



Organization of the Petroleum Exporting Countries

2024

World Oil Outlook 2050



2024
**World
Oil
Outlook
2050**



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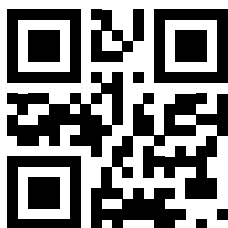
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Foreword

For OPEC, it is a great honour to launch the World Oil Outlook (WOO) 2024 in Brazil. The country's comprehensive and inclusive approach to energy issues has been on display through its G20 presidency in 2024, and will no doubt be central to its hosting of COP30 in 2025. This stance is fully in line with OPEC's development of its WOO, as well as the Charter of Cooperation between OPEC and participating non-OPEC countries, a voluntary framework for dialogue and a platform for multilateralism.

This year's WOO provides governments, policymakers and people around the world with realistic and sustainable future energy pathways. Central and common realities pervade all pathways: the fact that the world requires more energy in the decades to come, available in a secure, stable and sustainable manner; the imperative of energy access for all; and the need to reduce emissions.

Over the past year, there has been further recognition that the world can only phase in new energy sources at scale when they are genuinely ready, economically competitive, acceptable to consumers and with the right infrastructure in place. Moreover, there is a need to continually recognize the different national circumstances and approaches for all nations, keeping in mind inclusivity, and the principle of 'common but differentiated responsibilities'.

The WOO 2024, with the Outlook this year extended to 2050, looks to weave together all the various strands of the current debates and discussions on energy. This means understanding the needs and ambitions of every energy consumer around the world, appreciating what each energy source can offer, and finding ways forward that can deliver energy security, energy availability, affordability and emissions reduction. It is not about fixating on one part to the detriment of the others. The world needs to deliver on them all.

The need for more energy comes as economies grow, populations expand and urbanization levels increase. We should also remember the fact that billions of people are playing energy catch up, with too many lacking access to modern energy services, such as basic lighting and clean cooking options, and many more having never owned a car, been on an airplane, or travelled outside of their home country.

Global energy demand in this year's WOO is set to expand by 24% in the period to 2050, driven by significant expansion in the non-OECD region. The Outlook sees the need for an expansion in all energy sources, with the exception of coal. For oil alone, we see demand reaching over 120 million barrels a day by 2050, with the potential for it to be higher. There is no peak oil demand on the horizon.

What the Outlook underscores is that the fantasy of phasing out oil and gas bears no relation to fact. Combined they make up well over 50% of the energy mix today and are expected to do the same in 2050. A realistic view of demand growth expectations necessitate adequate investments in oil and gas, today, tomorrow, and for many decades into the future.

For oil alone, investment requirements out to 2050 total \$17.4 trillion. All policymakers and stakeholders need to work together to ensure a long-term investment-friendly climate, one that works for producers and consumers, as well as developed and developing countries.

At the same time, the WOO also highlights the need to ramp up efforts to reduce emissions, continually improve efficiencies, and introduce lower carbon solutions. In this regard, the oil industry is already playing a role.

At COP28, in OPEC Member Country, the United Arab Emirates, 50 oil and gas companies representing more than 40% of global oil production pledged to reach near-zero upstream methane emissions and end routine flaring in their operations by 2030. The oil industry is also investing in technologies, such as carbon capture utilization and storage, direct air capture, clean hydrogen technologies, and others. The industry is showing that it is possible to reduce emissions, while also producing the oil the world needs.

As the WOO underscores once again, the platform for building a sustainable energy future for all not only comes from stability in energy markets, as pursued by OPEC through the Declaration of Cooperation with non-OPEC producers, but also through teamwork, data transparency and international cooperation.

The WOO 2024 provides a basis for this, underlining the realities on the ground, and the importance of developing pragmatic policies that can help the world navigate the complexities of tomorrow's energy landscape. Ones that deliver for consumers, producers, and enable societal mobility, economic growth and a reduction in emissions.

I would also like to take this opportunity to thank all those involved in producing this year's WOO. It is a tremendous achievement, one that everyone should be proud of, and a publication we believe offers valuable insights into the key questions that are central to our shared energy future.



Haitham Al Ghaiss
Secretary General



Executive Summary

Outlook extended to 2050, further underscoring the challenges of energy security and reducing emissions

This year's World Oil Outlook (WOO) extends its perspective through to 2050, shedding further light on pivotal global trends and shifts. This includes looking at what each energy can offer in terms of delivering energy security, energy availability and reducing emissions, with an emphasis on the need for just and inclusive future energy pathways for all. The outlook examines economic, demographic, policy and technological developments to provide a balanced and realistic outlook based on real world data.

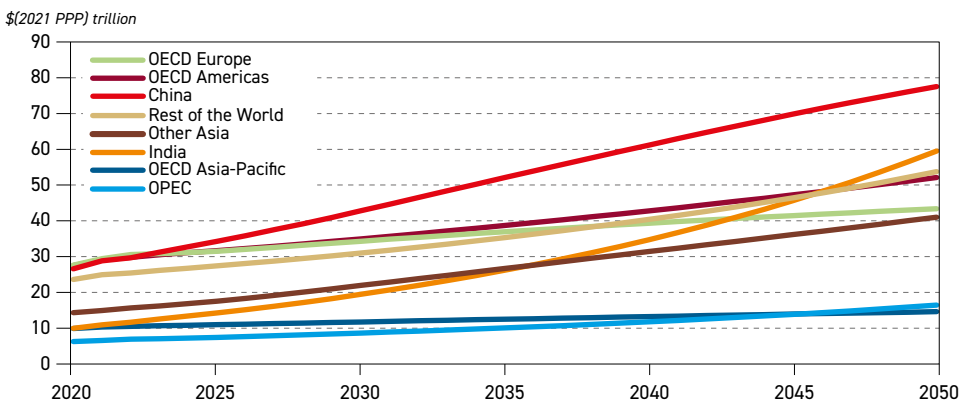
Global population growth, urbanization trends, drive energy demand requirements

The outlook is underscored by a robust increase in the world's population, with projections indicating a rise to 9.7 billion by 2050 from a level of just over eight billion today. This growth is predominantly driven by a substantial demographic surge in non-OECD regions. Urbanization trends are set to intensify, with an estimated two-thirds of the population, translating to over 6.6 billion people, expected to inhabit urban centres by the end of the forecast period. The global workforce, comprised of individuals between 15 and 64 years, is on course to exceed six billion by 2050, effectively integrating nearly 870 million new entrants into the labour market.

Average global economic growth of 2.9% p.a. through 2050

Global GDP is set to grow robustly, with an average annual increase of 2.9% per annum (p.a.) between 2023 and 2050. Non-OECD countries are set to lead this growth, expanding at an annual rate of 3.7%, while OECD nations experience more modest annual growth at 1.6%. As a result, in absolute terms the global economy is expected to more than double in size from \$165 trillion in 2023 to \$358 trillion in 2050.

Size of major economies, 2020–2050



Source: OPEC.

Energy policy ambitions remain high, but pushback on overly ambitious targets

COP28 in OPEC Member Country, the UAE, marked a significant milestone as it conducted the first global stocktake (GST) under the Paris Agreement. The importance of national contributions to emissions reduction was underscored, however, the GST also acknowledged the potential for disruptions due to various uncertainties. While energy policy ambitions

remain high, the outlook expects greater scrutiny and pushback on some overly ambitious policy targets, both from policymakers and populations. It is evident that energy security continues to be a paramount concern.

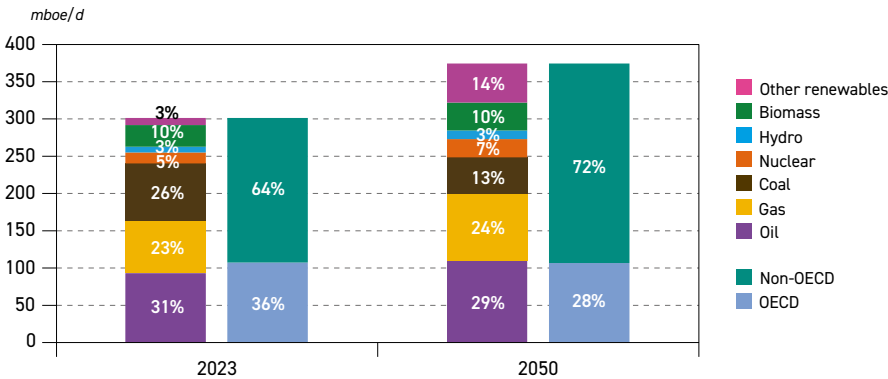
Technology will continue to significantly impact energy demand and supply

The WOO recognizes incremental technological advancements that help to improve efficiency and reduce costs, but does not assume sudden technology breakthroughs. Internal combustion engine (ICE) vehicles are expected to continue to dominate road transportation. Electric vehicles (EVs) are poised for a larger market share, but obstacles remain, such as electricity grids, battery manufacturing capacity and access to critical minerals. Elsewhere in transportation, the aviation sector is grappling with decarbonization challenges, while maritime shipping is embracing alternative fuels. A significant expansion of carbon abatement capacity, mainly carbon capture utilization & storage (CCUS), is expected.

Global primary energy demand to increase by 24% to 2050, driven by the non-OECD

Global primary energy demand is set to increase from 301 million barrels of oil equivalent a day (mboe/d) in 2023 to 374 mboe/d in 2050, an increase of 24% over the outlook period. Energy demand growth is driven by developing regions (non-OECD), which are projected to see an increase of 73.5 mboe/d. Around 30% of non-OECD growth comes from India alone. At the same time, primary energy demand in OECD countries drops slightly. The share of the non-OECD in global primary energy demand increases to 71.5% in 2050, up by 7 percentage points from 2023.

Total primary energy demand by fuel and region, 2023 and 2050



Source: OPEC.

Demand for all energy sources increases, except coal; wind and solar grow at the fastest rate

In the Reference Case, with the exception of coal, demand for all primary fuels is set to increase over the outlook period. The largest increase is expected to come from other renewables (mainly wind and solar), with absolute growth of almost 43 mboe/d, expanding from 9.6 mboe/d in 2023 to 52.4 mboe/d in 2050. The second largest increase is anticipated from natural gas, rising by 20.5 mboe/d through 2050. Oil demand is expected to grow significantly, increasing by 16.7 mboe/d. Increments in the period 2023–2050 are expected from nuclear energy (9.6 mboe/d) and biomass (8.2 mboe/d), as well as hydro (4 mboe/d). Due to stringent energy policies in most regions, coal demand is forecast to decline by almost 29 mboe/d between 2023 and 2050.



World primary energy demand by fuel type, 2023–2050

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Fuel share %	
	2023	2030	2035	2040	2045	2050	2023–2050	2023–2050	2023	2050
Oil	92.9	103.1	106.0	107.4	108.5	109.6	16.7	0.6	30.9	29.3
Coal	78.0	71.6	66.1	60.0	54.4	49.1	–28.9	–1.7	25.9	13.1
Gas	69.1	75.9	80.6	84.8	87.9	89.6	20.5	1.0	23.0	24.0
Nuclear	14.8	17.0	18.9	20.9	22.7	24.3	9.6	1.9	4.9	6.5
Hydro	7.6	8.6	9.2	9.9	10.7	11.6	4.0	1.6	2.5	3.1
Biomass	29.1	32.1	34.0	35.5	36.5	37.4	8.2	0.9	9.7	10.0
Other renewables	9.6	19.0	27.1	35.1	43.6	52.4	42.9	6.5	3.2	14.0
Total	301.1	327.3	342.0	353.7	364.4	374.1	72.9	0.8	100.0	100.0

Source: OPEC.

The share of oil and gas in the energy mix stays above 53% through 2050, with oil retaining the largest share at above 29%

Big shifts in the energy mix are seen throughout the outlook period, but oil and gas are set to remain crucial for energy supply in the period to 2050. Their combined share in the energy mix is expected to stay above 53% throughout the outlook period. Oil retains the largest share at 29.3% in 2050, with gas at 24%.

Oil demand sees robust medium-term growth and reaches over 120 mb/d by 2050, driven by the non-OECD

Global oil demand is projected to reach 112.3 million barrels a day (mb/d) in 2029, representing a strong increase of 10.1 mb/d compared to 2023. However, the regional breakdown of this medium-term expansion shows a contrasting picture between continued non-OECD demand growth and rather stagnating OECD demand. Non-OECD oil demand is projected to increase by a healthy 9.6 mb/d between 2023 and 2029 to reach 66.2 mb/d, while OECD demand is set to oscillate around 46 mb/d over the same period.

In the long term, global oil demand is expected to increase by almost 18 mb/d, rising from 102.2 mb/d in 2023 to 120.1 mb/d in 2050. While non-OECD demand is projected to increase by 28 mb/d between 2023 and 2050, OECD demand is set to witness a decline.

Long-term oil demand by region

mb/d

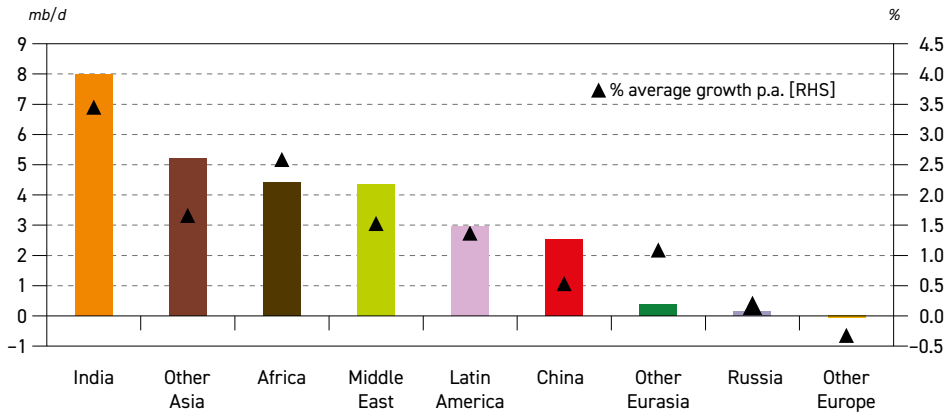
	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Americas	25.0	25.6	24.9	23.5	22.2	21.1	–3.8
OECD Europe	13.4	13.1	12.1	11.0	10.0	9.2	–4.2
OECD Asia-Pacific	7.2	7.2	6.7	6.1	5.7	5.2	–2.0
OECD	45.7	45.9	43.7	40.6	37.9	35.6	–10.1
China	16.4	18.6	19.0	19.2	19.1	18.9	2.5
India	5.3	7.1	8.6	10.2	11.8	13.3	8.0
Other Asia	9.3	11.2	12.3	13.1	13.8	14.5	5.2
Latin America	6.7	8.0	8.8	9.2	9.5	9.7	3.0
Middle East	8.6	10.7	11.5	12.1	12.6	13.0	4.4
Africa	4.5	5.4	6.2	7.0	7.9	8.9	4.4
Russia	3.8	4.1	4.1	4.1	4.1	4.0	0.2
Other Eurasia	1.2	1.4	1.5	1.5	1.6	1.6	0.4
Other Europe	0.8	0.8	0.8	0.8	0.8	0.7	–0.1
Non-OECD	56.6	67.4	72.7	77.2	81.1	84.6	28.0
World	102.2	113.3	116.4	117.8	118.9	120.1	17.9

Source: OPEC.

India drives incremental long-term demand growth

Extending the outlook's time horizon to 2050 amplifies the role of India, Other Asia, Africa and the Middle East as the key sources of incremental demand in the coming years. Combined demand in these four regions is set to increase by 22 mb/d between 2023 and 2050. India alone will add 8 mb/d to its oil demand during the forecast period. China's oil demand is projected to increase by 2.5 mb/d.

Non-OECD regional oil demand growth, 2023-2050



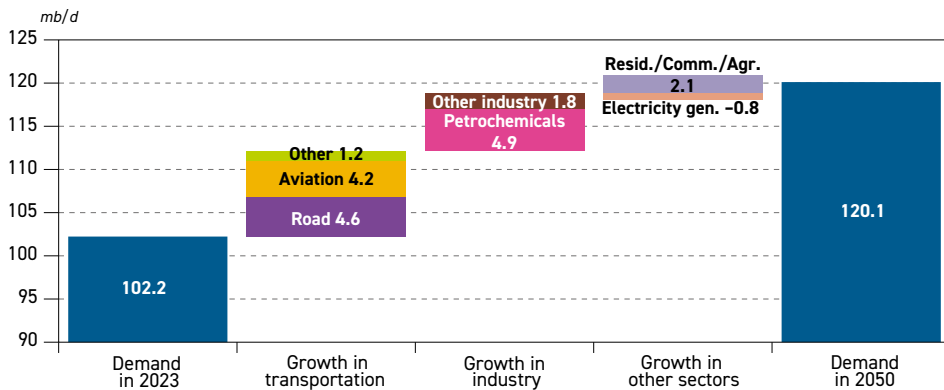
Source: OPEC.

Petrochemicals, road transport and aviation are critical for future demand growth

The largest incremental demand during the forecast period is projected for the petrochemicals, road transportation and aviation sectors. Oil demand in these sectors in the long term is set to increase by 4.9 mb/d, 4.6 mb/d and 4.2 mb/d, respectively.

Demand projections in the road transportation sector indicate strong growth over the current decade before stabilizing at levels above 50 mb/d for the rest of the forecast period. By then,

Oil demand growth by sector, 2023-2050

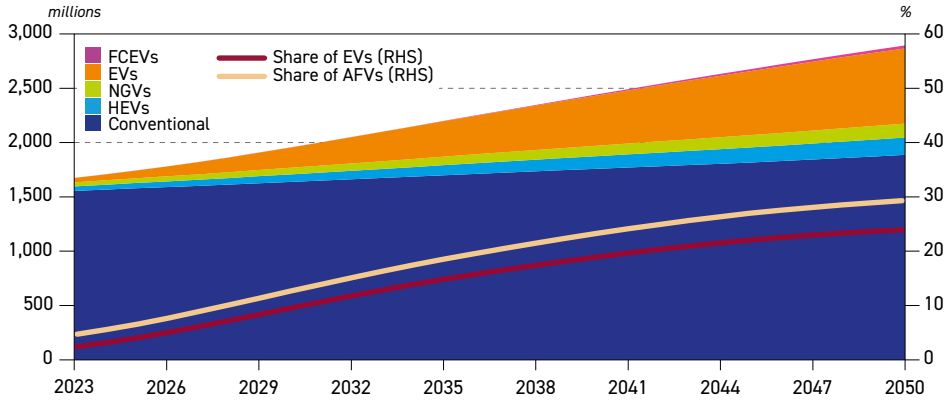


Source: OPEC.



the penetration of EVs is set to increasingly play a role. The global vehicle fleet is forecast to increase from 1.7 billion in 2023 to 2.9 billion in 2050 with the fastest growth expected in the EVs segment. Nevertheless, ICE-based vehicles are expected to continue to dominate the global fleet and still account for more than 70% in 2050.

Global fleet composition, 2023–2050



Source: OPEC.

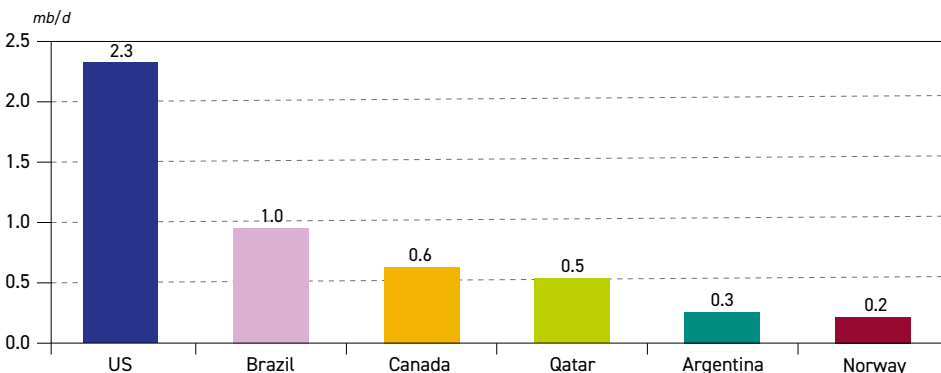
Petrochemical and transportation trends shift the global product slate to a much lighter average barrel

With respect to refined products, strong long-term demand growth is expected for ethane/liquefied petroleum gas (+4.2 mb/d). The larger part of this demand growth relates to the use of ethane as a petrochemical feedstock, mainly in OECD Americas and the Middle East. The strong projected demand growth in the petrochemical sector, especially in Asia, is set to lead to increased naphtha demand (+2.8 mb/d) too. Demand growth in the aviation sector sees jet/kerosene rising by 4 mb/d between 2023 and 2050, while road transportation is the key sector for increases in diesel/gasoil (+3.5 mb/d) and gasoline (+2.5 mb/d).

US, Brazil and Canada drive medium-term non-DoC liquids supply growth of 7.1 mb/d

This year's WOO focuses on non-Declaration of Cooperation (non-DoC) liquids supply. In the medium term, non-DoC liquids supply is projected to increase from 51.7 mb/d in 2023 to

Select contributors to non-DoC total liquids change, 2023–2029



Source: OPEC.

58.8 mb/d in 2029, or by 7.1 mb/d. Once again, the largest medium-term source of non-DoC liquids supply growth is the US, where total output is set to rise by 2.3 mb/d in the 2023–2029 period, or from 20.9 mb/d to 23.2 mb/d. Other significant supply increments in this timeframe come from Brazil (1 mb/d), Canada (0.6 mb/d), Qatar (0.5 mb/d), Argentina (0.3 mb/d) and Norway (0.2 mb/d).

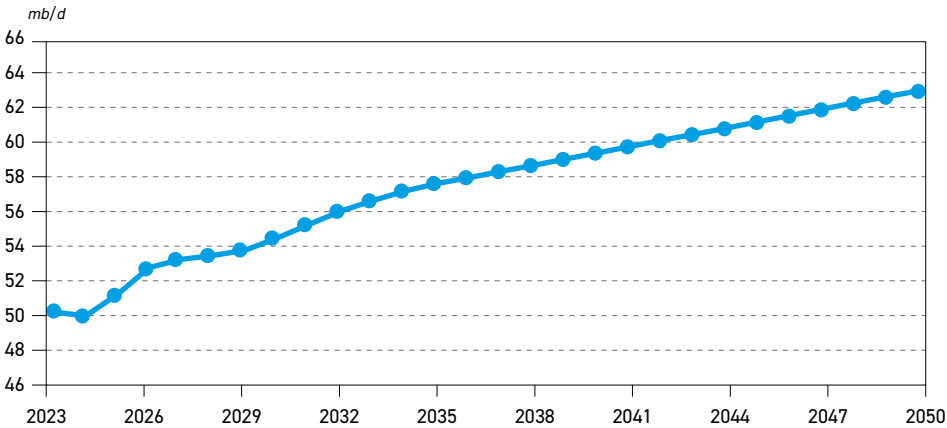
Non-DoC supply growth slows in the long term, after US supply peaks in 2030

Long-term non-DoC liquids supply expands from 51.7 mb/d in 2023 to 57.3 mb/d in 2050, or by 5.5 mb/d. Despite US production declining over this time horizon, after peaking around 2030, this is more than offset by higher output in Latin America, Canada, the (non-DoC) Middle East and global refinery processing gains. Other regions see only modest change.

DoC liquids supply grows by 12.7 mb/d from 2023–2050, increasing market share to 52%

DoC liquids supply is projected to expand from 50.3 mb/d in 2023 to 53.8 mb/d in 2029. After non-DoC liquids supply peaks in the early 2030s, DoC liquids supply by contrast keeps growing, rising to 62.9 mb/d by 2050. This means that the DoC's share in global liquids supply increases from 49% in 2023 to 52% in 2050.

Declaration of Cooperation (DoC) total liquids



Source: OPEC.

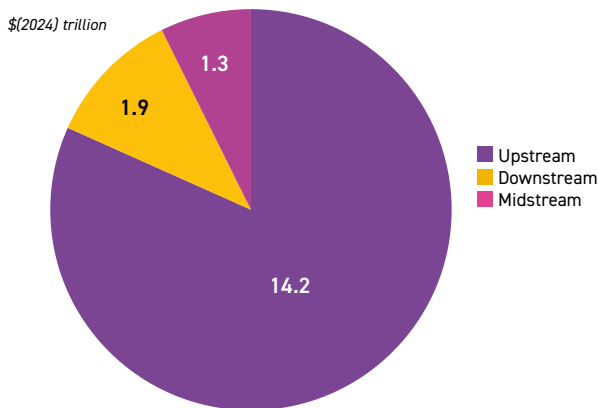
Oil sector requires cumulative investments of \$17.4 trillion by 2050 to meet growing demand needs

In order to reliably meet expected oil demand growth, oil sector investment needs are significant. Total cumulative requirements between 2024 and 2050 are estimated at \$17.4 trillion, or around \$640 billion p.a. on average (all in US\$2024).

The bulk of this is required in the upstream, where total investment needs are \$14.2 trillion, or around \$525 billion p.a. Downstream and midstream investment needs over the same period are forecast to be \$1.9 trillion and \$1.3 trillion, respectively.



