydro	7.7	8.2	8.9	9.6	10.2	10.5	2.8	1.3	2.7	2.9
Biomass*	26.6	27.9	30.2	32.3	34.1	35.2	8.6	1.2	9.1	9.8
Other renewables**	7.9	11.2	18.5	26.7	35.8	42.2	34.3	7.5	2.7	11.7
Total	290.9	303.9	322.9	338.3	351.6	359.2	68.3	0.9	100.0	100.0

* Biomass includes solid biomass, waste, biogas, biofuels and charcoal.

** Other renewables include wind, solar, geothermal and tidal energy.

Source: OPEC.



is expected for other renewables (notably wind and solar), which will increase by 34.3 mboe/d, based on strong policy support in many regions. The share of other renewables in the energy mix is set to rise from around 2.7% in 2022 to 11.7% in 2045. Oil demand will grow strongly too, and even though its share in the energy mix declines modestly, oil will remain the fuel with the largest share by 2045 at 29.5%. Natural gas demand is set to increase by 20 mboe/d over the outlook period, reaching 87 mboe/d in 2045. The share of fossil fuels in the energy mix will drop from above 80% in 2022 to about 69% in 2045, due to the decline of coal. In the same period, the combined share of oil and gas in the energy mix still represents 54% in 2045.

Oil demand shows strong medium-term growth; long-term oil demand rises to 116 mb/d by 2045

Global oil demand is set to reach a level of 110.2 million barrels a day (mb/d) in 2028, representing an increase of 10.6 mb/d compared to 2022. Non-OECD oil demand is expected to increase by a robust 10.1 mb/d, reaching a level of 63.7 mb/d by 2028. OECD demand will also increase by 0.5 mb/d over the medium-term.

Long-term oil demand by region

mb/d

	2022	2025	2030	2035	2040	2045	Growth 2022–2045
OECD Americas	25.0	25.5	25.8	24.8	23.2	21.5	-3.5
OECD Europe	13.5	13.5	13.1	12.0	10.8	9.8	-3.7
OECD Asia-Pacific	7.4	7.5	7.2	6.6	6.0	5.4	-2.0
OECD	45.9	46.5	46.0	43.4	40.0	36.7	-9.3
China	14.9	16.8	17.8	18.2	18.5	18.8	4.0
India	5.1	5.9	7.3	8.8	10.2	11.7	6.6
Other Asia	9.0	9.9	11.1	12.1	12.9	13.6	4.6
Latin America	6.4	6.9	7.8	8.4	8.7	9.0	2.5
Middle East	8.3	9.4	10.0	10.7	11.4	11.9	3.6
Africa	4.4	4.9	5.9	6.6	7.4	8.2	3.8
Russia	3.6	3.8	4.0	4.0	3.9	3.9	0.3
Other Eurasia	1.2	1.2	1.3	1.4	1.5	1.5	0.3
Other Europe	0.8	0.8	0.9	0.9	0.8	0.8	0.0
Non-OECD	53.6	59.6	66.0	71.0	75.4	79.4	25.7
World	99.6	106.1	112.0	114.4	115.4	116.0	16.4

Source: OPEC.



In the long-term, global oil demand is expected to increase by more than 16 mb/d between 2022 and 2045, rising from 99.6 mb/d in 2022 to 116 mb/d in 2045. Non-OECD oil demand is expected to increase by almost 26 mb/d between 2022 and 2045. In contrast, OECD oil demand is set to contract by around 9.3 mb/d.

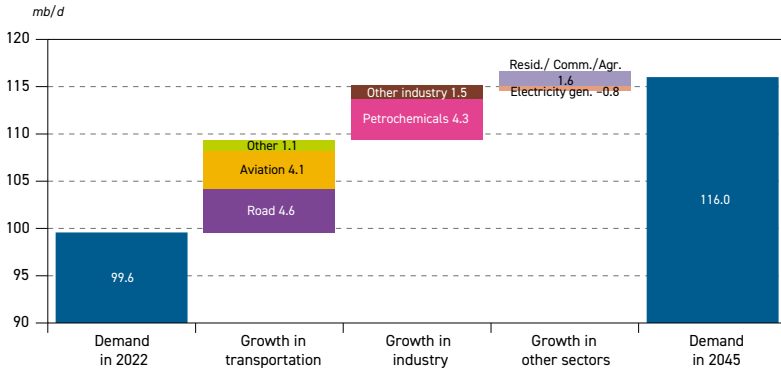
India leads in driving oil demand growth