Cumulative oil-related investment requirements by segment, 2024–2050

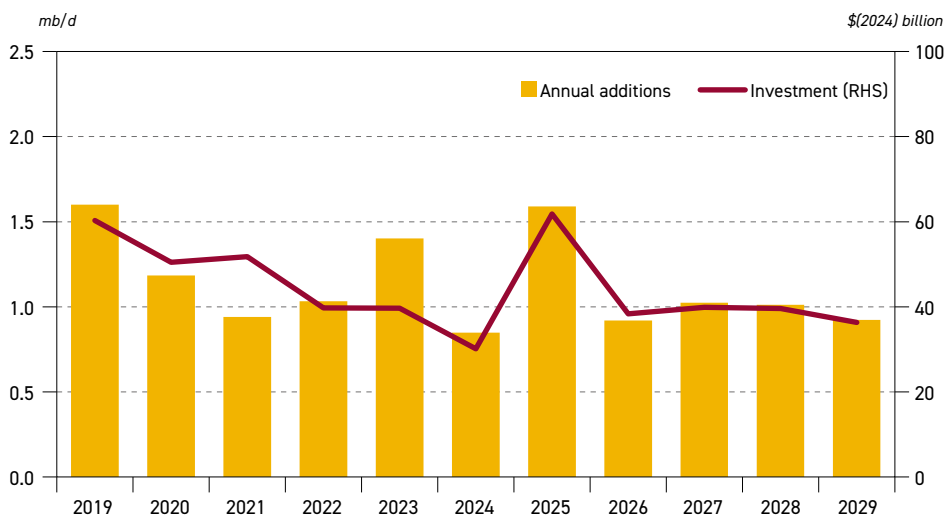


Source: OPEC.

Developing regions drive medium-term refinery expansions

In the medium term, around 6.3 mb/d of refining capacity additions are expected at the global level. The majority of new capacity is projected for the Asia-Pacific (3.2 mb/d), Africa (1.4 mb/d) and the Middle East (1.2 mb/d). The global annual average rate of capacity additions for the period from 2024–2029 is estimated at just above 1 mb/d.

Annual distillation capacity additions and total project investment

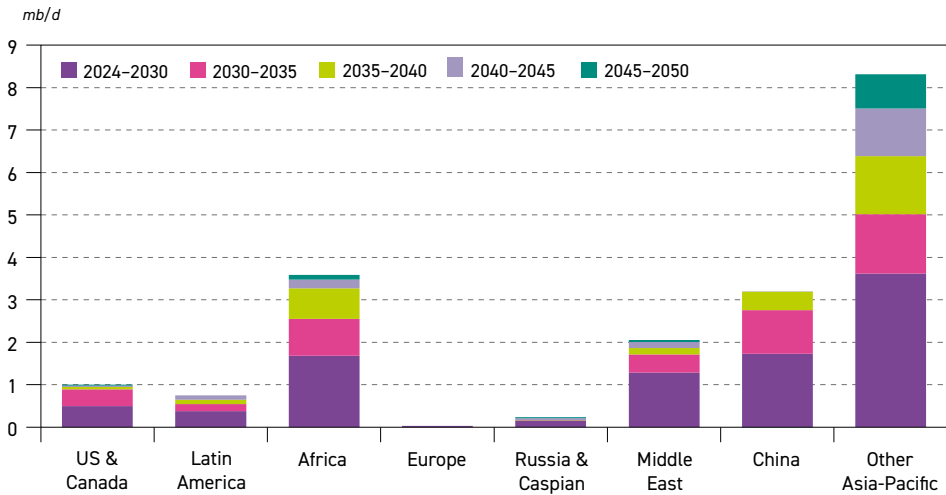


Source: OPEC.

New crude distillation capacity requirements estimated at 19.2 mb/d through 2050

Global required refining additions to 2050 are projected at 19.2 mb/d (including creep capacity expansions). Similar to oil demand growth, refining capacity additions are front-loaded, with a slowdown in the rate of additions after 2040. Almost 90% of new refining capacity is set to be located in the Asia-Pacific, Africa and the Middle East. This is a continuation of the historical trend that sees refining capacity migrating from developed to developing countries.

Crude distillation capacity additions, 2024–2050



Source: OPEC.

Strong refinery throughput growth expected in developing countries

Refinery runs are expected to increase from 81.8 mb/d in 2023 to almost 90 mb/d in 2030. The growth is set to be slower in the post-2030 period with global runs reaching 93 mb/d in 2040 and nearly 94 mb/d in 2050. US & Canada and Europe, as well as developed Asia-Pacific, are set to decline from 2030 onwards. This is more than offset by strong increases in developing regions, such as Asia-Pacific, Middle East, Africa and Latin America.

Crude unit throughputs, 2023–2050

mb/d

	US & Canada	Latin America	Africa	Europe	Russia & Caspian	Middle East	China	Other Asia-Pacific	Global
2023	17.7	4.6	1.8	11.8	6.6	8.0	14.8	16.7	81.8
2030	18.0	5.6	3.5	11.5	6.5	9.6	16.3	18.9	89.8
2035	18.0	6.1	4.4	11.2	6.2	10.0	16.5	20.0	92.4
2040	18.0	6.5	5.0	9.9	6.1	10.2	16.3	20.9	93.0
2045	17.6	6.7	5.2	9.7	6.1	10.4	16.3	21.4	93.4
2050	17.0	6.9	5.5	9.5	6.1	10.6	16.2	22.0	93.8

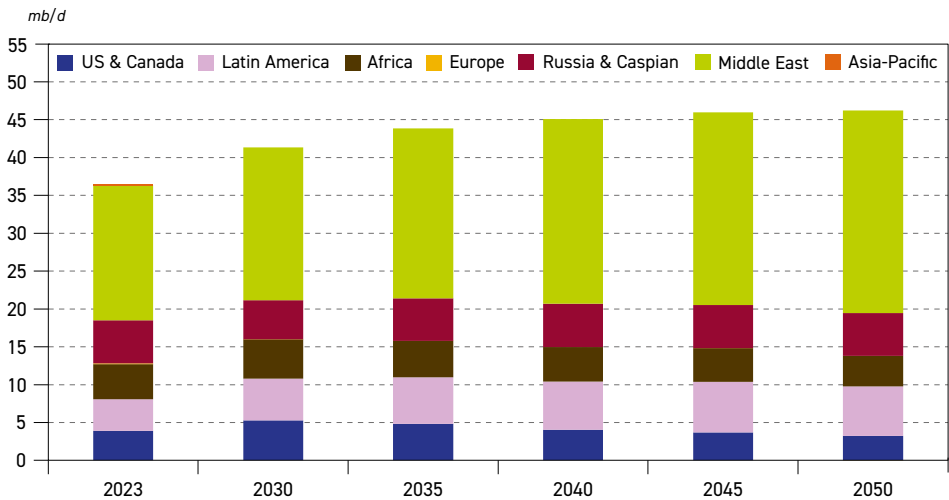
Source: OPEC.

Global crude and condensate trade flows rise to 46.2 mb/d by 2050

Global interregional crude oil and condensate trade are expected to increase from 36.5 mb/d in 2023 to 41.2 mb/d by 2030 on the back of strong oil demand growth. After 2030, trade is expected to continue to increase further, reaching levels around 46.2 mb/d by 2050. The Middle East and Latin America are expected to be the main contributors to global crude and condensate exports throughout the outlook period.



Global crude and condensate exports by origin*, 2023–2050

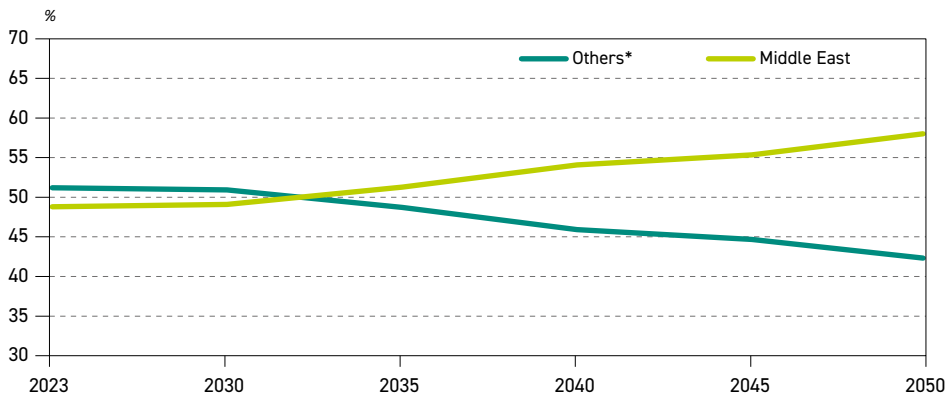


* Only trade between major regions is considered, intratrade is excluded.
Source: OPEC.

Middle East increases its share in global crude and condensate trade

Global crude and condensate exports are heavily dominated by the Middle East, with its share standing at almost 49% in 2023. Due to a strong increase in crude and condensate exports from Latin America and the US & Canada, the Middle East's share is expected to decline marginally by 2030. In the post-2030 period, however, the Middle East's share in the total export mix is projected to increase to almost 58% by 2050.

Middle East share in global crude and condensate trade, 2023–2050



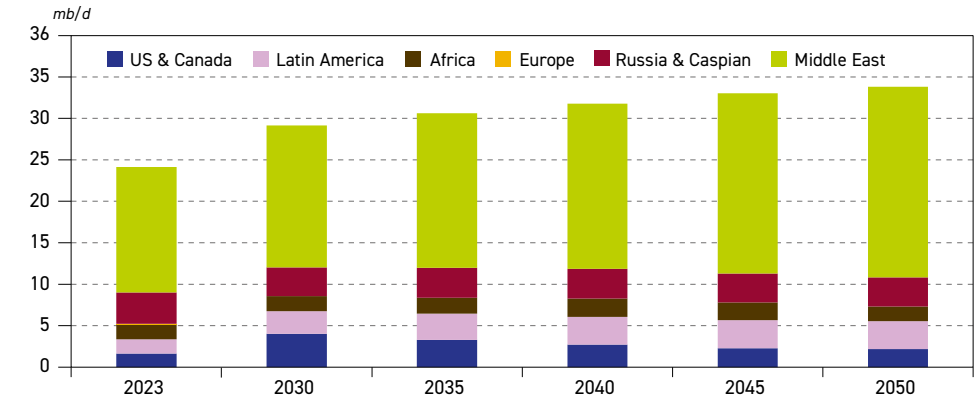
* Including Latin America, Russia & Caspian, Africa and the US & Canada.
Source: OPEC.

Asia-Pacific crude and condensate imports rise by almost 10 mb/d by 2050

Total crude and condensate import volumes to the Asia-Pacific reached levels of around 24 mb/d in 2023. They are expected to increase to above 29 mb/d in 2030 and rise further

to around 33.8 mb/d in 2050. This is predominantly due to increasing oil demand in the Asia-Pacific, but also because of declining domestic supply from ageing local oilfields. The major source of incremental volumes is set to come from the Middle East, with shipments increasing from 15.1 mb/d in 2023 to 23 mb/d in 2050.

Crude and condensate imports to the Asia-Pacific by origin, 2023-2050

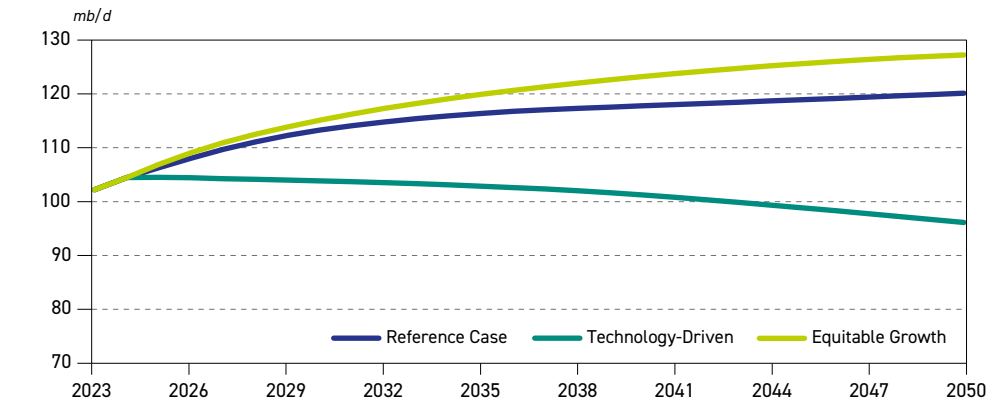


Source: OPEC.

Scenarios emphasize wide range of uncertainty for future energy and oil demand

This Outlook describes two alternative scenarios relative to the Reference Case. The 'Technology-Driven ' Scenario illustrates a different pathway to the dominant narrative on emissions reduction; one that achieves the goal of limiting the global temperature increase at well below 2°C, while avoiding a substantial negative economic impact on developing economies, especially those who export energy, and at the same time, ensuring a high degree of energy security. Global oil demand in this scenario stabilizes at a level above 100 mb/d in the period to around 2040, before moderately slowing to 96 mb/d over the last ten years

Global liquids demand in the Reference Case and alternative scenarios, 2023-2050



Source: OPEC.



of the outlook period. This represents a demand difference of 24 mb/d compared to the Reference Case in 2050.

By contrast, the 'Equitable Growth' Scenario illustrates a pathway that envisages a more equitable and prosperous economic future for developing countries, coupled with a differentiated approach to how and when to achieve emission reduction targets. This scenario results in higher long-term energy demand, in general, and oil, in particular. Oil demand in this scenario tops 115 mb/d by 2030 and continues growing to 127 mb/d in 2050. Compared to the Reference Case, this is higher by almost 2 mb/d in 2030 and by 7.1 mb/d in 2050.

Energy and oil industry face both challenges and opportunities

The long-term outlook for the energy sector remains uncertain. The challenge of how to balance sustainable, equitable development with much-needed energy affordability and energy security, while at the same time addressing climate concerns, has led to much debate and polarization among key stakeholders. The Outlook discusses critical issues, challenges and opportunities that the global energy industry, in general, and the oil industry, in particular, could face in the coming decades, touching on such factors as energy policy and climate negotiations, investment and the role of new technologies.

Introduction

Until a few years ago, the main focus of policymakers was on emissions reduction, with the dominant mainstream narrative almost exclusively on a wholesale transition to using renewable energy and EVs, as if this were a silver bullet to solve all the world's climate and energy issues. Since then, voices have increasingly been calling out the shortcomings of this approach given the realities of following this path. This includes renewables' integration costs, the sourcing of critical minerals, electricity grid requirements, battery manufacturing capacity, rising prices for consumers, and more generally, the wider public beginning to understand what the real-life implications of these kinds of major transitions actually are.

In the midst of this debate, developments in 2022 also provided a wake-up call. Energy prices surged on the back of geopolitical developments; major concerns about supply chains and energy flows were raised, especially in Europe, albeit with clear ramifications for other regions. At this point, the focus returned to the inter-linked challenges of energy security, energy affordability and energy accessibility, alongside reducing emissions. The result of this was that policymakers were required to re-assess policy targets and a broad debate about the speed of energy transitions ensued.

These developments were the main reason for OPEC making upward revisions to the outlook for both energy and oil demand projections in 2023, as published in last year's edition of the WOO. Since then, the public discussion on these issues has intensified and broadened, and increasingly, the debate has shifted towards a more comprehensive and holistic view, one advocated by OPEC.

Moreover, there were also important market signals in 2023 that serve to underpin the growing realization that any large-scale restructuring of the global energy system will take time. Global oil demand increased by 2.5 mb/d in 2023, rising to its highest level ever, while coal demand, despite all policies and efforts to target a reduction in use, also reached levels unseen previously.

At the same time, it should be noted that with regard to renewables, the world saw the greatest annual increase in capacity over the course of 2023, and EVs saw their strongest ever annual sales. When zooming in on the details, however, strikingly, a large part of this growth was concentrated in China, while growth in other countries and regions was not as expected. Additionally, renewables and EVs expansion is coming from a low base.

It is becoming increasingly evident that one key lesson policymakers are taking into consideration is that initial, overly optimistic assumptions that renewable energy deployment costs would inevitably and irreversibly decline in line with technology advances and with growing economies of scale, was misguided. It is important to be reminded that this theoretical concept only works assuming that all other factors remain constant. However, this is clearly not the case given the real-world impacts of geopolitics, macro-economic and trade developments, as well as often unforeseen knock-on consequences of attempting to scale up at a such a rapid pace. These can all throw up barriers, and offset the impact of progress on technology, for instance.

To be specific, the example of EVs is instructive. Again, the expectation underpinning policymakers' calculations has been that the purchase cost of EVs will inevitably drop over time, thus incentivizing consumers to buy an EV over a conventional vehicle. Recent announcements of scaling back or delaying investments in EV production capacity by several major car manufacturers speaks volumes. Moreover, it is unlikely that consumers in Europe

and the US will see lower EV prices that could be offered by Chinese EV producers as these are being offset by trade barriers thrown up in an atmosphere of protectionism and support for domestic carmakers. There is also now more talk of giving consumers a choice, not pushing policy on them in one direction.

On the policy level too, recent much-softened proposals for Euro-7 emissions norms, the US debate to temper emissions standards on vehicle model years as of 2027, or even the UK decision to entirely push back a 2030 sales ban on ICEs are instructive in this regard.

To be clear, these examples are not an indication that EV and renewable energy deployment costs will not decline further, or that EV sales and renewable energy capacity will not increase in the years to come. The point is that overly ambitious expectations about how fast they will penetrate energy markets and substitute oil-based products can be viewed as overblown.

Elsewhere in this year's WOO, it is also important to highlight that the economic outlook has brightened since the publication of the WOO 2023, with inflation pressure dwindling, and central banks starting to lower interest rates. Combined with other factors, this has led to an upward revision to global oil and energy demand within the outlook horizon, which has now been extended to 2050.

On the supply side, a new methodology has been introduced to reflect oil production by countries participating in the Declaration of Cooperation (DoC) and other countries (non-DoC).

Once again, this WOO aims to provide insightful views, be thought-provoking and instructive, and thus provide perspectives to underpin a broadening and deepening of the ever-important global debate on our common energy future.



Key assumptions



Key takeaways

- This year's WOO extends the outlook period to 2050.
- The global population is expected to rise by about 1.6 billion, from its current level of just over eight billion in 2023 to an estimated 9.7 billion by 2050.
- The global working-age population is projected to surpass six billion by 2050, with around 870 million workers added to the labour force over the forecast period.
- An estimated 68% of the world's population, or over 6.6 billion people, are expected to live in urban areas by the end of the outlook period.
- Global gross domestic product (GDP) growth between 2023 and 2050 is expected to remain robust and increase at an average rate of 2.9% p.a. Non-OECD countries dominate the growth outlook with an expected average rate of 3.7% p.a., while OECD countries are expected to grow at a rate of 1.6% p.a.
- The global economy is set to more than double in size in absolute terms from \$165 trillion in 2023 to \$358 trillion in 2050, while global average income is projected to rise from roughly \$20,600 (2021 PPP) in 2023 to \$36,800 (2021 PPP) by 2050.
- COP28 concluded the first GST under the Paris Agreement, emphasizing the importance of national contributions to the reduction of emissions.
- Energy security concerns are likely to remain paramount for decision makers, with an anticipated greater pushback and scrutiny of new energy policies on several fronts.
- The WOO assumes a gradual evolution of technology, with no sudden technological breakthroughs, the timing and impact of which are challenging to forecast.
- ICE vehicles will remain predominant in road transport, while EVs continue to encounter challenges related to driving range, supply chains and reliable charging infrastructure. However, these issues are expected to improve over the long term.
- Aviation transport remains one of the most difficult sectors to decarbonize, whereas major technological advancements have resulted in the adoption of alternative fuels in the maritime shipping sector.
- The oil industry's infrastructure, technological expertise and capacity for investment, position it uniquely to lead in hydrogen production, distribution and storage.

This year's WOO considers a multitude of pivotal key assumptions, including population and demographic trends, as well as the potential for economic growth. The expected effects of significant shifts in energy policies and the potential technology advancements within the energy sector also serve as key underpinnings. These assumptions have been thoroughly analyzed in establishing the Reference Case.

1.1 Population and demographics

Numerous factors, including continuous advances in healthcare, multi-dimensional wellness and access to both water and sanitation services have enhanced the standard of living and thus extended the average lifespan globally in recent decades. However, the rate of population growth is decelerating, particularly in OECD countries. Certain developing nations may witness a similar demographic transition as to that observed in the OECD, although others may not. This chapter thoroughly examines various demographic factors to guide the projections within the WOO's Reference Case. Furthermore, the extension of the outlook period in this year's WOO to 2050 provides a longer horizon for population and demographic trends to play out.

This Outlook utilizes the 2024 revision of World Population Prospects from the United Nations Department of Economic and Social Affairs (UNDESA). This document, being the 28th edition of the UN's definitive population estimates and projections, encompasses a wide range of crucial demographic indicators, all of which are comprehensively addressed in this section.

Based on the projections, the total global population is expected to rise by roughly 1.6 billion, increasing from its current level of 8.1 billion in 2023 to an estimated 9.7 billion by

Table 1.1

Population by region

millions

	Levels						Growth
	2023	2030	2035	2040	2045	2050	2023–2050
OECD Americas	536	558	571	582	592	599	63
OECD Europe	590	590	589	587	583	577	–13
OECD Asia-Pacific	217	215	212	209	205	202	–15
OECD	1,343	1,363	1,372	1,378	1,380	1,377	34
Latin America	478	498	510	519	524	527	49
Middle East & Africa	1,284	1,507	1,672	1,839	2,007	2,175	891
India	1,438	1,525	1,579	1,623	1,656	1,680	242
China	1,423	1,398	1,373	1,343	1,306	1,260	–162
Other Asia	1,280	1,367	1,428	1,484	1,533	1,575	295
OPEC	505	564	605	646	684	721	216
Russia	145	142	140	138	137	136	–9
Other Eurasia	196	204	206	209	211	213	17
Non-OECD	6,749	7,206	7,513	7,799	8,060	8,287	1,538
World	8,092	8,569	8,885	9,177	9,440	9,664	1,573

Source: UN.



2050 (Table 1.1). However, an important point highlighted in recent demographic data is the persistent drop in fertility rates.

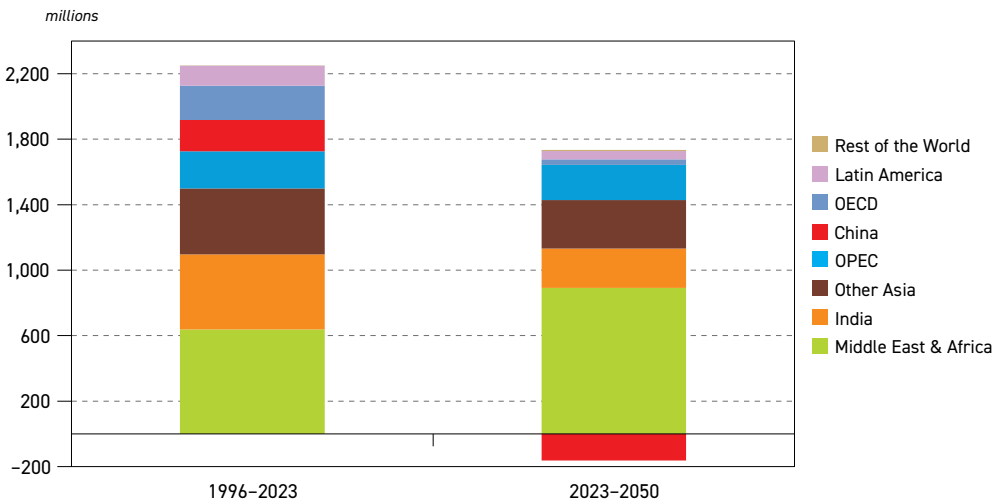
On a regional basis, as per the WOO's regional classifications (see Annex B), it is clear that non-OECD regions are set to provide almost all of the world's population growth, with the Middle East and Africa (excluding OPEC nations) projected to account for over half of the global population additions. Other notable increases are in OPEC, where the size of the population increases by 43% by 2050 and in Other Asia, which increases by 23%.

For the OECD region, population growth to the year 2050 is expected to be only 34 million, which is drastically lower than the 210 million increase experienced during a similar timeframe between 1996 and 2023. In fact, growth in OECD Americas is expected to more than compensate for a combined 28 million drop in OECD Europe and OECD Asia-Pacific.

Among non-OECD countries, China stands out as the only one projected to experience a significant population decline, with an estimated drop of 162 million over the next 27 years. This represents, by far, the largest decline among the major economies and is in stark contrast to China's previous population growth of approximately 192 million during the period from 1996 to 2023, as shown in Figure 1.1. Moreover, China lost its position as the world's most populous country to India in 2022, as illustrated in Figure 1.2. India's population is projected to grow by 242 million between 2023 and 2050, although growth is set to be much slower than the level of 458 million it witnessed over the previous 27 years.

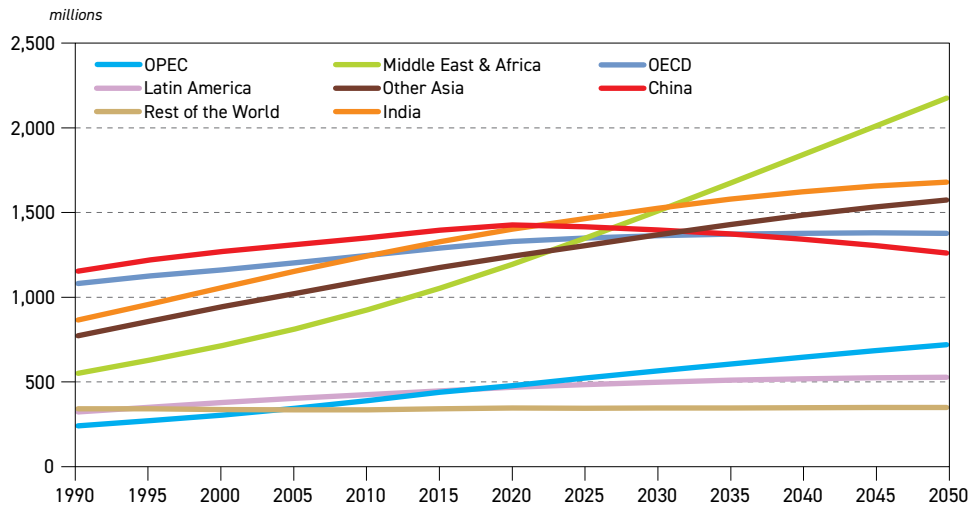
India is expected to remain the most populous region until the early 2030s, when the Middle East & Africa region is anticipated to surge past it on the back of a significant increase of 891 million from 2023 to 2050, to become, by far, the region with the largest population. This is noticeably larger than the 638 million people added between 1996 and 2023. OPEC is the only other region with a population growth rate comparable to the previous 27 years, with an expected increase of 216 million people from 2023 to 2050.

Figure 1.1
World population growth, 1996–2023 versus 2023–2050



Source: UN.

Figure 1.2
World population trends, 1990–2050



Source: UN.

1.1.1 Working-age population

The global working-age population (i.e. between 15 and 64 years) is projected to surpass six billion by 2050, contributing an additional 859 million workers to the labour force over the next 27 years (Table 1.2). This growth trajectory, however, is tempered by an ageing global population. Thus, while the world’s total population continues to expand, the percentage of the population that is of working age is set to drop from 65% in 2023 to 63% in 2050. Furthermore, regional disparities are expected to emerge. Non-OECD countries are expected to retain the majority of their workforce, with their share dropping only slightly from 65% in 2023 to 64% in 2050. In contrast, OECD countries are set to experience a more pronounced decline, falling from 65% to just over 59% over the same period – a loss of 54 million people in the working population.

Within the OECD, only OECD Americas is positioned to experience a modest increase in its working-age population, primarily attributable to immigration. In contrast, the OECD Asia-Pacific region is expected to have to confront a significant decline of 20% in its working-age population during the outlook period. OECD Europe sees a more moderate, but still noteworthy reduction of 12%.

The gap between the working populations of the OECD and non-OECD region widens further in the long term. Leading non-OECD working population growth is the Middle East & Africa region with an estimated surge of 638 million by 2050. After the Middle East & Africa, OPEC countries see the largest relative increase, with the working population jumping by 50% by 2050. Additionally, both Other Asia and the world’s most populous country, India, are set to add a robust 192 million and 156 million to their working-age cohorts, respectively. In contrast to these regions is China, which is projected to experience a large decline of 238 million in its working-age population by 2050 – the equivalent of 24% of its current workforce.



Table 1.2

Working population (aged 15–64 years) by region*millions*

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Americas	352	361	366	369	372	372	20
OECD Europe	380	373	365	355	344	333	–47
OECD Asia-Pacific	136	131	126	119	113	109	–27
OECD	867	865	857	843	828	813	–54
Latin America	324	338	344	346	345	339	15
Middle East & Africa	736	890	1,006	1,127	1,252	1,375	638
India	978	1,053	1,092	1,118	1,133	1,134	156
China	983	972	930	859	807	745	–238
Other Asia	835	903	945	979	1,007	1,027	192
OPEC	311	360	392	420	446	468	157
Russia	96	93	92	90	86	82	–13
Other Eurasia	127	131	132	134	133	132	5
Non-OECD	4,391	4,740	4,934	5,073	5,208	5,304	913
World	5,258	5,605	5,791	5,916	6,036	6,117	859

Source: UN.

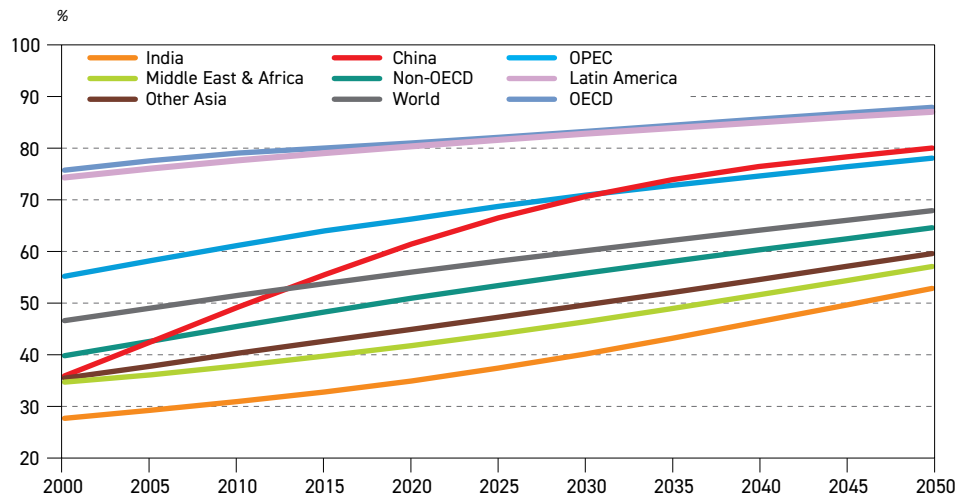
1.1.2 Urbanization

Urbanization, a critical driver of improved energy access, plays a pivotal role in mitigating energy poverty. As both economic development and energy consumption rise, urbanization becomes increasingly intertwined with these factors. In 2023, approximately 4.6 billion people, constituting over 57% of the global population, resided in urban areas (Figure 1.3). This represents a substantial surge from the 44% recorded just three decades earlier. Looking ahead, urbanization is projected to continue its upward trajectory across all regions, with an estimated 68% of the world's population – equivalent to around 6.6 billion people – expected to inhabit urban areas by the end of the outlook period.

In 2023, OECD and Latin America were the most urbanized regions globally, with over 80% of their populations residing in urban areas. Within the OECD, the Asia-Pacific region boasts the highest urbanization rate, reaching nearly 89%, closely followed by OECD Americas at 83%. Remarkably, the historical upward trajectory in urbanization is expected to persist, despite already elevated rates. By 2050, projections indicate that OECD and Latin America will achieve urbanization rates of 88% and 87%, respectively, while the OECD Asia-Pacific region is poised to surpass 92%.

The most incredible transformation in urbanization has been seen in China. At the beginning of the 21st century, its urbanization rate was at 36%, already up almost 10 percentage points (pp) from 1990. Alongside swift economic advancement in the economy, the rate had increased to almost 65% in 2023. However, as China's economy matures, urbanization is projected to proceed at a more gradual pace, culminating in an anticipated urbanization rate of 80% by the year 2050. India's experience of urbanization is very

Figure 1.3
Urbanization rate for selected regions, 2000–2050



Source: UN.

different to what has been witnessed in China. While China surged ahead with rapid urbanization, India's shift in its urban population remained measured, resulting in an urbanization rate of 36% by 2023. For the previous three decades, India has consistently had the lowest urbanization rate, and this is expected to remain true in the long term despite the urbanization rate accelerating to reach nearly 53%. Notably, urbanization in Other Asia mirrors India's trajectory throughout the projection period, albeit from a higher starting point.

OPEC Member Countries presently exhibit an urbanization rate of 68%, and this trajectory is poised to reach 78% by 2050. Notably, the Middle East & Africa region anticipates significant urbanization growth in the ensuing decades, transforming itself from a majority rural to a majority urban region. The urbanization rate is set to increase from 43% in 2023 to approximately 57% in 2050.

1.1.3 Migration

Migration represents a dynamic force within the landscape of demographic disparities at the regional level. Migration could help to offset population declines in some regions with low fertility rates, such as in many OECD countries, or support local economies by increasing the size of their working-age populations. Specifically, net migration, as seen in Table 1.3, quantifies the population change arising from the contrast between the UN's medium variant case and its zero migration case.

In the short term, net migration figures are markedly influenced by geopolitical instability, leading to a considerable outflow of individuals from one region to another.

In both the medium and long term, net migration is expected to revert to historical patterns, characterized by a consistent influx of individuals relocating to OECD countries from non-OECD



Table 1.3

Net migration by region*millions*

	2023-2030	2030-2035	2035-2040	2040-2045	2045-2050
OECD Americas	10.5	7.0	7.0	7.1	7.1
OECD Europe	5.4	4.1	3.9	3.8	3.7
OECD Asia-Pacific	2.6	1.6	1.6	1.6	1.6
OECD	18.5	12.8	12.5	12.5	12.5
Latin America	-1.7	-1.0	-0.8	-0.7	-0.7
Middle East & Africa	-0.9	-3.4	-3.6	-4.2	-4.7
India	-3.7	-1.9	-1.9	-1.9	-1.9
China	-2.1	-1.1	-1.1	-1.0	-1.0
Other Asia	-14.2	-5.8	-5.8	-5.5	-5.2
OPEC	1.7	-0.4	-0.2	-0.2	-0.1
Russia	0.8	1.5	1.5	1.6	1.7
Other Eurasia	1.6	-0.7	-0.7	-0.6	-0.6
Non-OECD	-18.5	-12.8	-12.5	-12.5	-12.5

Source: UN.

regions. However, the trajectory of future migration will likely remain susceptible to evolving geopolitics and major world developments.

1.2 Economic growth

The global economic forecast, the analysis of key trends, challenges and opportunities, is pivotal to understanding future energy market developments. This comprehensive overview will provide insights as to the future trajectory of the global economy in the medium to long term.

Since 2019, the global economic landscape has undergone significant shifts. Prior to that, the world economy experienced a period of steady growth, albeit with increasing concerns over geopolitical uncertainties, slowing economic momentum in key regions and a trend towards global fragmentation that started to accelerate before the COVID-19 pandemic. The pandemic exacerbated these issues, plunging the world into an economic recession. Governments responded with unprecedented fiscal and monetary stimulus, but supply chain disruptions, labour shortages and rising inflation, resulting in a rapid monetary tightening in key economies from 2022 onwards, provided significant challenges. This was then compounded by geopolitical conflicts in Eastern Europe in 2022.

Considering these developments in recent years, it has become increasingly likely that the structure of the global economy will witness change, albeit gradually. The advanced economies will continue to account for a major part of wealth and income in the global economy and are expected to expand at moderate growth levels up to the end of the long-term horizon in 2050. Developing and emerging economies, however, are set to produce relatively higher growth rates during the outlook period, catching up not only on per-capita growth, but also in terms

of accumulated wealth. This trend will boost the influence of these economies within the global economy and impact future energy demand developments.

To accompany the economic outlook in this chapter that forms the basis for the Reference Case, an 'Equitable Growth' Scenario is presented in Chapter 7 to shed light on an alternative future based on higher economic growth.

1.2.1 Current situation and short-term growth

The global economic growth dynamic held up relatively well in 2023 given the rapid rise in key policy rates in major economies, the increasingly limited fiscal space, the rising global fragmentation and the consequences of geopolitical conflicts. This dynamic provides a sound footing for the years to come, although numerous challenges remain.

It is important to note, however, that economic momentum in various key economies has continued to see diverging trends. The US, India and, to some extent, Brazil surprised to the upside in 2H23, with stronger-than-expected growth rates. China and Russia recorded steady growth towards the end of the year. Nonetheless, the Eurozone and Japan, jointly representing almost 20% of the global economy, experienced declines in 2H23, although there are tentative signs suggesting a potential recovery in 2024.

While inflation stayed at relatively high levels during 2023, it has retracted from past year highs. While it is expected to continue retracting in 2024 and 2025, in most key economies it is set to remain relatively higher than that seen in the pre-pandemic years. An exception, so far, has been China, which experienced a deflationary trend in 2H23 and 1H24, but this dynamic is expected to normalize towards 2025 and beyond.

With these consumer price trends, monetary easing is anticipated to continue, albeit with ongoing tight financial conditions, particularly when compared to the pre-pandemic environment. In terms of pursuing less stringent monetary policies in the near term, India and Brazil have possibly more room to manoeuvre and, in China, the continuation of a more accommodative monetary policy is likely, at least in the medium term.

Although 2024 global economic growth is technically at its lowest level since the pandemic impacted recession of 2020, at slightly below 3%, growth in 2024 and 2025 is expected to remain resilient. Moreover, although challenges remain, additional upside to global economic growth beyond the current outlook is possible, particularly if inflation drops at a faster rate than currently anticipated. This would not only boost disposable income levels, but also prompt major central banks to consider relatively more accommodative monetary policies.

Furthermore, prospects for a more robust growth trajectory in Asian economies, predominantly India and China, have the potential to provide further impetus to global economic growth in both 2024 and 2025. In the case of China, in particular, there is upside potential driven by additional government-led stimulus.

Additionally, within the non-OECD group of countries, Brazil and Russia have the potential to surpass expectations with further improvements in domestic demand and external trade. Elsewhere, the expected steady growth momentum in the US throughout 2024 and 2025 could potentially accelerate, resulting in economic growth surpassing current expectations with a positive carry-over into the medium-term period.



1.2.2 Medium-term economic growth

The key trends in economic activity for the medium to long term as described in last year's WOO have broadly continued. Furthermore, it is evident that certain structural shifts are taking place, either caused or advanced by the impact of the COVID-19 pandemic. Therefore, the differentiation between pre-pandemic and post-pandemic trends seems even more relevant in this year's edition.

In the medium to long term, several significant trends are expected to shape the global economic outlook. Ongoing global fragmentation persists, posing challenges to international trade and cooperation. This fragmentation is compounded by expectations of higher inflation levels compared to pre-pandemic times, particularly affecting major economies like the US, the Eurozone and the UK. The resulting tight financial conditions, combined with high global debt levels from pandemic-era fiscal measures, may dampen the future economic growth dynamic.

Growing fiscal constraints, rising government income requirements driven by debt obligations and growing defense spending, among other factors, could lead to higher levies worldwide. These fiscal dynamics intersect with widening income and wealth disparities within and between nations, potentially fueling social tensions and necessitating income and wealth redistribution. Additionally, the shortage of skilled labour, exacerbated by stagnant or declining working-age populations in key economies, may offset productivity growth gains. Despite these challenges, advancements in artificial intelligence (AI) and robotics may contribute to improving productivity growth.

As short-term issues are expected to continue shaping the trajectory of the medium-term economic growth dynamic, the following major assumptions are taken into consideration for the Reference Case.

Inflation is expected to witness a gradual further drop in the coming years and then normalize towards the end of the medium-term period. While global inflation stood at more than 6% in 2023, the level is expected to retract to stand at above 4% in 2024 and then move to around 3% in 2025. From 2025 onwards, the medium-term inflation path is anticipated to see a gradual slowdown, reaching 2.5% by 2029.

As inflation retracts, monetary policies are expected to become relatively more accommodative in key economies, the exception being Japan, which has a diverging monetary policy path compared to the rest of the major economies. Outside of Japan, interest rates are forecast to peak in 2024, followed by gradual monetary easing from 2025 onwards. While key policy rates are set to gradually normalize in most key economies from 2024 onwards, an additional focus of monetary policy will be on reducing balance sheets. Global liquidity remains very high, but is expected to be reduced, with this forecast seeing a gradual and transitory dynamic in the normalization of monetary policy tools.

In the OECD, **interest rates** are expected to be lowered from 2024 onwards. As Japan has maintained a considerably more accommodative monetary policy stance in past years, expectations suggest a shift towards a tightening of its key policy rate in the upcoming years, although it is projected to stay modest, likely at around 1% until the end of the medium-term period. Interest rates in major emerging markets are expected to stay at relatively higher levels throughout the period, but in these economies, there is flexibility to lower interest rates amid an anticipated drop in inflation, or given the already very low inflationary levels, as seen in China.

With regards to current **geopolitical developments**, assumptions are challenging to make, although, in general, geopolitics are not anticipated to significantly impact growth momentum. It is, however, obvious that the resolution of conflicts could yield higher regional and global growth.

In connection with inflation and interest rate trends, **debt-related** challenges in various economies will need to be closely monitored. While global debt levels seem to be relatively well-digested to date, expanding debt levels, in combination with the recent financial tightening across the world, may cause challenges going forward. Global debt rose by over \$15 trillion in 2023, following a decline of around \$7 trillion in 2022, according to the Institute of International Finance. This development lifted global debt to a new record high of \$313 trillion. Approximately 55% of this increase came from developed markets, primarily driven by the US, France and Germany, according to data from the Institute. In emerging markets, the bulk of the accumulated debt was concentrated in China, India and Brazil.

Going forward, no major dislocation from this situation is assumed in the outlook, but it is clear that some highly indebted economies may face potentially mounting issues, of which fiscal constraint would be only a minor one. Moreover, some countries could potentially face default in the medium term.

In periods of elevated debt, various types of taxes, such as those on assets, capital gains, property, top-tier incomes and corporate earnings are often increased to pay for rising debt services and/or to mitigate debt levels. More environmental taxes are also expected to be introduced in the coming years, particularly in developed economies. Rising tax levels could also occur due to widening income and wealth gaps, especially in advanced economies, which may lead to the introduction of further taxes geared towards the wealthier parts of society.

In the medium-term outlook, however, it is assumed that potential **tax** hikes do not hinder the global economic dynamic as additional taxes are foreseen to be well-directed. Nonetheless, the introduction of further taxes could impact certain growth aspects, but this is expected to be on a minor scale.

Additionally, the transfer of taxes from one part of the economy to another could support the growth dynamic, if not entirely used for repaying rising debt services. If taxes on consumers and middle and lower income groups increase, a more substantial inhibiting effect on GDP growth could become evident.

In this context, regions or domestic inequalities within economies could be successfully managed via multilateral cooperation, redistribution efforts or other policy measures.

The trend of global **fragmentation** is expected to continue, which could lead to a gradual dampening effect. Global trade is forecast to become more regionally segmented, with a steady increase in interactions between the three main trading hubs established in recent decades. One is the US-centred trade region of the Americas, dominated by North America. Another is the European region, with its dominant forces of Germany, France and the UK, while the third is the Asian region, centred on China, India and Japan. Trading within South America is likely to increase over the medium term too, with rising regional engagements led by Brazil and anticipated improvements in Argentina.

As in the assumptions seen in previous years, it is important to note that emerging and developing economies are forecast to outgrow advanced economies in the medium term.

However, some of these economies will likely see growth rates levelling off, or even gradually decelerating, amid maturing domestic economies, particularly in China.

Another important element related to economic growth is productivity. In advanced economies, in particular, productivity was in decline in the pre-pandemic years. While current forecasts anticipate productivity gains to remain low, the current severe staff shortages, in combination with the drive towards digitalization, may lead to a pick-up in productivity growth.

The effective utilization of new technologies and robotics, including AI, could potentially provide a significant boost to productivity growth, particularly in industrial production and the services sector. There are also challenges associated with such potentially significant productivity improvements, such as how to best utilize human resources that could be idled, and how to best avoid social conflict.

Taking into consideration the above-mentioned economic factors, GDP growth in both 2024 and 2025 is forecast at a rate of 2.9%. Thereafter, growth is anticipated to continue rising towards the medium-term growth potential of around 3.2%, supported by a gradual recovery in both the OECD and non-OECD. Emerging economies will likely experience a maturing growth trend, relative to advanced economies, and this trend is expected to continue in the long term.

Table 1.4

Medium-term annual real GDP growth rate

% p.a.

	2023	2024	2025	2026	2027	2028	2029	Average 2023–2029
OECD Americas	2.4	2.0	1.8	1.9	2.0	2.0	2.1	2.0
OECD Europe	0.8	0.9	1.3	1.7	1.8	1.8	1.7	1.5
OECD Asia-Pacific	1.7	1.0	1.3	1.4	1.4	1.4	1.4	1.3
OECD	1.6	1.4	1.5	1.7	1.8	1.8	1.8	1.7
Latin America	1.8	1.2	2.2	2.3	2.3	2.4	2.4	2.1
Middle East & Africa	2.7	2.7	3.1	3.3	3.4	3.4	3.4	3.2
India	7.7	6.6	6.3	6.4	6.4	6.4	6.5	6.4
China	5.2	4.9	4.6	4.6	4.6	4.5	4.5	4.6
Other Asia	3.6	4.1	4.1	4.5	4.6	4.6	4.6	4.4
OPEC	2.0	2.8	2.8	2.9	3.0	3.0	3.1	2.9
Russia	3.6	3.1	1.5	1.3	1.3	1.4	1.4	1.7
Other Eurasia	3.7	3.0	3.0	2.7	2.6	2.5	2.5	2.7
Non-OECD	4.3	4.1	4.0	4.1	4.2	4.2	4.2	4.1
World	3.1	2.9	2.9	3.1	3.2	3.2	3.2	3.1

Source: OPEC.

Economic growth by region

Despite the rapidly rising interest rates of 2022 and 2023, **OECD** economies, and particularly OECD Americas, with the US as the region's growth engine, are expected to do better than expected in 2024, when compared to original expectations. However, OECD America's growth is anticipated to slow in both 2024 and 2025, before rebounding towards the end of the

medium-term period. While OECD Europe is anticipated to show relatively lower growth than the other two OECD sub-regions in 2024, it is expected to see a further rebound in 2025. This will be supported by an anticipated improving global industrial sector and its positive impact on European exports. OECD Asia-Pacific is expected to witness a slowdown in 2024, followed by a stagnant growth trajectory over the medium term. The OECD is expected to see growth of 1.4% in 2024, rising to 1.5% in 2025 and then 1.8% at the end of the medium-term period in 2029.

While **OECD Americas** was supposed to be particularly impacted by the interest rate regimes of the US Fed and the central bank of Canada, the growth dynamic turned out much better than expected in 2023, with a consequent carry-over into 2024. Growth in 2024 is expected to stand at 2.0%, with only a minor retraction to 1.8% in 2025. Beyond 2025, growth is expected to continue rising to 2.1% in 2029. A major positive effect from 2024 onwards is set to come from monetary easing as inflation is expected to retract significantly over the medium term. On the flip side, very high US debt levels, in combination with any sustained high interest rate regime, could challenge the growth momentum.

OECD Europe's growth is expected to be impacted by continued high interest rates, although inflation has been retracting since 2023 and a more accommodative monetary policy is anticipated in 2024. In addition, the conflict in Eastern Europe and its outcome, as well as its ripple effect on both Europe's energy supplies and energy prices, has continued to impair economic developments. This is anticipated to impact the growth trajectory, at least at the beginning of the medium-term period. Moreover, debt-related issues in some EU economies, particularly those in Southern Europe, may re-emerge at a time of continued high interest rates and low GDP growth. Positively, however, interest rates are anticipated to be lowered by the ECB over the medium-term period, given that inflation is expected to recede from 2024 onwards. This dynamic is set to result in growth rebounding from 0.9% in 2024 to 1.3% in 2025 and 1.7% in 2029.

In **OECD Asia-Pacific**, Japan is expected to witness a relatively stagnant medium-term growth dynamic. The region's major trading partner, China, also provides helpful guidance for future growth, given its importance as a customer for input goods from OECD Asia-Pacific economies. China is set to see a trend of slowing growth, while OECD Asia-Pacific's other important group of trading partners, the G7 economies, are expected to accelerate. Monetary stimulus is anticipated to taper off in most OECD Asia-Pacific economies, but the Bank of Japan's monetary policy is expected to remain relatively more accommodative, particularly when compared to its G4 central bank peers in the US, Eurozone and the UK. For OECD Asia-Pacific, growth is set to stand at 1.0% in 2024 and 1.3% in 2025. A growth level of 1.4% is then set to be maintained up to the end of the medium-term period in 2029.

Medium-term growth in **non-OECD** countries remains relatively strong, with a diverse growth trend. While non-OECD in total is somewhat plateauing, the growth trend is very much impacted by slowing growth in China, while most other economies are at least seeing gradual medium-term expansion.

India is anticipated to see a gradual rise in GDP growth from 2025 onwards and is set to keep a steady and high growth dynamic. Moreover, other Asian regions, as well as Latin America and the Middle East & Africa, are expected to see GDP levels expand over the period. This is driven more by the anticipation of improving domestic activity in these economies than by external factors. In this respect, high population growth will play a pivotal role, an aspect



that will be especially relevant in the longer term. The non-OECD is expected to see growth of 4.1% in 2024, declining slightly to 4.0% in 2025, before climbing to 4.2% at the end of the medium-term period.

In **Latin America**, the two major economies, Brazil and Argentina, will likely shape the growth pattern. Brazil is expected to continue to benefit from fiscal reform and selective governmental support measures. With inflation set to decelerate further, the impact of a more accommodative monetary policy should provide additional support to medium-term growth. Argentina still has to deal with a number of fiscal challenges, at least at the beginning of the medium term, but the introduction of a number of policies by the new administration may accelerate the recovery. However, considering the country's high debt levels, Argentina has limited fiscal space in which to manoeuvre. Growth in Latin America is expected at 1.2% in 2024, 2.2% in 2025 and 2.4% at the end of the medium-term period.

In the **Middle East & Africa**, medium-term growth is expected to rise from 2024 onwards. This is supported by the anticipation of ongoing steady commodity demand, growing regional trade, a rise in domestic demand and an expansion in the middle class. Additionally, the continued expansion in global growth is expected to increase foreign investment into the region. Growth in the Middle East and Africa is expected at 2.7% in 2024 and 3.4% in 2029.

China is expected to witness a slightly decelerating growth rate of 4.9% in 2024 and 4.6% in 2025. The economy's growth is expected to remain relatively stable over the course of the medium-term. While challenges in external trade are expected to remain in the medium-term, domestic demand is set to gradually pick up. Furthermore, the central government is anticipated to counterbalance any deviation from the government's growth target. Growth is expected to retract slightly to stand at 4.5% in 2029 at the end of the medium-term.

India's growth is forecast to see some acceleration from 2025 onwards. The economy is set to benefit from the country's population growth, a rising middle-class and major infrastructure projects over the medium-term. An ongoing deceleration of inflation and the expectation of a consequent accommodative monetary policy is set to provide further support to medium-term growth. India's growth is expected to stand at 6.6% in 2024, 6.3% in 2025 and 6.5% in 2029.

Other Asia is expected to see relatively robust medium-term growth. In 2024 and 2025, growth is expected at 4.1%. Growth is then set to accelerate and by the end of the medium-term period it stands at 4.6%.

The **OPEC** region is supported by continued diversification efforts, an expanding and relatively young population, rising domestic economic activity and steady commodity market growth momentum. Growth is expected to stand at 2.8% in both 2024 and 2025 before reaching a level of 3.1% in 2029.