The largest contributions to the non-OECD oil demand increase are set to come from India, Other Asia, China, Africa and the Middle East. India will add 6.6 mb/d to oil demand over the forecast period. Other Asia's oil demand is set to increase by 4.6 mb/d, China's by 4 mb/d, Africa's by 3.8 mb/d and the Middle East's by 3.6 mb/d.

Road transport, petrochemicals and aviation are key to oil demand growth

The largest incremental demand over the forecast period is projected for the road transportation, petrochemical and aviation sectors. Oil demand in these sectors is set to increase by 4.6 mb/d, 4.3 mb/d and 4.1 mb/d, respectively. With respect to refined products, major long-term demand growth is expected for jet/kerosene (4 mb/d) followed by ethane/liquefied petroleum gas (3.6 mb/d), diesel/gasoil (3.1 mb/d), naphtha (2.5 mb/d) and gasoline (2.5 mb/d).

Oil demand growth by sector, 2022–2045



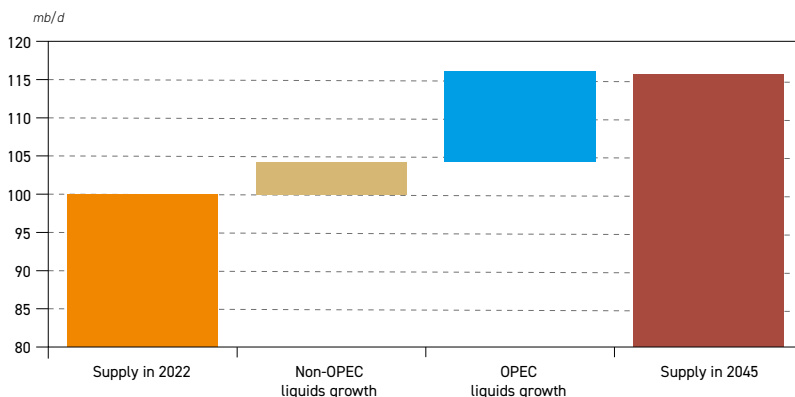
Source: OPEC.

Strong medium-term non-OPEC liquids supply growth, led by the US

Non-OPEC liquids supply is expected to grow from 65.8 mb/d in 2022 to 72.7 mb/d in 2028, or by almost 7 mb/d. Incremental supply in the US makes up nearly half of this, at 3.4 mb/d, with other major drivers being Brazil, Guyana, Canada, Qatar and Norway.

With US liquids supply set to peak around the end of the current decade, overall non-OPEC production starts declining from the early 2030s, eventually falling to 69.9 mb/d by 2045. Guyana, Canada, Argentina, Brazil and Kazakhstan are some of the few non-OPEC producers set to expand beyond the medium-term, but non-crude liquids including biofuels and other unconventionals will also keep increasing.

Composition of global liquids supply growth



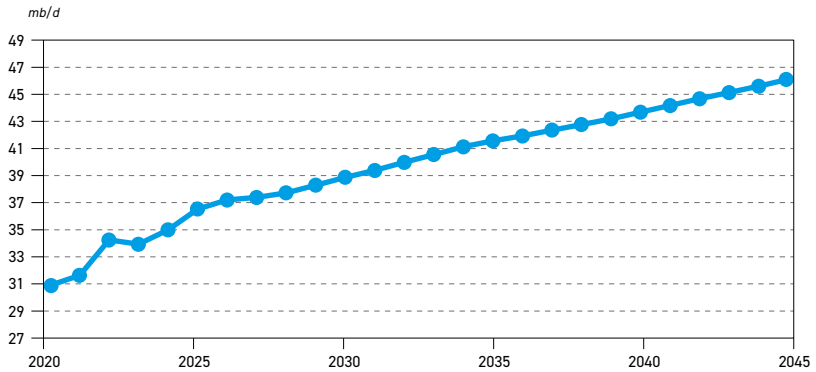
Source: OPEC.