In **Eurasia**, Russia constitutes the most important economy, where growth has been impacted by geopolitical issues, including the associated effects of sanctions. However, Russia has overcome these external challenges much better than originally expected by most observers, and a steady growth trend with likely further structural changes may continue to positively impact the economy. Russia's growth is expected to decelerate from an exceptionally high 3.1% in 2024 to stand at 1.5% in 2025. However, it will continue to witness a steady growth dynamic, thereafter, with a rate of 1.4% expected in 2029.

Other Eurasia is set to see a decelerated growth rate over the medium term. Growth is set to stand at 3.0% in 2024 and 2025, and be at a level of 2.5% in 2029.

1.2.3 Long-term economic growth

This year's WOO embraces a traditional approach to economic growth modeling, centered on robust analysis of current global economic fundamentals and drivers. Yet, it also takes into consideration the unfolding chain of global events and their potential to impact the global economy and energy industry, potentially even resulting in transformative shifts.

With the fragmentation of the global economy into regionally powerful blocs, a pattern of decentralized economic centres of gravity is emerging. This shift does not imply a collapse of the existing system, but rather a reorientation of the global economy towards a multipolar system.

This multipolar world order is emerging along with changing dynamics in international organizations such as the World Trade Organization (WTO). Additionally, bilateral and regional free trade agreements are proliferating, which is strengthening regional economic integration. Examples include Mercosur in Latin America, the Gulf Cooperation Council (GCC), the Association of Southeast Asian Nations (ASEAN) and the Regional Comprehensive Economic Partnership (RCEP). Moreover, the ascent of BRICS nations further underlines the diversification of global economic power centres.

In this context, it is assumed that there will be no further escalation of the conflict in Eastern Europe, nor any spillover into neighbouring economies. It is further presumed that the geopolitical flashpoints witnessed in 2023 and 2024, including those in the Middle East and Latin America, will be effectively contained. Moreover, there is an assumption that no new geopolitical conflicts will emerge, especially involving major global economies, which could have significant and far-reaching impacts on the global economy and energy markets.

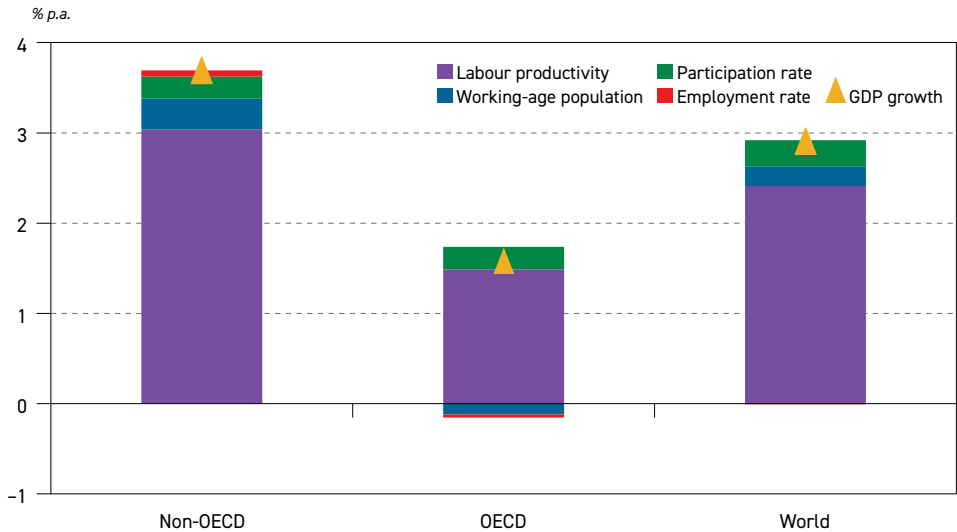
Among other developments that may affect the long-term trajectory of the global economy, the US-dollar is poised to remain the primary global reserve currency, but more transactions are likely to occur outside the US-dollar system. This trend will gradually open space for alternative currencies to take on larger roles in global trade. Countries closely tied to China may increasingly adopt transactions in Renminbi, as China seeks to globalize its currency. The Euro is expected to maintain its significance as an alternative reserve currency too. However, the development of projects that aim to create regional cross-border unified currencies may face obstacles as the global economy becomes more competitive.

Additionally, technological advancements are poised to impact labour productivity, which is a vital component of economic growth (Figure 1.4). AI, in particular, represents a new wave of productivity. AI represents a new wave of productivity enhancement akin to previous technological advancements, such as robotics, automation and semiconductors. Its implementation is expected to enhance workforce capacity and efficiency. This is particularly important in economies where the additions of labour productivity are plateauing with the high levels of technological penetration in workplaces. AI will likely provide new room for expanding labour productivity with additional technological capabilities.

While technological advancements, such as AI and automation, can lead to an increase in labour productivity, they also generate labour market challenges. These could include rising societal upheaval due to heightened inequality, social unrest and high levels of



Figure 1.4
Long-term GDP growth rates by components, 2023–2050



Source: OPEC.

transitional unemployment as seen historically in the transition from agricultural to industrial economies. The AI revolution is expected to contain some elements of this kind of transition.

Many service sector roles are threatened by the widespread usage of AI in diverse fields such as medical imaging, video editing and tax accounting. The concern lies not in the complete elimination of jobs within these sectors, but rather in the diminishing requirement for human labour to meet demand. Similarly, in agriculture and manufacturing, technological innovations have significantly reduced the need for human employment relative to output demand. While the first wave of computing penetration in the workplace threatened standardized and repetitive tasks, the widespread adoption of AI could soon threaten jobs previously considered too creative to be performed by machines. This significantly widens the scope of tasks and jobs that can be replaced by AI and magnifies the impact on productivity and labour markets.

Simultaneously, many service jobs remain relatively insulated from AI disruption due to hardware limitations. Despite the long-standing technological capability to automate service processes, such as restaurant operations, the widespread adoption of fully automated models has been hindered by prohibitive costs associated with equipment installation and maintenance. Consequently, many service jobs are unlikely to face an imminent threat from AI-driven automation. This is primarily due to the economic inefficiency of investing in mass-produced machinery, particularly in resource-constrained environments where human labour remains cost-effective and adaptable to diverse tasks.

At the same time, highly skilled jobs will likely leverage AI to augment productivity, while occupations in the trades and creative industries may remain resilient. This trend exacerbates income polarization and inequality, with supervisors experiencing upward mobility, while displaced workers are pushed downward.

Despite the challenges, AI adoption promises quality of life improvements by reducing the necessity for human labour to achieve high growth and productivity. This alleviates pressure on increasing retirement ages, a necessity in ageing populations, particularly in the developed world and China. Globally, the gap between advanced and developing economies is expected to persist, driven by varying growth rates and demographic shifts.

Rising inequality is particularly evident in major economies fostering discontent with political systems. Increased polarization within countries can lead to large swings in trade barriers as different administrations adopt opposing policies. This further reinforces protectionism and economic fragmentation.

As national barriers rise and regional hubs grow, migration will be an issue that many countries face. Causes ranging from food insecurity, weather-related crises and regional conflicts that could trigger mass migration and generate cross-border political tensions (see section 1.1.3).

Similarly, the potential transformations in energy systems could have profound implications for economies worldwide. While the move towards alternative energy gains momentum, particularly renewables, a pivotal and growing discourse centres around the role of fossil fuels in a sustainable energy framework. This discourse is fueled by heightened concerns over energy security and the stark disparities in economic development, especially among emerging economies. This evolving narrative underscores the urgent need to strike a delicate balance between environmental imperatives and the economic realities of energy security, energy availability and economic development. It calls for innovative, sustainable solutions that cater to the needs of all stakeholders.

One possible significant consequence of these economic and technological shifts is the likelihood of prolonged higher inflation. The low inflation rates witnessed since 2000, attributable to advancements in global supply chains and technological improvements, may give way to increased prices as countries prioritize security over efficiency. Supply chain vulnerabilities may prompt countries to consider localized production, redundancies and reshoring, thereby raising costs. Higher rates of inflation will, in turn, likely spur an era of higher interest rates as the norm. As the factors that held inflation down, namely globalization, fade out, an era of higher interest rates will ensue.

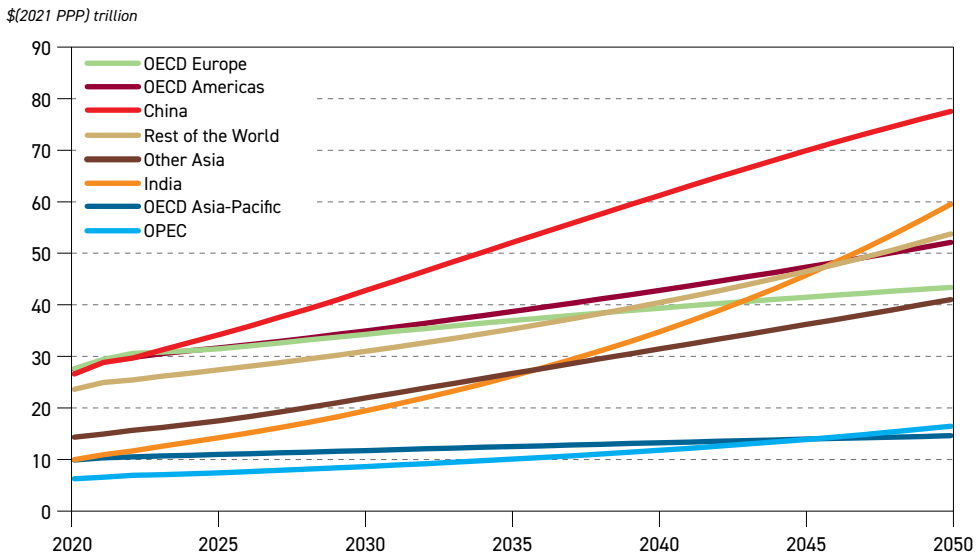
Moreover, the slowing transfer of knowledge due to the retreat from globalization could impede economic growth, particularly in emerging economies reliant on knowledge transfer from advanced economies.

The high level of uncertainty in long-term forecasts comes not only from technological variables, but also from policies adopted by government leaders. Adopting different responses to rising inequality gaps, for example, with generous redistributive policies, could result in higher social cohesion and less economic uncertainty, but potentially at the expense of a less dynamic entrepreneurial class. More robust support for international frameworks and more inclusion of underrepresented rising economies could re-energize international institutions. This could provide new avenues for cooperation and sustain strong levels of global trade.

Global GDP between 2023 and 2050 is expected to remain strong and increase at an average rate of 2.9% p.a. As with previous editions of the WOO, this view takes into account the

increasing economic risks, uncertainty around inflation and interest rates, high debt levels and geopolitical tensions. Non-OECD countries dominate the growth forecast through 2050 where growth is forecast at 3.7% p.a. This is due to improving labour productivity, a growing working-age population and further technological penetration. OECD countries are expected to grow at a slower rate of 1.6% p.a. Figure 1.5 shows the size of regional economies in absolute terms. Overall, the global economy is expected to more than double in size in absolute terms from \$165 trillion in 2023 to \$358 trillion in 2050 (in 2021 PPP).

Figure 1.5
Size of major economies, 2020–2050



Source: OPEC.

OECD Americas is the fastest growing region within the OECD at a rate of 2.0% p.a. from 2023 to 2050 as shown in Table 1.5. This takes into account the effects of potentially higher inflation rates and higher interest rates at the beginning of the period. However, after strong growth rates seen in the US in the short term, there are signs of continued robust growth. Immigration is set to support expansion in the working-age population, and AI will likely provide a new wave of labour productivity growth.

OECD Europe is expected to experience a slowdown in growth from 1.5% p.a. from 2023 through 2029, to 1.4% p.a. from 2029 through 2040, and then 1.0% from 2040 through 2050. The decline in the labour force is the strongest contributor to this trend. The overall slowdown within the economy is due to high inflation and interest rates, as well as increased competition from other regions in the world.

OECD Asia-Pacific is expected to follow a similar pattern with a momentum slowdown. China, the region's largest trading partner, plays a major role in this process. A declining labour force due to an ageing population and a continued maturation of the economy will further this trend. However, labour productivity is expected to increase and sustain growth rates of 1.2% p.a. from 2029–2040 and 1.0% p.a. from 2040–2050.

Table 1.5
Long-term annual real GDP growth rate

% p.a.

	2023–2029	2029–2040	2040–2050	2023–2050
OECD Americas	2.0	2.0	2.0	2.0
OECD Europe	1.5	1.4	1.0	1.3
OECD Asia Pacific	1.3	1.2	1.0	1.2
OECD	1.7	1.7	1.4	1.6
Latin America	2.1	2.2	1.7	2.0
Middle East & Africa	3.2	4.1	4.9	4.2
India	6.4	6.0	5.5	5.9
China	4.6	3.7	2.4	3.4
Other Asia	4.4	3.7	2.7	3.5
OPEC	2.9	3.1	3.4	3.2
Russia	1.7	1.4	1.1	1.3
Other Eurasia	2.7	2.4	2.1	2.4
Non-OECD	4.1	3.8	3.3	3.7
World	3.1	3.0	2.7	2.9

Source: OPEC.

Latin America is expected to grow at 2.2% p.a. between 2029 and 2040, lifted by expanding commodity and agricultural sectors, and by increased workforce participation. Brazil's long-term growth will likely be constrained by ongoing elevated debt levels and insufficient savings. However, tax system reforms and a robust and dynamic energy sector in Brazil is set to help boost growth, and medium-term structural reforms are expected to be a major factor for growth in the latter years of the long term. In the last decade of this analysis, a shrinking working-age population is expected to slow growth potential.

In the **Middle East & Africa**, growth is estimated to average 4.2% p.a. from 2023 to 2050. A large working-age population and rising income levels are set to help boost consumption rates. Growth outside of the region is expected to increase demand for commodities, providing stable support for growth. The main challenge will be diversification and enhancing the non-commodity sector. This will require more investments and government spending on infrastructure and education. The region's demographics will support the establishment of manufacturing hubs and further industrial expansion. However, rising debt levels and volatile inflation pose a downside risk.

Growth in **China** is expected to gradually decelerate through 2050, averaging 3.4% p.a. over the outlook period. Government support for the economy is expected to transition from infrastructure-heavy spending to boosting middle class income to sustaining a consumption-based growth model. This transition will potentially be limited by declining demographics. The main challenge is the high household savings rate, which is currently at around 35% and does not support strong consumption. Lowering household savings is a difficult challenge for the government and will require not only raising income levels, but also increasing social safety nets to lower excessive emergency cash holdings. Households with access to a robust and guaranteed healthcare system, for example, are less likely to require cash savings for emergencies.



By the last decade of the outlook period, China is expected to approach growth levels of around 2.4% p.a. The population decline will be the major source of the slowdown, but improving education and health levels will allow for increased productivity amid this trend.

India is set to be the world's fastest growing economy through the outlook period, expanding at an annual average of 5.9% from 2023 to 2050. Benefitting from strong growth in the medium term, the growth rate is expected to remain at 6.0% p.a. from 2029–2040 and then at 5.5% p.a. from 2040–2050. This growth rate comes on the back of strong support from demographic trends, as the country continues to see growth in the population and labour force.

Combined with improvements in education, healthcare and expanding urban centres, India is set to potentially unlock new growth areas throughout the outlook period. This potential for strong growth in India assumes government support, albeit at a gradually declining rate for key industries such as IT, pharmaceuticals, manufacturing and communications technology. Additionally, the growth of large consolidated multinational corporations in India is expected to provide the foundation for dynamic research and development, especially in technologically driven sectors. At the same time, the services sector is set to grow and continue to be the largest contributor to GDP, lifted by an expanding middle class.

In **Other Asia**, growth is expected to average 3.5% p.a. through 2050. Growth rates will likely peak in the medium term at 4.4% p.a. and then decelerate to 3.7% p.a. from 2029 to 2040 and 2.7% in the last decade of the forecast. Even though some countries in the region are expected to see high growth rates, particularly in Southeast Asia, large countries in the region are anticipated to see a slower pace of growth. The region's economies are also closely linked to China, and the slowdown there will have spillover effects on regional growth. There is room for the upside, however, as many countries could become new centres of manufacturing in the wake of rising incomes in China and given its unfavourable demographics.

Russia's economy overcame the challenges of sanctions faster and has proven to be more resilient than most observers initially expected. This resilience will likely continue in the long term as it initiates a new technological investment cycle, reorients trade flows and deepens structural reforms focused on re-industrialization. There is great potential for economic transformation with the country's highly educated population, abundant resources and a growing productivity base.

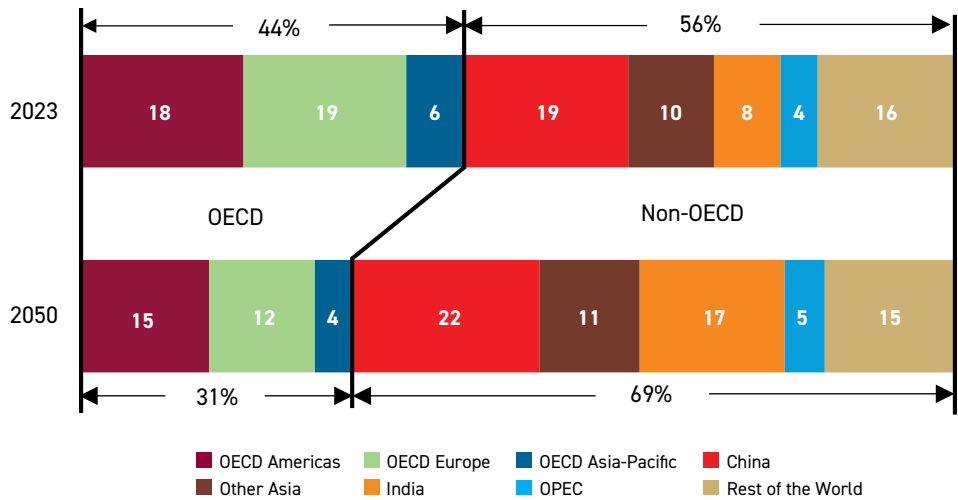
However, transitioning to a new economic growth paradigm presents significant challenges, including diversifying the economic base amidst ongoing security concerns and demographic shifts marked by an ageing population and a declining workforce. As a result, Russia is expected to sustain a medium-term growth rate of 1.7% annually in the initial decade of the forecast period, with a projected slowdown to 1.1% annually in the last decade due to demographic trends.

Other Eurasia is expected to grow by 2.4% p.a. from 2029–2040 and by 2.1% p.a. from 2040–2050, supported by improving labour productivity and a slight increase in the working age population.

The higher **non-OECD** growth rates are set to increase the region's share of the global economy from 56% in 2023 to 69% in 2050 (Figure 1.6). India is expected to see the largest increase in its share of the global economy, rising from 8% in 2023 to 17% in 2050. In absolute

Figure 1.6
Distribution of the global economy, 2023 and 2050

%

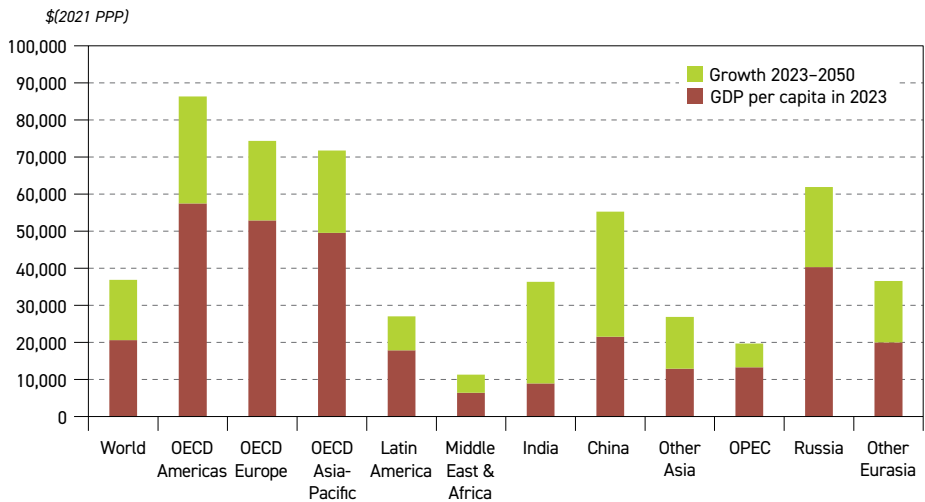


Source: OPEC.

terms, India is projected to add \$47 trillion to its GDP in this timeframe, a nearly fourfold increase. China is set to increase its share of global GDP from 19% in 2023 to 22% in 2050, corresponding to a \$46 trillion addition to its GDP.

Looking at GDP per capita (Figure 1.7), the gaps between advanced and emerging economies are narrowing, but they are still significant. China and India are the strongest growth regions by GDP per capita. China's continuing growth, alongside a declining population, makes GDP

Figure 1.7
Real GDP per capita in 2023 and 2050



Source: OPEC.



per capita an even stronger factor. India, on the other hand, is still projected to witness population growth through 2050, but the robust growth rate will factor into GDP per capita growth.

The global average income is projected to rise from roughly \$20,600 (2021 PPP) in 2023 to \$36,800 (2021 PPP) in 2050.

The Middle East & Africa (excluding OPEC) is expected to more than double its GDP, with the population growth rate similar, albeit slightly lower. The addition of GDP per capita in this region is expected to marginally increase, but remain low relative to other regions. This leaves the Middle East & Africa with GDP per capita at around \$11,300 by 2050.

In the OECD countries, declining populations increase the effect of even minor GDP growth rates when measured per capita. In OECD Americas, robust growth levels are set to push GDP per capita to around \$86,000, while OECD Europe and OECD Asia-Pacific reach close to \$72,000 by 2050.

1.3 Energy policies

Energy security as a priority

In the last few years, it has become clear that the idea of the world undergoing a singular energy transition does not match with the realities on the ground. It is now evident that talk among decision makers across the globe is of multiple energy pathways, reflecting the understanding that different countries, regions and even whole continents will evolve and navigate their own energy transitions that structurally impact their energy systems. A key factor in determining the outcomes of this, and the pace at which they occur, will be energy sector policies.

Thus, it is vital to consider the impact of enacted and proposed policies in projections of the future global energy sector. In the Reference Case for this year's WOO, enacted policies are examined in detail. While these policies are broadly expected to achieve their goals, a viability check considers their current progress, cost and implementation timeframe, to help provide a realistic picture of their potential impact on the energy system. In addition, the Reference Case assumes a continuous evolution of energy policies going forward.

Energy security concerns are likely to remain paramount for decision makers, especially as countries continue to face challenges and potential disruptions to energy supply in the near future. This is reflected in newly established policies and a greater importance being placed on domestic energy supplies. Addressing energy security, not only from the demand side, but also the supply side too, is key to a more sustainable and resilient energy future. For developed and developing countries alike, energy security is also crucial for market stability and affordability.

Evolving climate policies

After the release of the WOO 2023, the policy landscape for enhancing climate ambitions has continued to evolve, one that considers the complex interplay of urgent priorities, including energy security and the latest scientific evidence on different options for reducing global

emissions. Prospects concerning climate mitigation actions and emerging measures in energy systems were, therefore, reassessed in this year's WOO along with the energy policies of major economies and regions. Analysis relied on the key outcome of UN negotiations on climate change, as well as recent developments in climate diplomacy.

At COP28 in late 2023, Parties to the Paris Agreement convened in Dubai and reached consensus on a set of critical decisions known as the 'UAE Consensus.' These decisions relate to the outcome of the first GST under the agreement, a mitigation work programme aimed at scaling up ambition and implementation by 2030, and a work programme focused on just transition pathways to achieve the agreement's goals. Additionally, the 'UAE Consensus' confirms the establishment of a loss and damage fund, designed to assist developing countries particularly vulnerable to the adverse effects of climate change.

Completing a two-year process, the first GST culminated at COP28 as a milestone for the implementation of the Paris Agreement. Several technical reports released by the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat were considered during negotiations, including those for the GST's technical phase and the latest submissions of Parties' nationally determined contributions (NDCs). This showed that global emissions are not expected to increase after 2030, compared to 2019 levels, but progress in achieving the agreement's long-term goals is currently slow.

The IPCC synthesis report under its sixth cycle and a UNFCCC report on Parties' long-term low-emission development strategies (LT-LEDS) further indicated that full implementation of such strategies could lead to lower global emissions in 2050, compared to 2019 levels, yet many targets incorporated in Parties' submissions remain highly uncertain. In this context, the first GST outcome – with substantive aspects on mitigation, finance, technology and international cooperation, among others – is seen as a core juncture impacting the momentum on climate action.

The adopted outcome is expected to inform Parties as they develop their updated NDCs to set emission reduction targets for 2035. As captured in the subject decision, Parties are called to contribute to global efforts, in a nationally determined manner, taking into account their different national circumstances and following alternate pathways and approaches. The outcome makes clear that tackling climate change requires transformation across all sectors of the economy rather than any single sector. A key message that also emerged from this process is that the global climate change challenge cannot be addressed without considering an all energies, all peoples and all technologies approach.

A number of mitigation options were included in the outcome for Parties to consider, stressing the importance of strengthening the global response to climate change in the context of sustainable development and efforts to eradicate poverty. This involves adherence to the principles of the convention on equity and common but differentiated responsibilities and respective capabilities (CBDR-RC). Similar to previous COP decisions adopted in Glasgow and Sharm El-Sheikh, the call for accelerating efforts to remove unabated coal from power generation was reiterated, as well as for inefficient subsidies that do not address energy poverty or just transitions.

Moreover, a call for contributing to global efforts to triple renewables capacity and double the average annual rate of energy efficiency improvements by 2030 were included, further recognizing that the transformation of energy systems requires technological solutions.



There was also a call for the greater deployment of low-emission technologies, such as CCUS, as well as hydrogen.

Besides the COP decisions, diverse initiatives were launched on the sidelines of the negotiations, giving a sense of direction for accelerating international collaboration. These relate, *inter alia*, to reductions of methane emissions from oil and gas operations, a hydrogen certification standard, as well as partnerships for reducing cooling-related emissions and boosting nuclear energy capacity. In this context, climate action remains high on the political agenda, however, other fundamental factors could lead to a derailing of the momentum for the implementation of climate policies.

This relates primarily to developing countries' calls for developed countries to honour their historical responsibilities and fulfil their obligations in taking the lead on climate action and provide support to developing countries. There are ongoing calls for meaningful climate finance as a key enabler for the implementation of NDCs, and any NDC updates of developing countries will likely be affected by the availability of sufficient funding. With a low number of NDC submissions over the last year, there is also limited understanding on possible challenges developing countries are expected to face owing to outstanding finance gaps.

The implementation of any updated NDCs will therefore be impacted by the outcome of the ongoing debate on issues related to climate finance – including on the new collective quantified goal beyond the existing \$100 billion per year target that is set to conclude at COP29, in late 2024, in Baku. Progress on other negotiating issues concerning the operationalization of the Paris Agreement, such as mitigation ambition and just transition pathways, along with delays in the full implementation of cooperative mechanisms under Article 6 of the agreement could also affect climate action.

In light of the above, it remains to be seen how Parties may consider the GST outcome for updating their NDCs, and whether developed countries will mobilize adequate financial support to ensure developing countries have the resources needed to actually deliver their plans.

Developments in future energy policies

Energy policy ambition may remain high, but greater pushback and scrutiny of new energy policies on several fronts is anticipated as policymakers deal with a multitude of often divergent priorities and limited space for additional expenditure. The result is the potential for policy goals to be altered and, although individual effects from such changes on a per policy basis can be small, the cumulative effects on the demand for energy sources at a country or global level can be much more impactful.

As one of the most significant developments, the **electrification** of the energy system is expected to continue in the long term with supportive policy frameworks and regulations. The power sector is expected to continue to electrify with the deployment of renewable energy sources increasing. In the residential sector – another area generally considered to be 'low hanging fruit' – electrification should continue with supportive policies for heat pumps and residential scale solar panels.

One of the most dynamic sectors for electrification is the road transportation sector through the adoption of **EVs**. Sales of EVs have witnessed rapid growth, but the speed at which this

growth continues is not a given and challenges certainly remain. Policies limiting or outright banning the sale of ICE vehicles in the future or imposing tighter limits on vehicle emissions support the demand for EVs, however, there has been growing pushback as targets for the end of the decade come into view.

For instance, the UK announced a delay in September 2023 of its ban on new gasoline and diesel cars by five years to 2035, while the EU's new Euro 7 emission requirements were weaker than initially anticipated, tightening requirements on trucks and buses, but leaving passenger cars largely unchanged from Euro 6 levels. Recent protectionist policies that have led to tariffs on imported EVs in the US and EU will likely limit sales growth by denying consumers access to cheaper EV models.

The cost and ease of use for the consumer, who must be convinced to switch to an EV, will remain an important factor in the penetration of EVs. It should be noted that some recent reports underline the challenges facing EV expansion. For example, a 2024 McKinsey & Company presentation (Mobility Consumer Pulse) highlights that almost one in three EV vehicle owners are considering a switch back to a traditional combustion engine, with a variety of reasons offered, including difficulties with charging and the total cost of ownership.

At the same time, for vehicle manufacturers, business plans are continuously reevaluated to ensure adequate return on investment. Recently, there has been a delay from some manufacturers on their ambitions to offer only EVs to the market and some re-orientation of investments. Government subsidies have undoubtedly been a key growth enabler in EVs so far, but these expensive outlays should not be taken for granted, as seen in Germany at the end of 2023 when the government abruptly ended its subsidy programme to meet budget restrictions.

The concentration of the EV market in China, Europe and the US, where policy support and incentives are strongest, also leads to uncertainties in how the penetration of EVs into other markets will play out in the long term.

Another major energy demand driver in the long term is the **aviation sector**. This Outlook expects the effects of policies to be more muted in this area. While noting the efforts of the ongoing Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) from the International Civil Aviation Organization (ICAO), it is assumed that long-term targets for net zero carbon emissions will not be fully met. Similarly, ambitious aspirations for the role of Sustainable Aviation Fuels (SAF) in the sector, such as the EU target for fuel supplied at EU airports to comprise of 70% SAF by 2050, could potentially be too ambitious. As a result, the role of biofuels in the aviation sector will remain minor, while electricity and hydrogen are assumed to have no significant impact on global energy demand in the sector.

In the **power sector**, this WOO assumes a continued rollout of renewable energy sources. However, this is enabled by a decline in costs that improves the competitiveness of renewable energy, and the importance of this trend was made clear in 2023 when other factors made renewable energy projects less attractive.

Analysis also considers the goals of major economies, for example, the US government's aim to reach 100% carbon-free electricity by 2035, along with recent announcements such as that from the Environmental Protection Agency (EPA) to exclude existing gas power plants from emission reduction requirements, which will now only apply to newly built plants and coal power plants. Moreover, the latest report from China's National Development and Reform



Commission acknowledges the shortcomings in efforts to meet energy and carbon intensity targets, and states that coal will continue to play a crucial role in ensuring energy supply.

Uncertainties abound

One of the reasons that future pathways for energy policy looks so uncertain is given the number of elections in major economies in 2024, with battle lines between parties often including plans for environmental and energy policies. For example, the UK's Labour government lifted a de-facto ban on onshore wind almost immediately upon entering office. Certainly, the outcomes of elections across the year could potentially increase the complexity of climate diplomacy, alter the speed of energy transitions, or lead to a new pathways being followed, which could involve rolling back some policies.

The biggest uncertainty comes from the US election in November 2024, but the election of a new EU Parliament, which has so often been at the forefront of new energy policies, has the potential to alter trends. It is also noteworthy that the chief climate diplomats of the US and China are stepping down this year, which has the potential to impact upcoming negotiations, particularly given wider geopolitical tensions.

Such developments could affect international cooperation, creating additional challenges for overcoming financial constraints and responding to the needs of developing countries. For example, the Just Energy Transition Partnerships. This was set up to coordinate financial resources and technical assistance from countries in the Global North to a recipient country. South Africa and Indonesia have announced such partnerships to support their climate action, but there have been difficulties in terms of actual implementation and some question whether it can be considered as an effective solution.

1.4 Technology and innovation

This year's WOO incorporates a broad range of assumptions on the development of technology. In general, the WOO's Reference Case assumes a gradual evolution of technology with no sudden technology breakthroughs, the timing and impact of which are quite difficult to forecast. To explore an alternative future that could comprise a greater diffusion of carbon removal technologies in various sectors, investment in blue hydrogen production and distribution, as well as the increasing adoption of the circular carbon economy (CCE) platform across the global economy, a 'Technology-Driven Mitigation' scenario has been developed and is detailed in Chapter 7.

1.4.1 Road transportation

Basic technological advancements in road transportation will require further efficiency improvements and lower operational costs. In the Reference Case, ICEs are still predominant compared to other powertrains. The EV market is driven by an increase in sales (especially in China), however, EVs are still battling a number of significant challenges related to range and a reliable charging infrastructure, although improvements are expected over the long term.

Current ICE technologies are based on the same concept and gradually add efficiency over time while lowering operational costs. In the longer term, the enhancements of advanced engine technologies such as turbocharging or direct fuel injection are expected. Utilizing

those technologies in tandem with variable valve timing and cylinder deactivation could lead to a significant improvement in efficiency. Furthermore, this is also driven by the implementation of efficient transmission systems. Automatic transmissions already provide a higher degree of energy efficiency. This technology can be further improved using dual clutch transmissions. Other conventional technological advancements include lighter materials and better aerodynamics.

In terms of plug-in hybrid electric vehicles (PHEVs), innovation has been driven by improvements in the electric drive and regenerative braking, where the vehicle recycles excess energy and stores it in batteries. This advancement, paired with smart decentralized charging stations, will lead to major efficiency gains. The same principle applies to hybrid electric vehicles (HEVs). The combination of electric motors and conventional ICEs will drive the energy transformation.

The EV penetration of the global road transportation fleet is expanding. This development is supported by various technologies. However, immature technology usage and disruptions limit the positive effects. The EV segment is also expected to optimize its battery options. Instead of being limited to lithium-ion batteries, so-called solid-state batteries could help the sector improve its overall EV efficiency. This technology could increase range and decrease charging downtimes significantly. The charging infrastructure in the Reference Case in some regions is expected to enable the promotion of faster charging stations and smart charging systems to further increase the effectiveness of EVs.

1.4.2 Air transportation

Global aviation energy demand will continue to grow in the OECD and non-OECD regions during the outlook period to 2050. The aviation transportation sector remains one of the most difficult sectors to decarbonize using technology. While each new generation of aircraft offers efficiency gains through design enhancements, improvements are not large enough to nullify the increasing demand for air travel. Moreover, with the average aircraft lifespan being over 20 years, improvements are not implemented often enough. This also means that fundamental re-designs of aircraft, away from the 'tube and wing' form to the 'blended wing body', are not anticipated in this outlook. The emission challenge is further addressed by the integration of SAF, offering a potent solution to reduce carbon emissions significantly when applied in tandem with technical advances in air transport and aircraft technology.

This WOO considers several potential improvements in SAF and in the materials utilized in the aviation transportation sector. In their long-term global aspiration goal (LTAG) to reach net zero by 2050, the International Air Transport Association (IATA) and the ICAO emphasize that SAFs have the potential to drastically reduce CO₂ emissions by 80% throughout their lifecycle in the aviation sector. In a recent pilot project, the airline Emirates completed the first Airbus A380 double decker flight operating solely on SAFs.

Current SAF technologies allow fuel production from sustainable feedstock, like biomass, cooking oil or waste. What is more, CO₂ captured from the air and combined with hydrogen can be employed as a synthetic pathway to produce SAFs. In general, the production of SAFs still lacks efficiency and requires technological improvements in the conversion process from feedstock to SAF. The optimization of the production process uses approaches like hydro-processed esters and fatty acids, in which the oxygen molecules are removed. This results in the production of hydrocarbons that are similar to conventional jet fuel.



Another method applies the Fischer-Tropsch Synthesis where carbon-containing materials like biomass are transformed to liquid hydrocarbons through gasification. Followed by catalytic synthesis, this process yields various fuel components, including SAFs. The third option is defined by the alcohol-to-jet production pathway in which alcohols such as ethanol are converted into olefins by dehydration resulting in SAFs as one of the end products.

1.4.3 Marine transportation

Alternative fuels define one of the major technological advancements in the maritime shipping sector. Taking liquified natural gas (LNG) as a cleaner alternative to conventional maritime fuels leads to a reduction in sulphur and nitrogen oxides, as well as CO₂ emissions. Expanding on alternative fuels, hydrogen and ammonia are also emerging alternatives to traditional fuels. Hydrogen offers intensified green features, whereas ammonia can be utilized to power engines or fuel cells.

As for current technological advancements, electric and hybrid propulsion systems are rising in popularity, especially for short sea hauls and inland waterways. These methods are heavily reliant on battery storage. The symbiosis of propulsion systems and battery technology makes these systems more viable and contributes to lowering emissions and reducing underwater noise. On the development front, technological advancements are captured by hydrogen fuel cells and the transition and development of modular fuel cell systems. These can be easily integrated into current maritime shipping technologies, resulting in reduced retrofitting.

The introduction of wind and solar energy into the maritime shipping sector supports traditional propulsion systems. New wind technologies introduce rotor sails and kites to harness wind energy, leading to a significant fuel efficiency improvements for long haul trips. Solar panels provide additional energy for onboard systems. Adding batteries to the mix enhances energy management and ensures a continuous power supply to the vessel. So-called cold ironing uses shoreside electricity to power auxiliary systems when the vessel lays on the dock, leading to lesser pollutants in the port area.

Another major driver of technology involves the potential use of CCUS on large vessels. New CCUS solutions allow for the capturing of CO₂ emissions on board, storing it on the ship and then discharging it in the port. A large part of a ship's CO₂ emissions can be stored without additional energy usage as waste heat can be used for this purpose.

Lastly, innovations in advanced ship design play an important role in the maritime shipping sector when it comes to energy efficiency. The optimization of the current design of a ship's hull supported by the application of lightweight materials not only reduces water displacement, but also improves hydrodynamic efficiency, leading to improved fuel economies and a reduction of emissions.

1.4.4 Conventional and renewable power generation

Coal

Within the scope of electricity generation, coal still represents a major share of the generation mix as a conventional energy source, especially in developing and emerging economies. Despite the technological advancements in improving efficiency, coal-fired power generation

plants are still scrutinized for their high CO₂ emissions. Current developments show that state-of-the-art technologies tend to minimize fuel and water consumption, as well as emissions. These effects are achieved by utilizing low-carbon fuels in current coal power generation units and by installing CCUS in existing coal-fired power plants.

By utilizing more efficient technology, coal-fired power plants have evolved from so-called supercritical power plants with an efficiency of 45% to advanced ultra-supercritical coal power plants pushing efficiency to a level of nearly 50%. The implementation of CCUS has the potential to reduce CO₂ emissions of coal-fired power plants by nearly 90%, but only a handful of plants currently utilize this technology at the moment. If coal does remain an important provider of energy in many countries in the future, the implementation of CO₂ removal technologies is vital to achieving climate goals.

Gas

Electricity generation demand from natural gas has increased considerably in recent decades. Combined cycle gas turbines are among the main technologies enhancing overall efficiency, with a combination of gas and steam turbines converting 60% and even more of the gas into power. Within this process, the waste heat is captured and utilized to produce more power, leading to improved efficiency and emission reductions. Adding CCUS to gas-powered plants leads to a notable drop in CO₂ emissions with a reduction of the overall efficiency because of increased energy requirements for the CCS process.

Nuclear

Technological innovations and advancements in nuclear energy are focused on improving safety and efficiency. This includes the introduction of advanced reactor designs. Some technologies utilize molten salt, hot gas or liquid metals. These reactors also include state-of-the-art safety features like automatic shutdown. Additionally, their efficiency is increased as they are designed to operate at higher temperatures. These reactors could support low-carbon systems by 2030.

The development of small modular reactors improves nuclear power plants by offering a distinct improvement in build time and operational flexibility. These reactors can ensure reliable energy production and grid stability. Their modular design allows them to tailor capacity to meet energy demand, expanding the flexibility of the baseload in the electricity grid. Leveraging this technology could result in an increase in energy security by deploying modular reactors in less accessible areas and smaller regions where it would not be feasible to construct a conventional nuclear power plant.

Wind and solar

Technological advancements in renewables, primarily solar PV and wind (onshore and offshore), drive the energy transformation not only through policies, but also by a gradual drop in the levelized cost of electricity (LCOE), leading to improved investment attractiveness and better financial planning for renewable projects. The LCOE calculates the average cost of electricity generation by dividing the total production costs by the total energy that is expected to be produced within a certain period. Historically, the LCOE of renewables compared to fossil fuels tended to range above the latter. Over time, renewables are expected to displace coal and natural gas-fired energy generation, changing the energy mix within the



power generation sector (despite regional differences, the cost of renewables has tended to decrease over time globally).

Recent solar photovoltaic (PV) technologies improve the performance and reliability of existing solar cell types. Bifacial solar cells have the technical characteristics to be illuminated from both sides, utilizing albedo radiation (reflective radiation) to capture reflected light from surrounding surfaces. Another advancement in solar PV technology focuses on transparent solar cells. Those cells absorb invisible light (infrared and ultraviolet), whilst being integrated into everyday objects. The primary example is the combination of such cells with windows. Another technology known as floating solar or floating PV (FPV) proposes solar panels mounted to structures on bodies of water, ensuring optimal land occupancy.

Technological advancements in wind, both offshore and onshore, are driven by enlarging the wind turbines to capture more wind energy, therefore generating more power. This includes manufacturing larger blades and taller wind towers. Another pathway for high-tech advancements includes the optimization of wind farms within the scope of grid integration, heavily lowering LCOE and grid integration costs.

Renewable energy sources come with huge intermittency, leading to the need for additional investments into the power system infrastructure. This includes energy storage systems, such as batteries, reserve capacity and grid reinforcement, to handle the variable input from renewable sources. Therefore, the total cost of renewable energy sources can be significantly higher than the calculated LCOE.

To improve the grid integration of renewables, several innovative technologies are being explored. Grid optimization technologies, such as advanced sensors, automation and real-time data analytics, are playing a significant role.

These technologies monitor and analyze grid conditions, facilitate efficient grid operations, reduce energy losses and enhance grid stability. Modern wind turbines often include inverters to convert direct current (DC) electricity to grid-compatible alternating current (AC). Solar technologies, including PV and concentrating solar power (CSP), are also being integrated into the grid. CSP plants, for instance, heat liquids that are used to produce steam to spin turbines and generators, using synchronous generators to connect to the power grid.

These advancements are paving the way for a more resilient and sustainable energy future, where renewable energy sources can be effectively and efficiently integrated into power grids. However, it is important to note that the successful implementation of these technologies requires careful planning and coordination, as well as financing.

Battery storage of electricity

When it comes to energy storage, the main conversation revolves around battery storage due to advancements in efficiency, capacity and sustainability. The most recent developments have made lithium-ion batteries the industry standard, not only for consumer electronics and EVs, but also for energy storage for renewables.

The next technological iteration of batteries could result in solid-state batteries, which will replace the conventional liquid electrolyte with a solid. Subsequently, this results in higher energy densities, longer battery lifespans and improved safety. Solid state

batteries are perceived as a game changer in the EV industry and for renewable energy storage. However, the commercialization of this technology is still lagging, due to technical challenges, high production costs and the need for additional development of industry standards.

The next potential battery technology that is expected to be introduced consists of the so-called flow battery, where the energy is stored in a chemical form in two liquid electrolytes. This battery would be suited for long-term energy storage of excess energy produced by renewables.

Data centres

The rise of AI in combination with cloud computing and the Internet of Things devices is expected to drive the expansion of data centres on a global scale. This surge is accompanied by an increase in electricity demand and a huge increase in the consumption of critical resources like water due to substantial cooling requirements.

The electricity demand in data centres is fundamentally driven by servers, including its core components (central processing units, memory, hard drives and fans). Additionally, data centres need to handle storage systems and networking equipment. These systems have to be backed up to ensure the continuity of the services deploying huge backup generators that are powered by diesel or gas. In general, the electricity required to power these computer facilities comes not only from renewables, but also from fossil fuels (mostly coal and gas), which provide stability to the grid.

Data centre efficiency is measured using power usage effectiveness (PUE), which is a unit-less ratio between a data centre's total energy consumption to the energy used by its IT equipment. Achieving a PUE of 1.0 is likely impossible due to losses in electricity conversion and in energy distribution. Hyperscale data centres achieve PUE rates around 1.12, especially when located in cooler areas of the world and because of their higher scaling efficiency, leading to higher operational utilization. Modern data centres aim, on average, for a PUE of 1.35 due to their updated IT infrastructure. Transitional and inefficient data centres come with severe energy inefficiencies, leading to a higher operating PUE, above 1.5 and 2.

Data centre components generate massive amounts of heat, which needs to be cooled using water and air cooling to provide stability to the infrastructure, adding significant water demand for each data centre. This raises environmental issues since data centres primarily source their water supply from traditional municipalities, mainly using potable water. Cooling systems of the next generation of data centres will likely pivot towards advanced liquid cooling to minimize water and energy consumption. Excess heat generated by the IT infrastructure of novel data centres will be repurposed to other operations within the data centre or will support external heating systems.

1.4.5 Hydrogen

Hydrogen has a unique position to increase synergies within the oil industry through providing mutual benefits. Hydrogen has been utilized by oil refineries for a long time in critical processes, such as hydrocracking and desulphurization, resulting in the production of cleaner fuels. Furthermore, the oil industry's infrastructure, expertise and investment capacity, uniquely position it to lead in hydrogen production, distribution and storage.



With existing pipelines and logistical networks, oil companies can readily incorporate hydrogen transportation and storage, reducing initial infrastructure investments for this emerging sector. Additionally, the industry's natural gas reserves make it possible to scale up blue hydrogen production at competitive costs, while CCS technologies advance. This provides a strategic advantage, allowing the industry to leverage existing assets and expertise in shifting towards cleaner energy practices.

Refineries leverage hydrogen within their transformation process. Additionally, hydrogen is important for ammonia, contributing to fertilizer production. Similarly, hydrogen is vital for methanol synthesis, and it is essential for manufacturing chemicals and alternative fuels. Steel producers are adopting hydrogen in direct reduction processes to minimize carbon emissions.

Most current hydrogen production comes from steam methane reforming, known as grey hydrogen, which emits a substantial amount of CO₂. However, cleaner alternatives like blue hydrogen (with CCS) and green hydrogen (generated via renewable electrolysis) offer more environmentally sustainable solutions.

Despite their promise, challenges remain in reducing costs and developing infrastructure. By 2050, however, clean hydrogen demand is expected to surge, propelled by decarbonization efforts and new applications in heavy transport and power generation.

Energy demand



Key takeaways

- Global primary energy demand is set to increase from 301 mboe/d in 2023 to 374 mboe/d in 2050, an increase of 24% over the entire outlook period.
- Energy demand growth slows gradually from relatively high short-term rates to more modest growth in the long term. This reflects slower population and economic growth, as well as rising energy efficiency in final use and energy transformation.
- Energy demand growth is driven by developing regions (non-OECD), which are projected to see an increase of 73.5 mboe/d over the outlook period. Around 30% of non-OECD growth comes from India alone. Energy demand in OECD countries drops slightly.
- In the Reference Case, demand for all primary fuels is set to increase in the long term, with the exception of coal.
- The strongest incremental demand in the outlook period is expected for other renewables (mostly wind and solar), which increases by almost 43 mboe/d, based on strong policy support and favourable economics in many regions. The share of other renewables in the energy mix rises from around 3.2% in 2023 to 14% in 2050.
- Natural gas demand is expected to increase by 20.5 mboe/d and reach 89.6 mboe/d in 2050. Natural gas will play an important role in CO₂ emissions reductions by replacing coal in the power generation mix.
- Oil demand is projected to increase by almost 16.7 mboe/d in the period to 2050 and reach 109.6 mboe/d. Oil's share in the energy mix declines from almost 31% in 2023 to 29.3% in 2050, but it remains the fuel with the largest share in the energy mix by 2050.
- The combined share of oil and gas in the energy mix remains above 53% throughout the outlook period.
- Coal is the only primary fuel expected to see a demand decline, dropping by about 29 mboe/d due to energy policy and climate commitments, as well as ageing power plants. Demand falls from almost 78 mboe/d in 2023 to just above 49 mboe/d in 2050, predominantly due to developments in China and OECD countries.
- Energy intensity is projected to decline in all regions, leading to a global average reduction rate of slightly more than 2% p.a. in the period to 2050. India and China are expected to see the largest reduction in energy intensity, with annual average rates of 3.2% p.a. and 3.1% p.a., respectively.
- While progress has been made in reducing energy poverty and narrowing the disparity between developed and developing countries, there are, in part, still wide gaps and much work needs to be done. Energy poverty and lack of energy access remain urgent global issues that require concerted efforts from policymakers to ensure affordable and sustainable energy for all.

This chapter provides an overview of medium- and long-term primary energy demand trends by different fuels and major regions and/or countries in the Reference Case. Key assumptions provided in Chapter 1, such as demographic and economic developments, as well as long-term energy technology trends and the evolution of energy policies, are taken into consideration in these projections. This chapter also focuses on the implications of energy demand trends on energy poverty and energy access in the Reference Case.

2.1 Major trends in energy demand

In recent years, the global energy landscape has undergone significant changes, including due to the COVID-19 pandemic and related global economic repercussions. At the same time, the narrative on environmental action and climate policies has continued to largely dominate the energy sector, although issues related to energy security have come increasingly to the fore in recent years.

In the midst of a strong post-pandemic recovery and rising energy demand, it became clear that the global energy sector was increasingly facing potential challenges due to inadequate energy-related investment. This was further amplified by the impact of the global energy crisis in early 2022, with accompanying record-high prices for energy. The result was the reemergence and renewed acknowledgement of energy security and energy affordability challenges. Consequently, governments and companies across the world were forced to reorder their priorities and strategies in the short, as well as the long term.

Unsurprisingly, countries reacted differently to energy shortages on the international market during the recent energy crisis, mirroring their respective capabilities. Wealthy and developed countries were able to help their citizens with significant energy subsidies, while at the same time securing sufficient energy supplies on the global market at often elevated prices. At the same time, in developing countries, where over 80% of the world population lives, governments had significantly less manoeuvring space. Many countries had to reduce their LNG imports due to high prices, which consequently led to repeated blackouts and energy shortages.

The current energy landscape can be described as competing narratives on future pathways, with no clear consensus on what the future should look like. Some scenarios, many of which are back casted, have overly ambitious targets for the medium and long term. These targets are challenging for developed countries and even more so for developing ones. Nevertheless, they have been at least partly adopted as a basis for energy policies and related investment decisions. Meanwhile, issues related to financing, technical viability and availability of resources are often neglected and ignored. This could lead to unintended consequences, including lack of energy security and affordability, as well as a lack of social cohesion.

However, this does not mean that the global energy landscape is standing still. The uptake of renewable energy has been noteworthy with record high-capacity additions observed in 2023. Nonetheless, this uptake is not equally distributed across the world. China is the clear leader, followed by the EU and the US and to some extent India and the Middle East. At the same time, additions in other regions are still negligible. The expansion of renewable energy will continue and its share in the energy mix will increase.