OPEC's share of global liquids supply rises from 34% in 2022 to 40% in 2045

OPEC liquids will rise steadily in the medium-term from 34.2 mb/d in 2022 to 37.7 mb/d, and further to 46.1 mb/d by 2045. Thus, OPEC's share of global liquids supply will increase from 34% in 2022 to 40% in 2045.



OPEC total liquids supply outlook

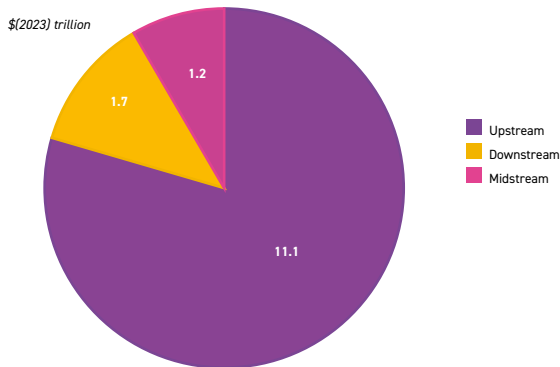


Source: OPEC.

Oil investment requirements total \$14 trillion by 2045

Investment requirements for the overall oil sector, between 2022 and 2045, are estimated at a cumulative \$14 trillion (in 2023 \$US), or around \$610 billion p.a. on average. Of this, \$11.1 trillion is expected to be required in the upstream sector, or an average of \$480 billion p.a. Downstream and midstream requirements

Cumulative oil-related investment requirements by segment, 2023–2045



Source: OPEC.

are estimated at \$1.7 and \$1.2 trillion, respectively. If these investments do not materialize, it represents a considerable challenge and risk to market stability and energy security.

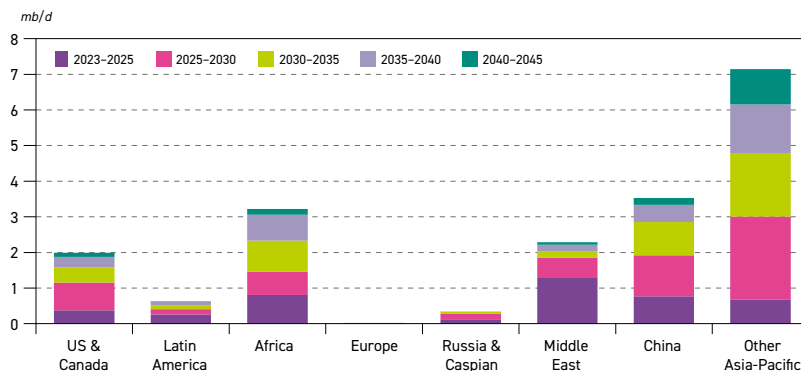
Asia-Pacific, Middle East & Africa drive medium-term refinery expansions

Around 6.6 mb/d of refining capacity additions are projected between 2022 and 2028. Most of this new capacity will be in the Asia-Pacific (3.1 mb/d), Middle East (1.6 mb/d) and Africa (1.2 mb/d). Additions in other regions are minor and mostly limited to the expansion of existing refineries.

New crude distillation capacity requirements at 19.2 mb/d through 2045

In the long-term (2023–2045), global refining capacity additions are set at 19.2 mb/d (including capacity creep). Similar to oil demand growth, additions are front-loaded, with a slowdown in the rate towards 2045. Around 85% of long-term additions are expected in the Asia-Pacific, Middle East and Africa. This continued trend of refining capacity migration from developed to developing countries mirrors the shifts in regional demand.

Crude distillation capacity additions, 2023–2045



Source: OPEC.