At the same time, global energy demand continues to expand strongly, driven by population growth and economic development. In 2023, global energy demand increased by around 1.6%

y-o-y. Demand for all fuels increased, including oil and gas, and even coal. Growth came predominantly from developing regions, such as China, India and the Middle East. OECD energy demand in 2023 remained largely flat relative to the previous year.

Table 2.1 shows the outlook for global energy demand in the medium and long term by primary fuel in the Reference Case. Total primary energy demand is expected to increase from around 301.1 mboe/d in 2023 to 374.1 mboe/d in 2050. This is an increase of around 73 mboe/d, or just above 24% over the outlook period. The average annual growth rate for the entire period is 0.8% p.a. with growth decelerating towards the end of the outlook. This is in line with slower population and economic growth, as well as increasing energy efficiency in end usage and energy transformation.

Table 2.1
World primary energy demand by fuel type, 2023–2050

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Fuel share %	
	2023	2030	2035	2040	2045	2050	2023–2050	2023–2050	2023	2050
Oil	92.9	103.1	106.0	107.4	108.5	109.6	16.7	0.6	30.9	29.3
Coal	78.0	71.6	66.1	60.0	54.4	49.1	–28.9	–1.7	25.9	13.1
Gas	69.1	75.9	80.6	84.8	87.9	89.6	20.5	1.0	23.0	24.0
Nuclear	14.8	17.0	18.9	20.9	22.7	24.3	9.6	1.9	4.9	6.5
Hydro	7.6	8.6	9.2	9.9	10.7	11.6	4.0	1.6	2.5	3.1
Biomass	29.1	32.1	34.0	35.5	36.5	37.4	8.2	0.9	9.7	10.0
Other renewables	9.6	19.0	27.1	35.1	43.6	52.4	42.9	6.5	3.2	14.0
Total	301.1	327.3	342.0	353.7	364.4	374.1	72.9	0.8	100.0	100.0

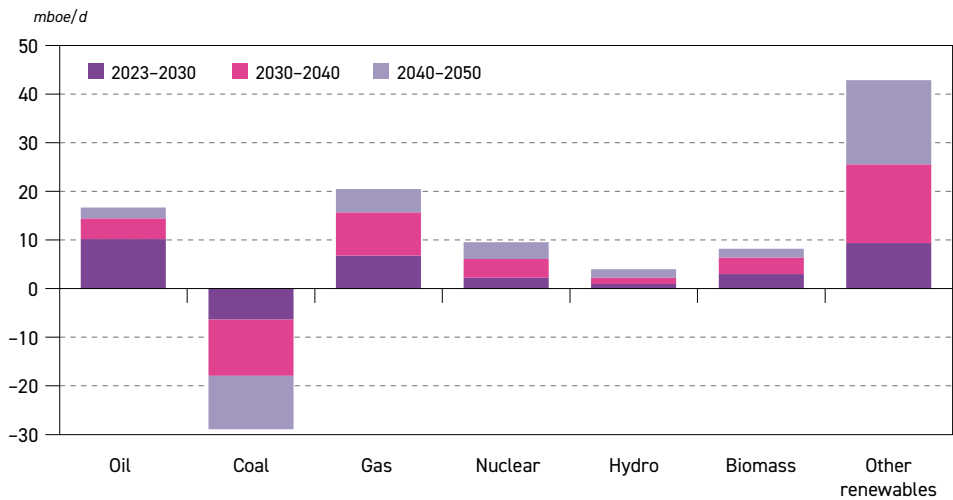
Source: OPEC.

It is important to note that the expected drop in primary energy demand growth is much less pronounced in terms of final energy demand (after energy transformation). This is due to the expected increase in the share of renewables, such as wind and solar, that have little or no transformation and/or transmission losses and given that they partially replace fossil fuels, such as coal, where transformation losses are normally significant.

With the exception of coal, demand for all primary fuels increases over the outlook period in the Reference Case (Figure 2.1). By far the largest increase is expected to come from 'other renewables', with absolute growth of almost 43 mboe/d over the outlook period, from 9.6 mboe/d in 2023 to 52.4 mboe/d in 2050. This is equivalent to an average annual growth rate of 6.5% p.a. The expansion of other renewables is supported by favourable energy policies, as well as declining power generation costs. Consequently, the share of other renewables in the global energy mix is expected to increase from 3.2% in 2023 to 14% in 2050.

The second-largest increase over the outlook period is expected from natural gas. Demand for gas is set to rise from around 69 mboe/d in 2023 to 89.6 mboe/d in 2050, up by 20.5 mboe/d. Due to its high base, the annual average growth is estimated at around 1% p.a. Natural gas is the fuel of choice for many countries seeking to reduce their CO₂ emissions and the role

Figure 2.1
Growth in primary energy demand by fuel type, 2023–2050



Source: OPEC.

of coal in the energy mix. In addition, given the rising share of renewables in electricity generation, gas-fired power plants can provide backup power, due to their flexibility. Natural gas is set to become the second-largest fuel in the energy mix by 2030, overtaking coal. In 2050, the share of natural gas is estimated at 24%, up from 23% in 2023.

Oil demand is expected to increase from 92.9 mboe/d in 2023 to 109.6 mboe/d in 2050, an increase of 16.7 mboe/d. Demand growth is expected to be driven by developing countries (mostly Asia, Africa and the Middle East), while OECD regions are estimated to see a decline in oil demand over the same period. While its share in the energy mix is expected to fall from almost 31% in 2023 to 29.3% in 2050, oil remains the fuel with the highest share throughout the outlook period. As discussed in more detail in Chapter 3, this corresponds to 120.1 mb/d of liquids demand in 2050, indicating an increase of nearly 18 mb/d from 2023 levels.

Nuclear power is projected to increase from 14.8 mboe/d in 2023 to 24.3 mboe/d in 2050, an increase of around 9.5 mboe/d. Strong support for new nuclear power plants, along with lifetime extensions for existing plants contribute to this increase. Nuclear power is set to remain an important baseload electricity provider in many regions, especially given the rising share of renewables in the generation mix. Novel technologies such as small modular reactors (SMRs) are also likely to contribute to nuclear demand growth in the long term. Consequently, the share of nuclear power in the energy mix is set to increase from 4.9% in 2023 to 6.5% in 2050.

Demand for biomass is expected to increase from 29.1 mboe/d in 2023 to 37.4 mboe/d in 2050, predominantly due to its modern usage. This includes rising demand for biofuels (including SAFs), biogas, bioplastics, as well as biomass for electricity generation. At the same time, the traditional use of biomass is expected to decline, mostly in developing countries in Africa and Asia.

Hydropower demand is expected to increase by 4 mboe/d in the outlook period to reach 11.6 mboe/d in 2050. The largest incremental growth is expected in regions with available resources



including Asia, Africa and Latin America. Growth in developed regions is based on minor expansions and efficiency improvements due to refurbishments of existing hydropower plants.

The only primary fuel expected to see a demand decline is coal, generally due to stringent energy policies in most regions that aim for closures of existing coal power plants and limiting new builds. Coal demand is projected to decline from 78 mboe/d in 2023 to just above 49 mboe/d, down by almost 29 mboe/d. Consequently, the share of coal in the energy mix is set to decline from almost 26% in 2023 to nearly 13% in 2050.

The Reference Case shows big shifts in the energy mix throughout the outlook period. However, it also indicates that all fuels will be needed to satisfy global energy demand growth. Oil and gas will remain crucial for energy supply in the period to 2050, with their combined energy mix share expected to stay above 53%.

The global long-term energy demand picture also combines different regional trajectories. Table 2.2 and Figure 2.2 show the energy demand outlook by major region. It becomes evident that demand growth to 2050 will come entirely from non-OECD regions, while energy demand in OECD countries is expected to stay flat or decline slightly.

Table 2.2
Total primary energy demand by region, 2023–2050

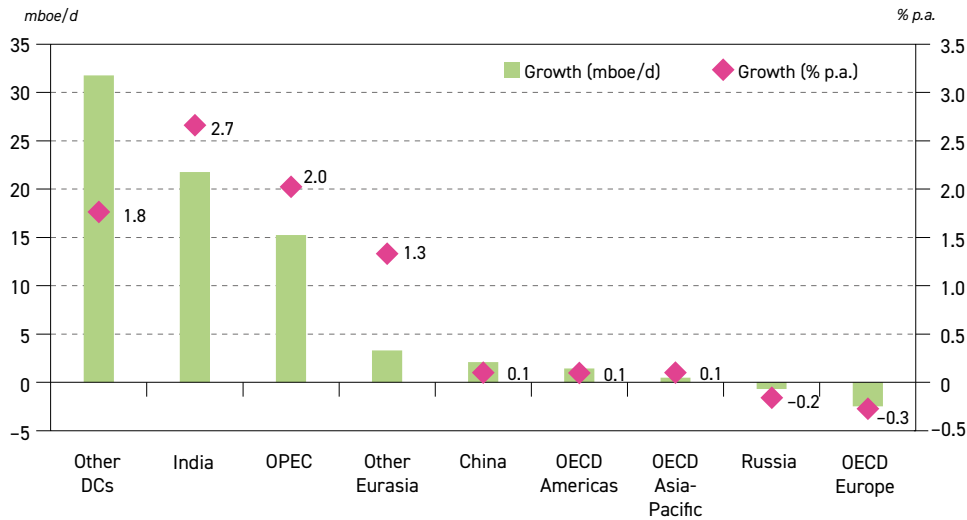
	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2023	2030	2035	2040	2045	2050	2023–2050	2023–2050	2023	2050
OECD Americas	54.9	56.1	56.5	56.2	56.1	56.4	1.4	0.1	18.2	15.1
OECD Europe	34.5	34.0	33.5	32.9	32.3	32.0	–2.5	–0.3	11.4	8.6
OECD Asia-Pacific	17.7	17.9	18.0	18.1	18.1	18.2	0.5	0.1	5.9	4.9
OECD	107.1	108.1	108.1	107.2	106.6	106.6	–0.6	0.0	35.6	28.5
China	74.8	78.9	79.4	78.3	77.5	76.9	2.1	0.1	24.8	20.6
India	21.1	26.6	30.6	34.6	38.8	42.9	21.8	2.7	7.0	11.5
OPEC	21.3	26.8	30.0	32.8	35.0	36.5	15.3	2.0	7.1	9.8
Other DCs	52.6	62.1	68.7	75.3	80.4	84.4	31.8	1.8	17.5	22.6
Russia	16.5	16.4	16.1	15.9	15.8	15.8	–0.7	–0.2	5.5	4.2
Other Eurasia	7.7	8.4	9.0	9.6	10.3	11.0	3.3	1.3	2.6	2.9
Non-OECD	194.0	219.3	234.0	246.5	257.8	267.5	73.5	1.2	64.4	71.5
World	301.1	327.3	342.0	353.7	364.4	374.1	72.9	0.8	100.0	100.0

Source: OPEC.

Within the non-OECD, there are several countries/regions that are crucial to energy demand growth. They include India, OPEC and the large group of 'Other Developing Countries'.

Energy demand in India is expected to more than double over the outlook period, reaching levels close to 43 mboe/d in 2050. The estimated average growth rate is 2.7% p.a., which makes

Figure 2.2
Growth in primary energy demand by region, 2023–2050



Source: OPEC.

it the region with the fastest energy demand growth. The major reason is a growing population and an expanding middle class, in combination with fast economic development. India's share in global energy demand is projected to increase from 7% in 2023 to 11.5% in 2050.

Energy demand in Other Developing Countries (consisting largely of developing countries in Asia, Africa and Latin America) is set to increase by 31.8 mboe/d over the outlook period and is expected reach 84.4 mboe/d in 2050. Energy demand in the OPEC group of countries is anticipated to increase from 21.3 mboe/d in 2023 to 36.5 mboe/d in 2050, driven by population and economic growth and ample available energy resources.

At the same time, energy demand in China is expected to increase only modestly, from 74.8 mboe/d in 2023 to 79.4 mboe/d in 2035, before witnessing a gradual decrease thereafter to just below 77 mboe/d in 2050. This is mostly due to declining coal demand and the rising share of renewables, nuclear and natural gas in the mix. Consequently, China's share in global energy demand is set to drop from 24.8% in 2023 to 20.6% in 2050.

Primary energy demand in the OECD region is projected to increase only slightly in the period to 2030, followed by a marginal decline between 2035 and 2050. Between 2023 and 2050, OECD energy demand is set to drop by around 0.6 mboe/d. This is due to low population and economic growth, market saturation and increasing energy efficiency (including the penetration of renewables). Looking within OECD sub-regions, OECD Americas and OECD Asia-Pacific are both expected to see modest growth of 1.4 mboe/d and 0.5 mboe/d, respectively. This will be more than offset by a decline from OECD Europe, where primary energy demand is set to fall by 2.5 mboe/d over the outlook period.

2.2 Energy demand by major regions

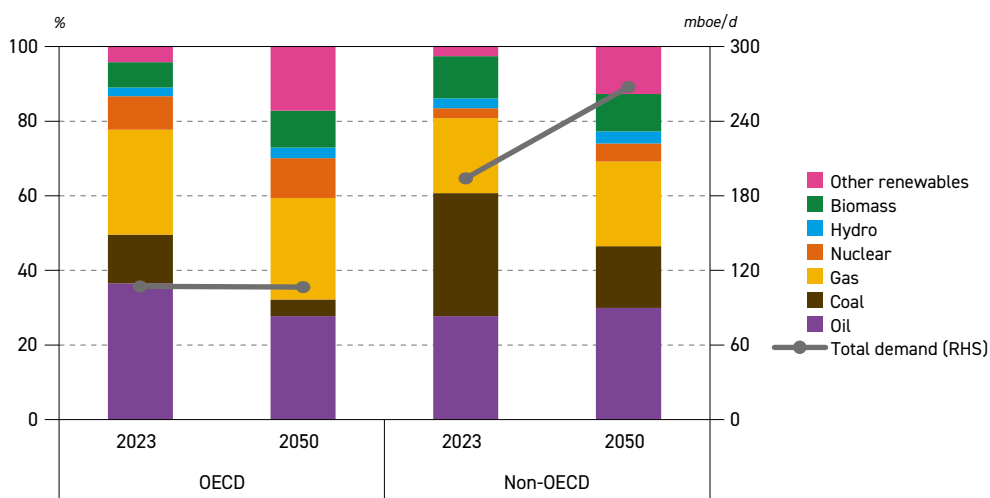
This section discusses regional details related to primary energy demand trends in the medium and long term. It also refers to the energy mix evolution in relation to regional economic



development and major energy policies. The focus of the section is on major regions, such as the OECD and non-OECD, as well as two major countries, China and India. Due to the size of their economies, these regions and/or countries have much higher significance for energy demand compared with the rest of the world.

Figure 2.3 shows the changing primary energy mix in the OECD and non-OECD between 2023 and 2050. In both regions, the share of fossil fuels in the energy mix is expected to decline over the outlook period. However, the figure illustrates very different regional patterns.

Figure 2.3
Total primary energy demand by fuel and region, 2023 and 2050



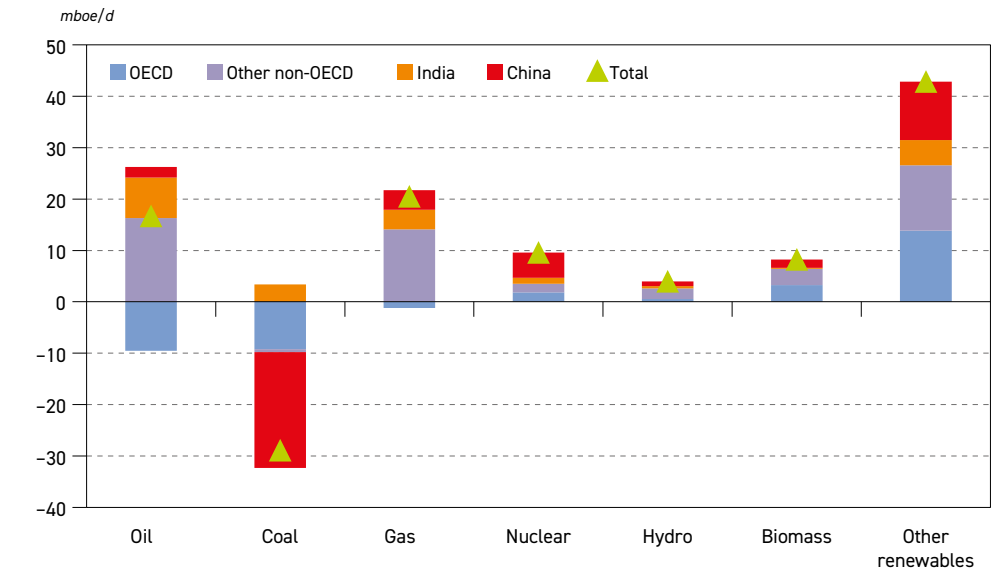
Source: OPEC.

The overall share of fossil fuels in the OECD is expected to decline from almost 78% in 2023 to 59.4% in 2050. This is mostly due to the decline of oil's share in the mix, which drops from 36.5% in 2023 to 27.7% in 2050. Coal also declines, losing more than 8.6 pp to reach 4.5% in 2050. The share of natural gas in the OECD energy mix is set to decline only slightly and settle at just below 27.2% in 2050. The gap will be filled by rising shares for other renewables (+13 pp), biomass (+3.1 pp), nuclear (+1.8 pp) and hydro (+0.5 pp).

In the non-OECD, the pattern in energy demand development is different. Based on strong population and economic growth, oil and gas increase their respective shares modestly to 2050 by 2.2 and 2.6 pp, respectively, and the share of coal in the mix drops by a hefty 16.4%. Consequently, the overall share of fossil fuels is expected to decline by 11.6 pp between 2023 and 2050. The increase will come predominantly from other renewables (+10.1 pp) and nuclear (+2.2 pp).

It is important to note that the overall level of energy demand is a key denominator for the final energy mix. In the OECD, primary energy demand is set to decline in the long term, which helps to hasten the increase in the share of renewables. In the non-OECD, energy demand increases throughout the outlook period, which is why the share of renewables in 2050 in the non-OECD is lower compared with the OECD.

Figure 2.4
Growth in energy demand by fuel type and region, 2023–2050



Source: OPEC.

Oil is expected to decline in the OECD, due to the overall stagnation of the energy market and the active substitution of renewables. At the same time, oil demand is expected to increase strongly in the non-OECD (Figure 2.4). Natural gas demand is set to increase exclusively in non-OECD regions, while remaining stagnant in the OECD. Finally, with the exception of India, coal demand declines in all regions, driven by China and, to some extent, the OECD.

2.2.1 OECD

Table 2.3 shows primary energy demand in the OECD by major fuel. Overall energy demand in the OECD is set to increase marginally from 107.1 mboe/d in 2023 to 108.1 mboe/d in 2030,

Table 2.3
OECD primary energy demand by fuel type, 2023–2050

	Levels <i>mboe/d</i>						Growth <i>mboe/d</i>	Growth <i>% p.a.</i>	Fuel share <i>%</i>	
	2023	2030	2035	2040	2045	2050	2023–2050	2023–2050	2023	2050
Oil	39.1	38.9	36.9	34.1	31.7	29.6	–9.6	–1.0	36.5	27.8
Coal	14.0	10.3	8.5	7.0	5.8	4.8	–9.2	–3.9	13.1	4.5
Gas	30.2	30.0	30.0	30.0	29.6	29.0	–1.2	–0.2	28.2	27.2
Nuclear	9.6	10.1	10.6	10.9	11.2	11.4	1.8	0.6	9.0	10.7
Hydro	2.5	2.6	2.7	2.8	2.9	3.0	0.5	0.7	2.3	2.8
Biomass	7.3	8.2	8.8	9.5	10.0	10.5	3.3	1.4	6.8	9.9
Other renewables	4.5	8.0	10.6	13.0	15.5	18.3	13.8	5.3	4.2	17.2
Total	107.1	108.1	108.1	107.2	106.6	106.6	–0.6	0.0	100.0	100.0

Source: OPEC.



which will be followed by a stepwise decline towards 106.6 mboe/d in 2050. Overall, OECD primary energy demand is set to decline only marginally by 0.6 mboe/d over the outlook period.

As already mentioned in Chapter 1, OECD energy demand trends are dominated by slow population growth and an ageing population, as well as modest economic growth. In addition, a variety of energy policies that promote energy efficiency and the trend of fossil fuel substitution by renewables will determine the future energy landscape in this region. In terms of the energy mix, OECD demand for oil, coal and gas is expected to drop in the outlook period, which will be largely offset by gains in other renewables, biomass, nuclear and hydro.

In total, OECD oil demand is expected to decline by around 9.6 mboe/d over the outlook period to reach 29.6 mboe/d in 2050. Consequently, the share of oil in the OECD energy mix drops from 36.5% in 2023 to 27.8% in 2050. The major driver is the penetration of EVs, supported by aggressive energy policies and regulations, many of which are already legally binding, as well as increasing efficiency gains related to traditional ICEs (see Chapter 3). The process of substituting oil with other energy carriers in the residential sector (e.g. for heating) and industry also contributes to the oil demand decline in the OECD. In OECD Americas and OECD Europe, oil demand is set to decline by 3.6 mboe/d and 3.9 mboe/d, respectively. Oil demand in OECD Asia-Pacific is expected to drop by 2 mboe/d between 2023 and 2050.

OECD coal demand is estimated to decline from 14 mboe/d in 2023 to 4.8 mboe/d in 2050, with its share falling from 13.1% to 4.5%. A large number of OECD countries are determined to reduce coal usage, especially in the power generation sector. This has been the case in the recent past, with coal's share in power generation declining from 33% in 2010 to almost 17% in 2023. Ageing coal power plants, as well as the substitution of coal by other energy sources, including natural gas, renewables and nuclear, are expected to contribute to reduced coal demand in the OECD.

Due to the recent energy crisis, some countries saw higher coal usage during 2022, such as Germany, but coal-fired generation use dropped again in 2023. Some regions will continue using coal, even in the long term. At least some coal plants could be equipped with CCUS facilities.

Natural gas demand in the OECD is expected to remain largely stable between 2023 and 2040, before declining marginally in the last decade of the outlook period. Overall, natural gas demand is set to drop from 30.2 mboe/d in 2023 to 29 mboe/d in 2050. This is due to the combination of a decline in European gas demand of roughly 1.8 mboe/d and a minor increase in OECD Americas demand, in the range of 0.5 mboe/d between 2023 and 2050.

Generally, natural gas remains the fuel of choice for many OECD countries given the focus on reducing CO₂ emissions, along with substituting coal in the energy mix and supporting renewable expansion. Germany announced plans to build up to 25 GW of new combined cycle gas turbine (CCGT) capacity by 2030, which would provide baseload power and allow for the retirement of existing coal plants.

Demand for other renewables in the OECD is expected to increase by almost 14 mboe/d between 2023 and 2050, with its share in the energy mix rising from 4.2% to 17.2%. Growth is supported by strong policy support and related medium- and long-term energy mix targets. Due to limited resources, hydropower demand is expected to only increase by 0.5 mboe/d in the outlook period, reaching 3 mboe/d in 2050. This includes the refurbishment of existing hydropower plants and increasing turbine efficiencies.

OECD biomass demand is projected to increase by 3.3 mboe/d, almost exclusively due to the advanced use of biomass in the production for biofuels (including SAF), biogas and bioplastics. This development is also heavily supported by energy policies, including mandates and subsidies.

Finally, OECD nuclear demand is set to increase by nearly 2 mboe/d over the outlook period and reach 11.4 mboe/d in 2050. The need for a baseload power supply with a low CO₂ footprint amid rising intermittent renewable power generation has helped to revive interest in nuclear energy. Several countries have extended the lifetime of their nuclear plants (e.g. Belgium), while Japan is in the process of restarting some of its nuclear power plants. For instance, the world's largest nuclear power plant, Kashiwazaki-Kariwa, with installed capacity of more than 8 GW, could be restarted in the near future as its safety ban was lifted in late 2023. More plants will likely follow. Several countries have expressed interest in building new nuclear plants, including France, the US, the UK, Japan, and others.

2.2.2 Non-OECD

Table 2.4 shows long-term primary energy demand in the non-OECD. Total energy is set to increase from 194 mboe/d in 2023 to 267.5 mboe/d in 2050. This represents an increase of 73.5 mboe/d, or around 38%, over the outlook period. The single-largest contribution comes from India, which accounts for almost 22 mboe/d of this increase, or around 30%.

Table 2.4
Non-OECD primary energy demand by fuel type, 2023–2050

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Fuel share %	
	2023	2030	2035	2040	2045	2050	2023–2050	2023–2050	2023	2050
Oil	53.8	64.2	69.1	73.3	76.9	80.0	26.3	1.5	27.7	29.9
Coal	64.0	61.4	57.7	53.0	48.6	44.3	–19.7	–1.4	33.0	16.6
Gas	39.0	46.0	50.6	54.9	58.4	60.7	21.7	1.7	20.1	22.7
Nuclear	5.1	6.9	8.3	10.0	11.5	12.9	7.8	3.5	2.7	4.8
Hydro	5.2	6.0	6.6	7.1	7.9	8.6	3.5	1.9	2.7	3.2
Biomass	21.9	24.0	25.1	26.1	26.5	26.8	5.0	0.8	11.3	10.0
Other renewables	5.0	10.9	16.5	22.1	28.1	34.1	29.0	7.3	2.6	12.7
Total	194.0	219.3	234.0	246.5	257.8	267.5	73.5	1.2	100.0	100.0

Source: OPEC.

Demand for other renewables is expected to see the largest increase in the non-OECD, rising from 5 mboe/d in 2023 to more than 34 mboe/d in 2050. This represents an increase of 29 mboe/d and a strong average annual growth rate of 7.3% p.a. The expansion is led by China, which accounts for almost 40% of this, while other regions are also expected to see strong growth, including India and OPEC. China is putting significant effort into expanding its solar and wind generation capacity, which not only helps reduce its CO₂ emissions, but also restructures its industry. Even with growing overall energy demand, the share of other renewables is projected to increase from 2.6% in 2023 to 12.7% in 2050.



Oil is expected to witness the second-largest demand increase in the non-OECD, rising from 53.8 mboe/d in 2023 to 80 mboe/d in 2050. This is an increase of over 26 mboe/d and is supported by strong population growth, an increasing middle class and rising energy access. The transportation sector, as well as industry (i.e. petrochemicals), is set to account for the largest share of this increase. Consequently, the share of oil in the non-OECD energy mix is expected to rise to almost 30% in 2050, up from 27.7% in 2023. Oil will become the fuel with the highest share in the non-OECD energy mix, overtaking coal by 2030.

Natural gas demand in the non-OECD is projected to increase from 39 mboe/d in 2023 to 60.7 mboe/d in 2050, shifting up by around 21.7 mboe/d over the outlook period. Strong demand growth for natural gas mirrors rising energy access in many developing countries, as well as resource availability in many regions, including the Middle East and Africa. Furthermore, many countries see an increasing role for natural gas in their strategies to reduce CO₂ emissions, mostly through replacing old and inefficient coal-fired power plants with CCGTs.

Biomass demand in the non-OECD is projected to increase from almost 22 mboe/d in 2023 to nearly 27 mboe/d, driven by the increasing use of advanced biomass. This will more than offset an expected decline in the traditional use of biomass, as access to modern energy services in developing countries increases. At the same time, hydropower demand is expected to expand from 5.2 mboe/d in 2023 to 8.6 mboe/d in 2050, driven by new capacity additions, mostly in Asia and Africa.

Finally, coal demand in the non-OECD is set to decline by nearly 20 mboe/d in the outlook period, due to efforts to reduce CO₂ emissions, the replacement of coal-fired electricity generation by other fuels, and swapping old and inefficient coal-fired plants with supercritical units. The reduction in coal use comes almost exclusively from China, where coal demand is anticipated to decline by 22.5 mboe/d, which is partly offset by increases elsewhere, including India.

This section also provides more details about China and India, which, due to their size, have a significant impact on the global energy landscape.

In **China**, primary energy demand is projected to increase in the first part of the outlook, rising from 74.8 mboe/d in 2023 to 79.4 mboe/d in 2035. However, overall energy demand is expected to peak, followed by a gradual decline towards 76.9 mboe/d in 2050. The expectation of a declining population, as well as slower GDP growth, market saturation and rising energy efficiency are the main factors behind this trend. The partial replacement of coal with renewables contributes greatly to an energy transformation efficiency increase.

This is also the most significant change in China's energy mix in the long term. Coal demand in the country is set to decline from 42.5 mboe/d in 2023 to just under 20 mboe/d in 2050. This represents a decline of 22.5 mboe/d and is in line with efforts to reach a CO₂ emissions peak by 2030 and possible carbon neutrality by 2060. The more efficient use of coal is also contributing to its decline in primary energy demand. The share of coal in the primary mix is expected to fall from 57% in 2023 to below 26% in 2050 (Table 2.5).

At the same time, China has recently approved a significant number of new coal-fired power plants, totalling 114 gigawatts (GW) in 2023. Combined approvals in 2022 and 2023 now stand at an astonishing 220 GW. This reflects Chinese efforts to secure a stable supply of

Table 2.5
China primary energy demand by fuel type, 2023–2050

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Fuel share %	
	2023	2030	2035	2040	2045	2050	2023–2050	2023–2050	2023	2050
Oil	15.4	17.4	17.8	17.9	17.7	17.5	2.1	0.5	20.6	22.7
Coal	42.5	38.0	33.5	28.3	23.7	19.9	–22.5	–2.8	56.8	25.9
Gas	6.3	8.1	9.1	9.9	10.3	10.2	3.8	1.8	8.5	13.2
Nuclear	2.5	3.7	4.6	5.6	6.5	7.4	4.9	4.1	3.3	9.6
Hydro	2.3	2.6	2.7	2.8	3.0	3.2	0.9	1.2	3.1	4.1
Biomass	3.0	3.6	4.0	4.2	4.4	4.5	1.6	1.6	4.0	5.9
Other renewables	2.9	5.6	7.8	9.7	11.9	14.2	11.4	6.1	3.8	18.5
Total	74.8	78.9	79.4	78.3	77.5	76.9	2.1	0.1	100.0	100.0

Source: OPEC.

electric power after the country faced shortages several years ago. It is clear, however, that some new coal power plants will replace old and inefficient units in the years to come, thus contributing to lowering primary coal demand in the country.

China's oil demand is projected to increase from 15.4 mboe/d in 2023 to 17.9 mboe/d in 2040, followed by a marginal decline to 17.7 mboe/d in 2045 and then 17.5 mboe/d in 2050. An expanding share of EVs in new vehicle sales is set to put some pressure on oil demand in the long term (see Chapter 3), with heavy-duty transportation, aviation and marine sectors, as well as petrochemicals, driving future oil demand growth.

Natural gas consumption in China is set to increase from 6.3 mboe/d in 2023 to 10.2 mboe/d in 2050. Higher usage of gas in the power generation and heating sectors will help to reach medium- and long-term targets related to CO₂ emissions. Rising gas demand in China is partly linked to the assumed increase in its domestic gas supply as laid out in the country's 14th Five-year Plan (FYP).

China is making huge investments into renewable energy, mostly wind and solar, not only targeting its own energy mix, but also developing a domestic industry. In 2023, China installed almost 300 GW of new renewable generation capacity, of which PV solar was almost 220 GW and the rest mostly for wind. Large renewables additions are likely to continue in the future, with other renewables in China increasing from just below 3 mboe/d in 2023 to 14.2 mboe/d in 2050. Their share is set to increase to 18.5% in 2050, up from below 4% in 2023.

China is also expanding its nuclear power plant capacity, with 25 reactors under construction. This would increase the existing installed capacity by almost 50% in the medium term. Expansion is likely to increase in the long term, with total nuclear energy almost tripling to 7.4 mboe/d in 2050, up from 2.5 mboe/d in 2023. Finally, hydropower and biomass demand are projected to increase modestly, inching up by 0.9 mboe/d and 1.6 mboe/d, respectively.



Table 2.6 shows the long-term primary energy demand outlook for **India**; it is expected to more than double between 2023 and 2050, reaching 42.9 mboe/d in 2050. The major drivers of this growth are increasing population, an expanding middle class and economic development.

Table 2.6
India primary energy demand by fuel type, 2023–2050

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Fuel share %	
	2023	2030	2035	2040	2045	2050	2023–2050	2023–2050	2023	2050
Oil	5.3	7.1	8.6	10.1	11.6	13.2	7.8	3.4	25.2	30.7
Coal	9.4	11.3	12.4	12.9	13.1	12.8	3.4	1.1	44.8	29.9
Gas	1.2	1.8	2.2	3.0	3.9	4.9	3.8	5.5	5.6	11.5
Nuclear	0.3	0.5	0.7	0.9	1.2	1.5	1.2	6.2	1.4	3.4
Hydro	0.3	0.4	0.5	0.5	0.7	0.8	0.5	3.6	1.4	1.9
Biomass	4.2	4.4	4.4	4.4	4.4	4.4	0.2	0.2	19.7	10.2
Other renewables	0.4	1.2	1.8	2.7	3.9	5.3	4.9	9.9	2.0	12.4
Total	21.1	26.6	30.6	34.6	38.8	42.9	21.8	2.7	100.0	100.0

Source: OPEC.

India is the single-largest driver of global energy demand in the outlook period, accounting for roughly 30%. Demand for all fuels is expected to increase between 2023 and 2050, including coal. By far the largest incremental demand is expected for oil, which is set to increase from 5.3 mboe/d in 2023 to 13.2 mboe/d in 2050, driven by the transportation, petrochemical and residential sectors. The share of oil in India's energy mix is, therefore, expected to increase from 25.2% in 2023 to 30.7 % in 2050.

Natural gas demand is poised for an increase of 3.8 mboe/d over the outlook period, reaching almost 5 mboe/d in 2050. Rising gas demand is the result of higher demand in the power generation sector, as well as the residential and transportation sectors. The government supports further gasification of the country (City Gas Distribution), which is helping to reduce the traditional use of biomass for cooking.

Supported by strong demand for electricity, coal demand is expected to increase from 9.4 mboe/d in 2023 to 13.1 mboe/d in 2045, followed by a marginal decline to 12.8 mboe/d in 2050. The peak in coal demand is in line with efforts to reduce the carbon footprint and reflects the rising share of renewables, nuclear and gas in the power generation mix.

Other renewables are expected to increase by almost 5 mboe/d over the outlook period to reach 5.3 mboe/d in 2050. Due to a low base, the average annual growth rate for other renewables is almost 10% p.a. The current official target is 500 GW by 2030, which appears to be ambitious, as the installed renewable capacity in 2023 was estimated at around 175 GW.

Nuclear energy is set to increase strongly, from only 0.3 mboe/d in 2023 to 1.5 mboe/d in 2050. India currently has seven nuclear reactors under construction, which should help almost double current installed capacity. Hydropower demand is projected to increase from 0.3 mboe/d in 2023 to 0.8 mboe/d, in line with the available sources in the country.

Finally, biomass demand is projected to rise only marginally, from 4.2 mboe/d in 2023 to 4.4 mboe/d. This figure stems from a combination of two opposing trends; a reduction in traditional biomass usage, which is more than offset by modern uses, including biofuels and biogas.

2.3 Energy demand by fuel

This section looks into energy demand trends by primary fuel and provides the Reference Case outlook to 2050.

2.3.1 Oil

Following the unprecedented fluctuations that oil markets experienced during the COVID-19 pandemic, demand for oil products surpassed pre-pandemic levels in 2023 when, on an energy content basis, demand increased by 2.2 mboe/d compared with 2022.

Strong demand growth in 2023 was mainly driven by positive developments in China, which accounted for almost half of the demand increase. The second half of the increase came from Other Developing Countries, whereas demand in the OECD and Eurasia experienced only minor changes. Looking forward, these regional trends are set to continue over the medium term and will likely be amplified in the long term.

This expectation is clearly visible in Table 2.7, which outlines oil demand prospects at the regional and global levels in the period to 2050. It shows that global primary oil demand is projected to reach 109.6 mboe/d in 2050, 16.7 mboe/d higher than the 92.9 mboe/d observed in 2023. Combining this projected demand growth with the large base demand of almost 93 mboe/d observed in 2023, means that oil will remain the largest energy source over the entire outlook period. This is despite the fact that its share in the global energy mix will slightly decline from around 31% in 2023 to 29.3% in 2050.

However, the table also shows a contrasting demand pattern for major regions. OECD long-term prospects see an ongoing demand decline to around 34 mboe/d by 2040 and further to almost 29.6 mboe/d by 2050. This represents an overall OECD demand decline of 9.6 mboe/d, compared with 2023.

It is important to note that the numbers shown in this chapter are not directly comparable with those shown in other chapters. There are two main reasons for this. First, Chapter 2 uses energy equivalent units (mboe/d) to allow for a comparison between the different primary fuel types. In other chapters, however, oil is expressed in volumetric units of mb/d. Second, the definition of oil in Chapter 2 is different from that used in Chapters 3 through 6. While Chapter 2 deals with primary energy sources, other chapters consider the outlook for all liquid fuels. In that sense, biofuels are considered biomass in this chapter and coal-to-liquids (CTLs) as coal and gas-to-liquids (GTLs) as gas, but they are all part of the liquids outlook in Chapters 3 and 4.

Table 2.7
Oil demand by region, 2023–2050

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2023	2030	2035	2040	2045	2050	2023–2050	2023–2050	2023	2050
OECD Americas	20.6	20.8	20.2	19.0	17.9	16.9	–3.6	–0.7	22.1	15.5
OECD Europe	11.8	11.5	10.6	9.5	8.6	7.9	–3.9	–1.5	12.7	7.2
OECD Asia-Pacific	6.7	6.6	6.1	5.6	5.1	4.7	–2.0	–1.3	7.3	4.3
OECD	39.1	38.9	36.9	34.1	31.7	29.6	–9.6	–1.0	42.1	27.0
China	15.4	17.4	17.8	17.9	17.7	17.5	2.1	0.5	16.6	15.9
India	5.3	7.1	8.6	10.1	11.6	13.2	7.8	3.4	5.7	12.0
OPEC	8.8	11.2	11.9	12.5	12.9	13.2	4.3	1.5	9.5	12.0
Other DCs	18.8	22.5	24.8	26.8	28.6	30.3	11.5	1.8	20.2	27.6
Russia	3.6	3.9	3.9	3.8	3.8	3.7	0.1	0.1	3.9	3.4
Other Eurasia	1.9	2.1	2.1	2.2	2.2	2.2	0.3	0.6	2.0	2.0
Non-OECD	53.8	64.2	69.1	73.3	76.9	80.0	26.3	1.5	57.9	73.0
World	92.9	103.1	106.0	107.4	108.5	109.6	16.7	0.6	100.0	100.0

Source: OPEC.

2.3.2 Coal

Even in 2023, coal demand increased, despite global efforts to limit its usage. Rising energy demand in developing countries and energy security concerns in some developed countries has helped to keep coal demand positive in recent years.

Coal demand in 2023 was estimated at almost 78 mboe/d, a new all-time high. Growth was driven mostly by developing countries (e.g. China, India, Indonesia, Vietnam etc.), and was generally seen in the power generation sector. China's and India's coal-fired generation reached an all-time high in 2023 of around 5,750 terawatt hours (TWh) and 1,500 TWh, respectively. In 2023, coal-fired generation in the two countries increased by almost 450 TWh, year-on-year (y-o-y).

Coal demand growth in developing countries was partly offset by declines in developed regions, again mostly driven by the power generation sector. For instance, the EU's coal-fired power generation declined by around 110 TWh in 2023, y-o-y, while the drop was even higher in the US, reaching almost 160 TWh in the same period.

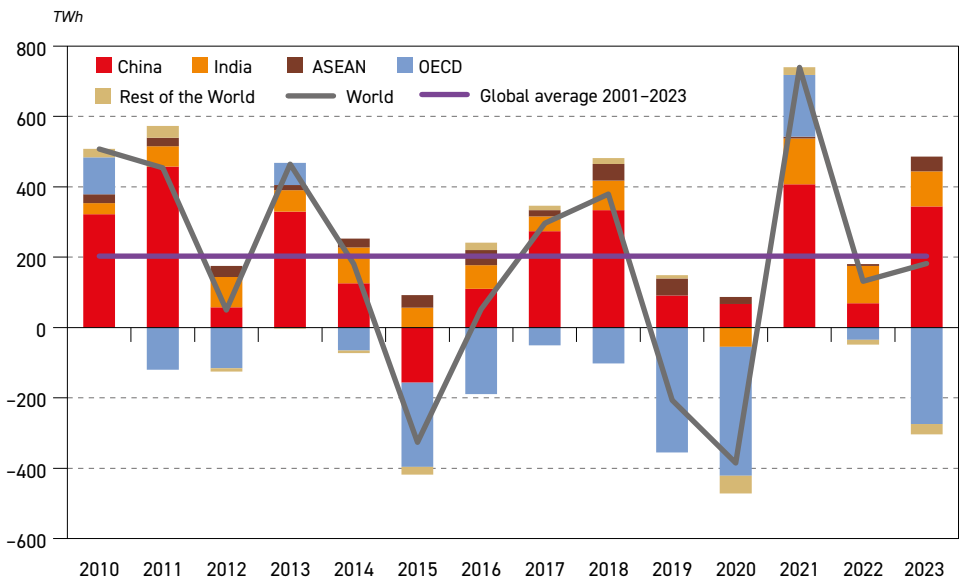
Coal has increasingly been the focus of many countries seeking to advance their energy security and prevent energy shortages, considering the recent energy crisis in 2022. This is especially the case for a number of developing countries, including China. China approved around 220 GW of new coal-fired capacity in 2022 and 2023. Construction of around 70 GW started in 2023, up from around 55 GW in 2022. Countries like India still rely heavily on coal power and are expected to expand its use in the years to come. All this could lead to increasing coal usage in the medium term.

At the same time, various energy and climate-change policies aimed at CO₂ emission reductions are putting pressure on coal usage across the globe. Many countries are willing to phase-out coal power, especially in developed regions. In addition, a rising share of substitution with

other energy sources, including renewables, natural gas and nuclear, are expected to limit the load hours of coal plants in the future.

Indeed, the share of coal in the mix has been declining in recent years. This is especially the case for the electricity generation sector, where an increase in renewables has led to a relative decline in coal-fired generation. In absolute terms, however, coal-fired generation has been increasing at the global level (Figure 2.5), driven by growth in developing countries, which was only partly offset by declines in developed regions. At the global level, coal-fired generation increased by around 180 TWh in 2023, which is only slightly lower than the global average for 2001–2023.

Figure 2.5
Incremental coal-fired generation, selected regions and global



Source: Ember.

As shown in Table 2.8 and Figure 2.6, coal use in several developing countries is expected to continue increasing in the medium term, especially in India and some ASEAN countries. This is set to be offset by an expected decline in OECD countries, in line with stated climate-related policies.

This outlook maintains the view that coal demand is expected to decline throughout the outlook period, from almost 78 mboe/d in 2023 to almost 66 mboe/d in 2035 and further to just above 49 mboe/d in 2050. This represents a drop of almost 29 mboe/d over the outlook period. Coal is the only primary fuel expected to decline in the Reference Case.

The role of China will be crucial. Energy and electricity security of supply is a top priority for the country, but this should also be viewed in light of a stated target to reach peak CO₂ emissions before 2030 and carbon neutrality by 2060. The expected decline in China is estimated at 22.5 mboe/d between 2023 and 2050, as coal is increasingly replaced by other fuels, including renewables, natural gas and nuclear.



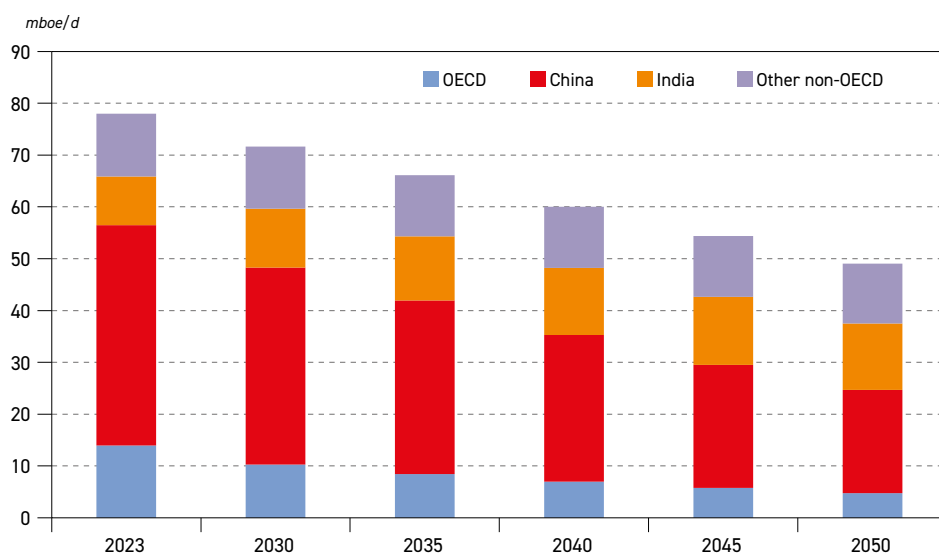
Furthermore, new coal power plant builds in China, most of which are supercritical plants, will likely contribute to more efficient coal usage in the long term and enable the phase out of older and inefficient plants. Ultra supercritical and supercritical coal plants can reach efficiencies of around 45% or sometimes even higher, which is significantly above the efficiencies of older plants at around 30%, or sometimes even lower.

Table 2.8
Coal demand by region, 2023–2050

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2023	2030	2035	2040	2045	2050	2023–2050	2023–2050	2023	2050
OECD Americas	5.2	3.9	3.1	2.3	1.7	1.2	–4.0	–5.2	6.7	2.5
OECD Europe	4.2	2.5	1.8	1.4	1.0	0.7	–3.4	–6.3	5.3	1.5
OECD Asia-Pacific	4.6	3.9	3.6	3.3	3.0	2.8	–1.8	–1.8	6.0	5.7
OECD	14.0	10.3	8.5	7.0	5.8	4.8	–9.2	–3.9	17.9	9.7
China	42.5	38.0	33.5	28.3	23.7	19.9	–22.5	–2.8	54.5	40.6
India	9.4	11.3	12.4	12.9	13.1	12.8	3.4	1.1	12.1	26.2
OPEC	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1
Other DCs	7.9	8.2	8.4	8.7	9.0	9.0	1.2	0.5	10.1	18.4
Russia	2.8	2.5	2.3	2.0	1.8	1.6	–1.2	–2.1	3.6	3.2
Other Eurasia	1.4	1.3	1.1	1.0	1.0	0.9	–0.5	–1.7	1.8	1.8
Non-OECD	64.0	61.4	57.7	53.0	48.6	44.3	–19.7	–1.4	82.1	90.3
World	78.0	71.6	66.1	60.0	54.4	49.1	–28.9	–1.7	100.0	100.0

Source: OPEC.

Figure 2.6
Coal demand by major region, 2023–2050



Source: OPEC.

Finally, although currently uncertain, some coal plants could include CCUS facilities, which could prolong their lifetime and align them with environmental targets for 2030 and 2060. While the 14th FYP recognizes the importance of coal for domestic energy security, it also seeks to 'strictly control' coal consumption, which is reflected in this outlook.

In the OECD, coal demand is expected to decline from 14 mboe/d in 2023 to 4.8 mboe/d in 2050, a drop of 9.2 mboe/d over the outlook period. This reflects the policies of numerous European countries to phase out coal plants and substitute coal-fired generation with other sources, mostly renewables and natural gas.

As of January 2024, most European countries have official phase-out plans for coal-fired generation that are still in place, despite recent delays in deadlines. Some countries still have not announced phase-out plans, including Poland and Türkiye, which still heavily rely on coal-fired electricity generation. In the Reference Case, coal demand in OECD Europe is projected to drop from 4.2 mboe/d in 2023 to just 0.7 mboe/d in 2050.

In the US, coal-fired generation has been on a steady decline for many years, due to plant retirements and limited load hours at the remaining coal plants because of rising substitution by natural gas and renewables. Since early 2021, the US has retired around 37 GW of coal-fired capacity, or 17% of the total coal-fired fleet. This trend will likely continue in the future and reflects the high competitiveness of natural gas in the US. Consequently, coal demand in OECD Americas is expected to decline by some 4 mboe/d over the outlook period, reaching 1.2 mboe/d in 2050.

A similar trend is expected in OECD Asia-Pacific, with coal demand declining from 4.6 mboe/d in 2023 to 2.8 mboe/d in 2050, driven by phase outs in Japan and Australia.

The only regions where coal demand is expected to rise are India and Other Developing Countries (mostly Asia-Pacific). Coal demand in India is expected to increase by 3.4 mboe/d to reach 13.1 mboe/d in 2045, followed by a marginal decline to 12.8 mboe/d in 2050. In Other Developing Countries, demand is seen to increase from just below 8 mboe/d in 2023 to 9 mboe/d by 2050, mostly in the ASEAN group of countries.

2.3.3 Natural gas

The natural gas market stabilized during 2023 and early 2024. Following the energy crisis of 2022, many regions reduced their natural gas consumption. This was especially the case for OECD Europe, where gas demand declined by almost 20% between 2021 and 2023. At the global level, natural gas demand recovered somewhat, driven by demand growth in developing countries (mostly Asia and the Middle East) and OECD Americas. However, despite this growth, global gas demand in 2023 was still below 2021 levels.

Looking ahead, global natural gas demand is expected to increase strongly. In recent years, many new LNG projects have been approved and some are under construction, which should bring more gas to consumers and help stabilize the market. High availability of gas resources at competitive prices, in combination with a low CO₂ footprint, will support demand growth in the medium and long term.

Nevertheless, uncertainties related to the security of gas supply are likely to remain and could play an important role for future gas demand in large importing regions, including



China. Natural gas is expected to remain the backbone of energy and electricity systems in many countries.