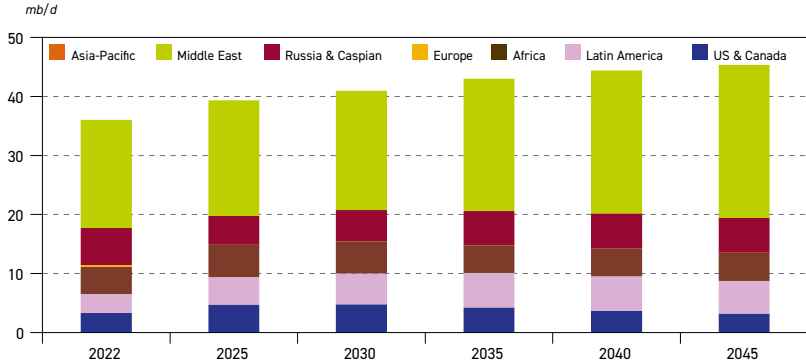
Long-term crude and condensate trade flows rise to above 45 mb/d by 2045

Driven by strong demand growth, global interregional crude and condensate trade is expected to reach levels above 39.3 mb/d in 2025, up by more than 3 mb/d relative to 2022 levels. After 2025, total crude and condensate flows are



set to increase gradually to 45.3 mb/d by 2045, driven by rising oil demand and declining supply in importing regions. Major contributors to the export growth are the Middle East, Latin America and the US & Canada.

Global crude and condensate exports by origin*, 2022–2045



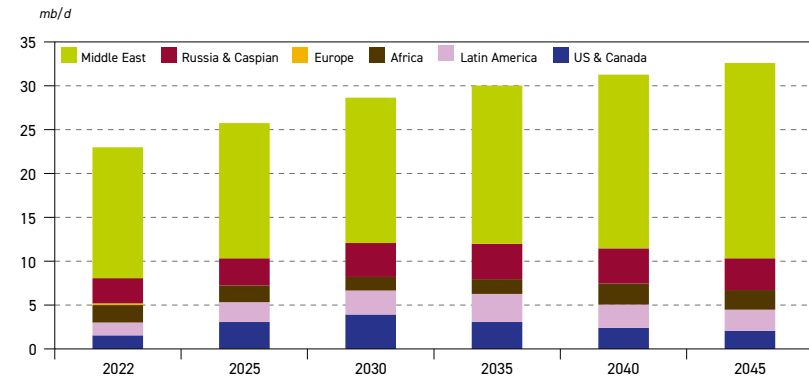
* Only trade between major regions is considered, intratrade is excluded.

Source: OPEC.

Asia-Pacific remains by far the largest destination for crude exports

The Asia-Pacific remains by far the main destination for global crude and condensate exports. Total imports increase gradually from 23 mb/d in 2022 to 32.6 mb/d

Crude and condensate imports to the Asia-Pacific by origin, 2022–2045



Source: OPEC.



in 2045. This translates into its share of the global interregional trade rising from around 64% in 2022 to almost 72% in 2045.

The Outlook considers two alternative scenarios relative to the Reference Case

An 'Advanced Technology' Scenario illustrates a technology-driven means of limiting the global temperature increase to well below 2°C. This includes a much greater diffusion of carbon capture utilization & storage (CCUS), carbon capture and storage (CCS) and direct air capture (DAC) technologies in industrial sectors, stronger investment in hydrogen supply networks, and the increasing adoption of a circular carbon economy (CCE) framework across the global economy. Primary energy demand in this scenario will be almost 55 mboe/d lower by 2045 compared to the Reference Case. Oil demand, after stabilizing at over 100 mb/d until around 2035, will then drop slightly towards 98 mb/d by 2045, which is 18 mb/d lower than in the Reference Case.

The 'Laissez-Faire' Scenario, which is a more optimistic and more equitable outlook for developing economies, assumes a faster return to higher economic growth during the medium-term and maintains this stronger growth in the long-term, especially for developing countries. Policies will tighten in the future, contributing to improved efficiencies and supporting the further expansion of renewables; however, in an isolated manner given the absence of a coordinated move to reduce future emissions. Moreover, protectionism and unilateralism will play a more important role in prioritizing local development needs over global issues. In this scenario, both primary energy demand and oil demand will be consistently higher than the Reference Case. Oil demand surpasses 113 mb/d by 2030 and continues growing to 122 mb/d in 2045. Compared to the Reference Case, this represents a difference of more than 1 mb/d by 2030, which then expands to 6.3 mb/d in 2045.







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