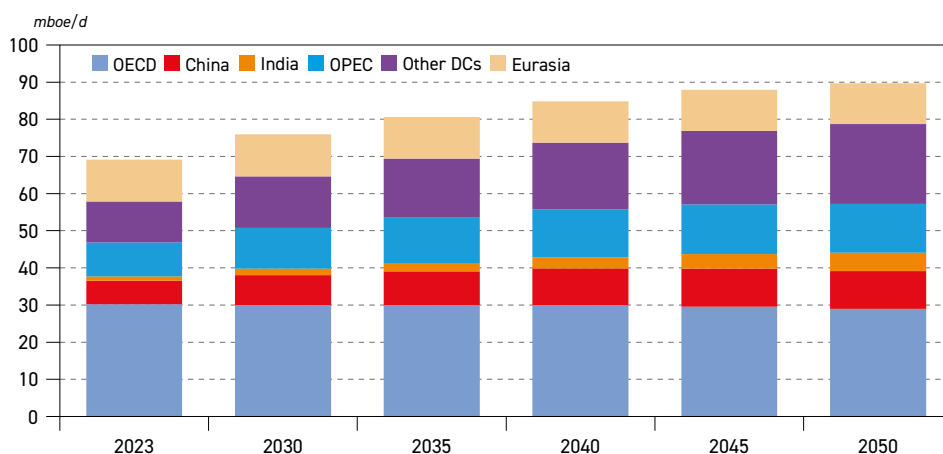
Table 2.9 and Figure 2.7 present the long-term demand outlook for natural gas in the Reference Case. Global gas demand is projected to increase by 20.5 mboe/d between 2023 and 2050, to reach 89.6 mboe/d. Gas is already expected to overtake coal in the energy mix by 2030 and become the second-largest fuel in terms of demand. The non-OECD region is expected to be the major driver of future gas demand, predominantly in countries in Asia, the Middle East

Table 2.9
Natural gas demand by region, 2023–2050

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2023	2030	2035	2040	2045	2050	2023–2050	2023–2050	2023	2050
OECD Americas	18.3	18.6	18.9	19.1	19.0	18.8	0.5	0.1	26.5	20.9
OECD Europe	8.2	7.7	7.4	7.1	6.8	6.4	–1.8	–0.9	11.9	7.2
OECD Asia-Pacific	3.6	3.7	3.7	3.8	3.8	3.7	0.1	0.1	5.3	4.2
OECD	30.2	30.0	30.0	30.0	29.6	29.0	–1.2	–0.2	43.6	32.3
China	6.3	8.1	9.1	9.9	10.3	10.2	3.8	1.8	9.2	11.4
India	1.2	1.8	2.2	3.0	3.9	4.9	3.8	5.5	1.7	5.5
OPEC	9.1	11.0	12.2	13.0	13.3	13.2	4.0	1.4	13.2	14.7
Other DCs	11.0	13.9	15.9	17.9	19.8	21.5	10.4	2.5	16.0	24.0
Russia	8.3	8.0	7.7	7.3	7.1	6.9	–1.4	–0.7	12.0	7.6
Other Eurasia	3.0	3.3	3.5	3.8	4.0	4.1	1.1	1.2	4.3	4.5
Non-OECD	39.0	46.0	50.6	54.9	58.4	60.7	21.7	1.7	56.4	67.7
World	69.1	75.9	80.6	84.8	87.9	89.6	20.5	1.0	100.0	100.0

Source: OPEC.

Figure 2.7
Natural gas demand by region, 2023–2050



Source: OPEC.

and Africa. Population and economic growth, as well as the substitution of coal by gas in the energy mix are seen to be the major drivers for this development.

The single-largest contributors to gas demand growth are China and India (+3.8 mboe/d each). In China, gas will increasingly play a role in lowering the country's CO₂ footprint, especially in the power and heat generation segments, as well as in industry. The desire to reduce local air pollution is also likely to support increased gas usage in the medium and long term. The rising use of renewables will increasingly require backup capacity, with gas plants being an ideal solution.

In India, the current government target is to increase the share of gas in the energy mix from 6.5% in 2020 to 15% in 2030, which will help to drive increased gas use throughout the outlook period. Additionally, this will improve access to modern energy services and reduce traditional biomass usage. Increasing electricity demand in India will also require larger amounts of gas, while coal expansion will be limited. Furthermore, limited gains are expected from the transportation sector in India, primarily from an expanding fleet of natural gas vehicles (NGVs) (see Chapter 3).

The OPEC region is another strong driver of gas demand, supported by robust energy and electricity demand growth and ample domestic natural gas supplies at a competitive cost. OPEC's gas demand is set to increase from 9.1 mboe/d in 2023 to 13.2 mboe/d in 2050. OPEC Member Countries are expected to increase the share of gas in their power generation mix, which will help reduce oil-fired generation.

Finally, strong growth is expected in a number of developing countries in Asia, Africa and Latin America. Natural gas is seen as an ideal vehicle for reducing energy poverty and increasing energy access, especially in sub-Saharan African countries. Furthermore, natural gas is likely to help reduce reliance on coal in some regions and support the expansion of renewables in power generation. Some countries in this region have significant gas resources (e.g. East Africa), which will provide additional support for gas demand growth. Natural gas demand in Other Developing Countries is projected to increase from 11 mboe/d in 2023 to 21.5 mboe/d in 2050.

In OECD Europe, natural gas demand is expected to continue declining in the medium and long term. This is due to the uncertainty of natural gas supplies from Russia, as well as an increased focus on renewables and nuclear. The REPowerEU programme aims to reduce gas usage for heating, grow the share of renewables in its energy mix, decarbonize industry and increase electrification. Furthermore, more biogas supply is expected in the long term. All of these measures point to negative gas demand growth in OECD Europe. Overall, natural gas demand in the region is seen declining from 8.2 mboe/d in 2023 to 6.4 mboe/d in 2050.

In OECD Americas, gas demand is expected to increase marginally, rising from 18.3 mboe/d in 2023 to 19.1 mboe/d in 2040. Thereafter, demand is anticipated to decline slightly to just under 19 mboe/d towards the end of the forecast period. This development is supported by ample domestic supply at competitive prices, thus replacing coal in electricity generation and supporting the expansion of renewables, by providing baseload electricity supply. OECD Asia-Pacific is also expected to see relatively stable gas demand throughout the outlook period.

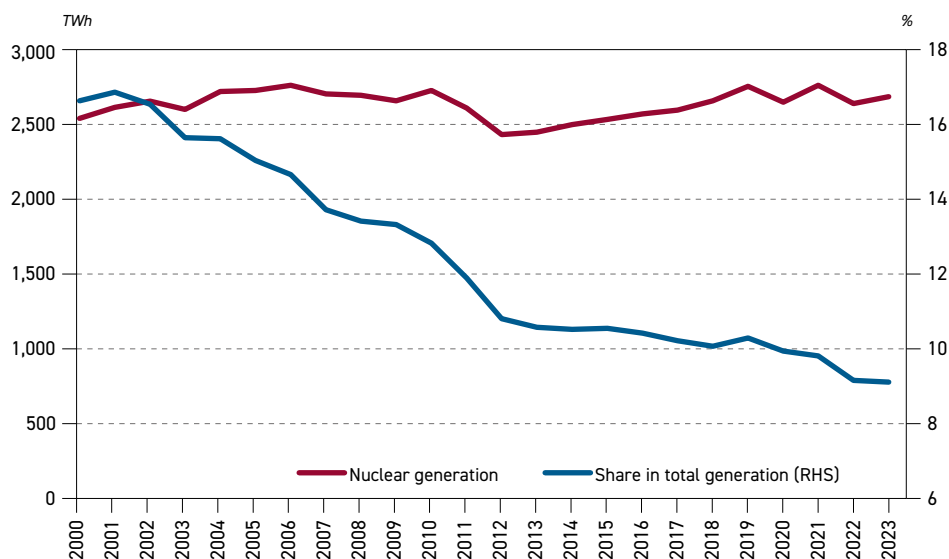
2.3.4 Nuclear

After a strong decline in 2022, global nuclear generation increased marginally in 2023, as several reactors returned to operation (e.g. in France). Looking back, however, global nuclear



power generation has been hovering in a range between 2,400 TWh and 2,800 TWh since 2000. To put this in some context, it is important to note that total electricity generation nearly doubled between 2000 and 2024. Consequently, the share of nuclear energy in power generation has been on a continuous decline, from above 16% in 2000 to almost 9% in 2024 (Figure 2.8).

Figure 2.8
Global nuclear generation and the share in total electricity generation



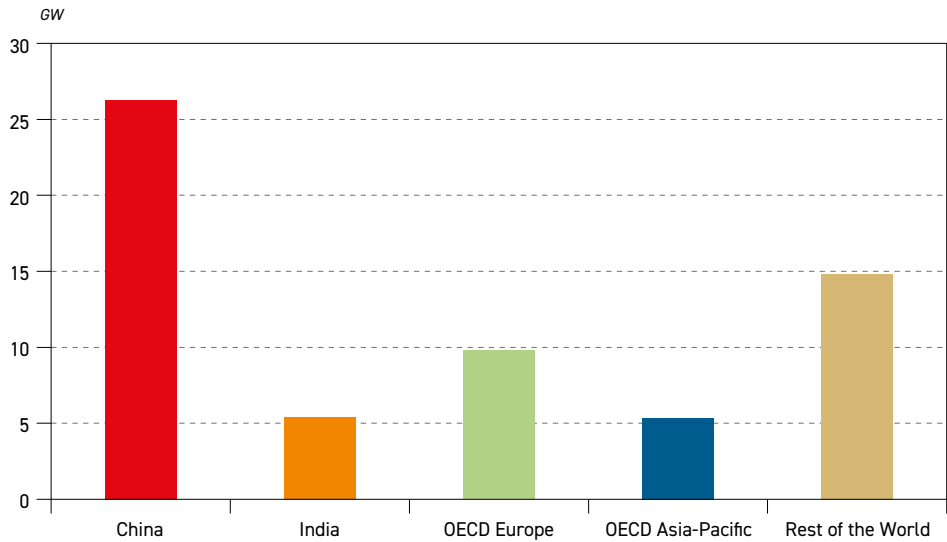
Source: Ember.

One of the major reasons for the relatively weak performance of nuclear power in recent years was the Fukushima disaster of 2011. This led to temporary and permanent shutdowns of nuclear energy in several countries. Following the disaster, Germany decided to phase out all nuclear power plants, the last of which was recently taken off the grid.

Only in recent years has nuclear energy experienced something of a renaissance, due to an increased focus on energy security and energy sustainability, as well as the rising need for a stable baseload power supply. The energy crisis and peaking electricity prices in 2022 also helped shed more positive light on nuclear power. In this context, low variable costs combined with a low carbon footprint have made it a desirable part of the overall energy mix. Furthermore, improved security standards since Fukushima have contributed to wider public acceptance. Many countries have new nuclear projects under construction and the planning and implementation of nuclear power plants is now playing a more important role in long-term strategies.

According to the International Atomic Energy Agency (IAEA), there are 59 reactors (around 61.5 GW) currently under construction, most of which are in the Asia-Pacific and Europe (Figure 2.9). China has more than 26 GW of nuclear capacity under construction, followed by OECD Europe (10 GW), India (5.3 GW) and OECD Asia-Pacific (5.3 GW). Furthermore, several projects in other, mostly developing, countries total almost 15 GW. New capacity additions will help increase nuclear generation, as well as offset losses from the decommissioning of old nuclear power plants in several countries.

Figure 2.9
Nuclear capacity under construction in selected regions, 2023



Source: IAEA.

Further support for rising nuclear generation is expected from lifetime extensions in several regions, including OECD Europe and OECD Asia Pacific (e.g. Japan). In most cases, this is connected to upgraded security measures.

In the medium and long term, a strong policy push will help expand nuclear energy in all regions in the Reference Case. Technological developments related to SMRs and floating nuclear power plants can also help accelerate the deployment of nuclear power in the long term.

As countries recognize the importance of security of supply and acknowledge that renewables alone cannot be the basis of a stable power generation system, many have intensified efforts to expand nuclear generation capacities. This includes OECD regions, as well as several developing countries. Global nuclear demand is projected to increase by around 9.6 mboe/d and reach 24.3 mboe/d in 2050 (Table 2.10 and Figure 2.10).

More than half of the global increment in nuclear demand is projected to materialize in China. The country accounts for more than 40% of global nuclear capacity under construction (more than 26 GW) according to the IAEA. Nuclear power in China cannot be ignored if the country is to reach a peak in CO₂ emissions by 2030. Nuclear would additionally help provide balance to the power generation system. According to the 14th FYP, China was expected to reach 70 GW of installed nuclear capacity by 2025, from its current level of 54 GW.

Nuclear demand in India is set to rise from 0.3 mboe/d in 2023 to 1.5 mboe/d in 2050. The official target of the Indian government is to reach an installed nuclear capacity of 22.5 GW by 2031. The country currently has almost 7 GW of capacity in operation, as well as 5.4 GW of capacity under construction. In OPEC Member Countries, nuclear power is expected to reach 0.6 mboe/d in 2050, as several Member Countries have started investing in nuclear energy. Additional nuclear energy totaling almost 1 mboe/d is expected to be developed in Russia and Other Eurasia.

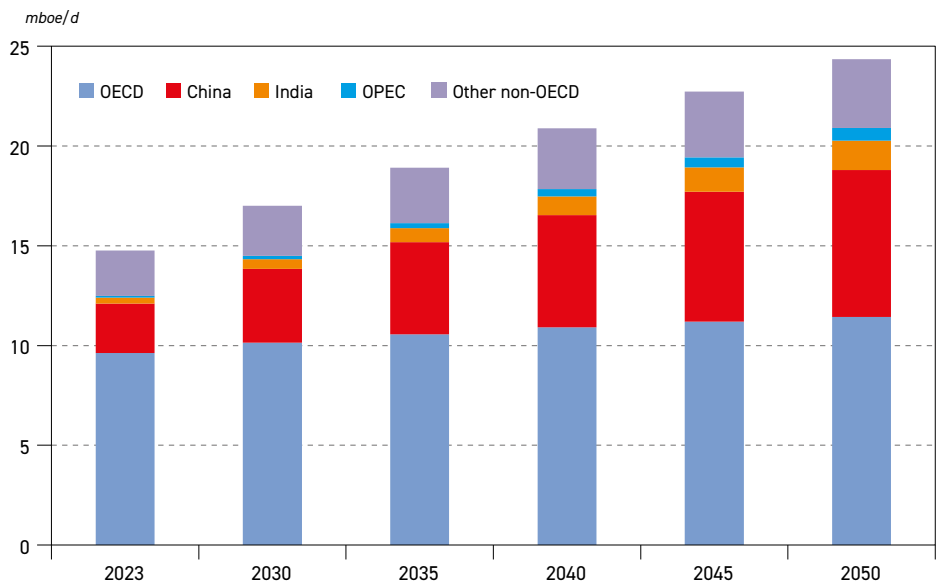


Table 2.10
Nuclear demand by region, 2023–2050

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2023	2030	2035	2040	2045	2050	2023–2050	2023–2050	2023	2050
OECD Americas	4.7	4.8	4.9	5.0	5.0	5.1	0.4	0.3	32.0	20.9
OECD Europe	3.6	3.6	3.7	3.8	3.8	3.9	0.2	0.2	24.5	15.9
OECD Asia-Pacific	1.3	1.7	2.0	2.2	2.4	2.5	1.2	2.5	8.6	10.2
OECD	9.6	10.1	10.6	10.9	11.2	11.4	1.8	0.6	65.1	47.0
China	2.5	3.7	4.6	5.6	6.5	7.4	4.9	4.1	16.8	30.2
India	0.3	0.5	0.7	0.9	1.2	1.5	1.2	6.2	1.9	6.0
OPEC	0.1	0.2	0.2	0.4	0.5	0.6	0.5	7.8	0.6	2.6
Other DCs	0.4	0.5	0.6	0.6	0.6	0.7	0.2	1.5	3.0	2.7
Russia	1.2	1.3	1.4	1.5	1.6	1.7	0.5	1.4	8.1	7.1
Other Eurasia	0.7	0.8	0.9	0.9	1.0	1.1	0.4	1.8	4.5	4.4
Non-OECD	5.1	6.9	8.3	10.0	11.5	12.9	7.8	3.5	34.9	53.0
World	14.8	17.0	18.9	20.9	22.7	24.3	9.6	1.9	100.0	100.0

Source: OPEC.

Figure 2.10
Nuclear energy demand by region, 2023–2050



Source: OPEC.

In the OECD, the largest increase in nuclear power is projected for OECD Asia-Pacific. This is in line with the restart of nuclear power plants in Japan, along with lifetime expansions of some plants from 40 to 60 years. In addition, several new plants in Japan and South Korea are under construction. This is why nuclear demand in OECD Asia-Pacific is projected to

increase by 1.2 mboe/d to 2.5 mboe/d in 2050. In the long term, nuclear power demand in OECD Americas and OECD Europe is expected to increase by 0.4 mboe/d and 0.2 mboe/d, respectively. Several countries are planning to renew their nuclear power plant fleets, including the US, France and the UK.

2.3.5 Hydro

Hydropower is an important part of the expansion of energy systems in many regions, especially in developing countries within Asia, Africa and Latin America, where there are still large, unused hydro resources. Hydropower storage plants can contribute to balancing the electricity system and supporting the expansion of intermittent renewables. Globally, around 130 GW of hydro capacity is under construction and 160 GW is planned. However, due to high capital costs and long lead times for many hydro projects, the build-up of hydropower is a rather slow process.

The Reference Case projects hydropower demand is set to rise from 7.6 mboe/d in 2023 to 11.6 mboe/d in 2050 (Table 2.11 and Figure 2.11), an increase of 4 mboe/d. The largest expansion is expected in China, where there are significant unused resources, with an expected increase of almost 1 mboe/d.

Hydropower demand is projected to increase in Other Developing Countries, as well as India. The incremental cumulative demand to 2050 for these regions is projected at 2.2 mboe/d, reaching 4.3 mboe/d in 2050.

In OECD Americas, hydro demand is set to increase by roughly 0.4 mboe/d to 1.7 mboe/d throughout the outlook period. North America still has sufficient hydro resources to support this growth. In addition, hydro projects are likely to benefit from the Inflation Reduction Act (IRA) in the US, adopted in 2022, as well as Canada's 2023 budget, which has supportive tax

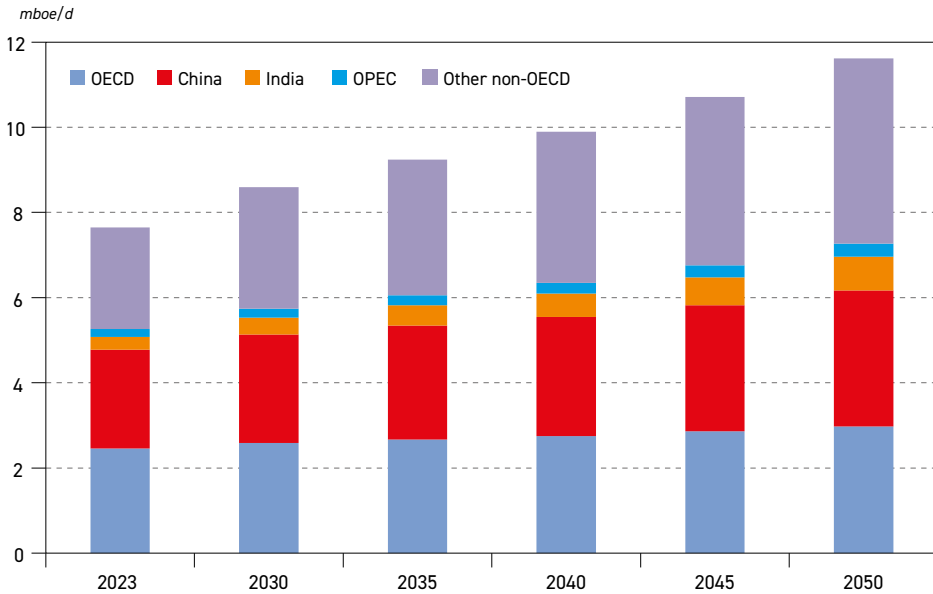
Table 2.11
Hydro demand by region, 2023–2050

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2023	2030	2035	2040	2045	2050	2023–2050	2023–2050	2023	2050
OECD Americas	1.4	1.4	1.5	1.6	1.6	1.7	0.4	0.9	17.9	14.8
OECD Europe	0.9	0.9	0.9	0.9	1.0	1.0	0.1	0.5	11.3	8.5
OECD Asia-Pacific	0.2	0.2	0.2	0.3	0.3	0.3	0.0	0.6	3.0	2.3
OECD	2.5	2.6	2.7	2.8	2.9	3.0	0.5	0.7	32.2	25.6
China	2.3	2.6	2.7	2.8	3.0	3.2	0.9	1.2	30.3	27.5
India	0.3	0.4	0.5	0.5	0.7	0.8	0.5	3.6	4.0	6.8
OPEC	0.2	0.2	0.2	0.3	0.3	0.3	0.1	2.0	2.4	2.7
Other DCs	1.8	2.2	2.5	2.8	3.2	3.5	1.7	2.5	23.2	30.0
Russia	0.4	0.4	0.4	0.4	0.5	0.5	0.1	1.1	4.9	4.4
Other Eurasia	0.2	0.3	0.3	0.3	0.3	0.3	0.1	1.5	3.0	2.9
Non-OECD	5.2	6.0	6.6	7.1	7.9	8.6	3.5	1.9	67.8	74.4
World	7.6	8.6	9.2	9.9	10.7	11.6	4.0	1.6	100.0	100.0

Source: OPEC.



Figure 2.11
Hydro demand by region, 2023–2050



Source: OPEC.

schemes. In OECD Europe, the expansion of hydropower is limited, as available resources have been mostly utilized. Total hydropower demand in this region is anticipated to reach 1 mboe/d in 2050, inching up from 2023 levels.

2.3.6 Biomass

The share of biomass in the primary energy mix was around 9.7% in 2023, which is significant, bearing in mind that the share of other renewables in the same year was only 3.2% and hydropower was at 2.5%. A large part of biomass is currently consumed in developing countries and regions, such as South Asia and sub-Saharan Africa, in the form of traditional applications, such as residential heating and cooking. Through the alleviation of energy poverty and increasing access to more modern energy sources (including oil, natural gas and renewables), it can be assumed that demand for traditional biomass will continue falling in the future.

At the same time, demand for advanced biomass and its variety of derivatives is likely to increase, particularly in developed countries. Energy and climate-change policies and related mandates, as well as subsidies, are the main support for this trend. Advanced applications of biomass include biofuels (biodiesel, ethanol, as well as bio jet fuel), biogas and/or bioplastics, and the advanced use of biomass can be important for residential and industrial heat and generating electricity.

The growth potential of biomass as an energy source, even in its advanced application, is limited by resource availability. This includes conflict over the use of agricultural land for food or biomass production, but also increasing demand for land using nature-based solutions that are considered to ensure healthy ecosystems. The challenges facing biomass and/or waste collecting makes the overall process even more expensive and less competitive compared with traditional fuels.

In this outlook, the average growth of global biomass energy demand is projected at 0.9% p.a. for the outlook period, resulting in global demand of 37.4 mboe/d by 2050 (Table 2.12). Biomass is set to increase its share of global primary energy demand from 9.7% in 2023 to just above 10% in 2050. The greater use of biomass is projected in almost all the world's regions, OECD and non-OECD countries alike. The intensified policy focus on energy security also supports growing demand for biomass.

Table 2.12
Biomass demand by region, 2023–2050

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2023	2030	2035	2040	2045	2050	2023–2050	2023–2050	2023	2050
OECD Americas	3.0	3.2	3.4	3.6	3.9	4.1	1.2	1.2	10.2	11.1
OECD Europe	3.7	4.3	4.7	5.0	5.3	5.5	1.9	1.5	12.6	14.8
OECD Asia-Pacific	0.6	0.7	0.8	0.8	0.8	0.9	0.3	1.3	2.1	2.3
OECD	7.3	8.2	8.8	9.5	10.0	10.5	3.3	1.4	24.9	28.2
China	3.0	3.6	4.0	4.2	4.4	4.5	1.6	1.6	10.2	12.2
India	4.2	4.4	4.4	4.4	4.4	4.4	0.2	0.2	14.3	11.7
OPEC	2.8	2.9	3.0	3.0	3.1	3.0	0.2	0.3	9.6	8.1
Other DCs	11.2	12.2	12.8	13.3	13.4	13.5	2.3	0.7	38.5	36.3
Russia	0.2	0.3	0.3	0.4	0.4	0.5	0.3	3.2	0.8	1.4
Other Eurasia	0.5	0.6	0.6	0.7	0.7	0.8	0.3	1.7	1.7	2.1
Non-OECD	21.9	24.0	25.1	26.1	26.5	26.8	5.0	0.8	75.1	71.8
World	29.1	32.1	34.0	35.5	36.5	37.4	8.2	0.9	100.0	100.0

Source: OPEC.

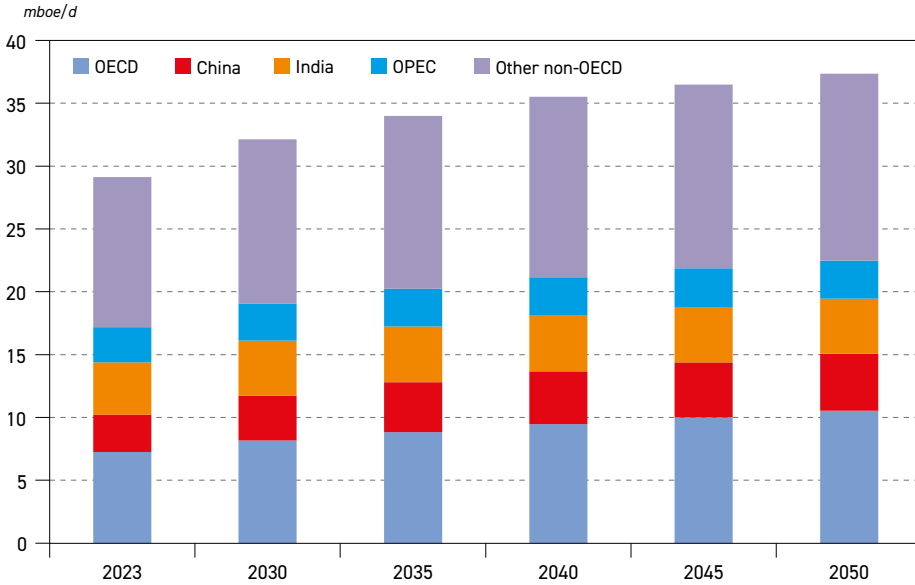
Figure 2.12 shows the projected development of biomass demand and its regional distribution. In the OECD, biomass is used mainly for heating, electricity generation and the production of liquid and/or gaseous biofuels. However, biomass use will have to increase to meet future policy targets. This is particularly the case in the aviation sector, as well as for biogas.

In OECD Europe, biomass demand is expected to increase from 3.7 mboe/d in 2023 to 5.5 mboe/d in 2050. This growth is driven by policies that require increasing levels of biofuels in the transport sector, including SAF for aviation. For instance, the EU's ReFuelEU programme foresees SAF at 2% of the total fuel requirement in the EU by 2025. This mandate will increase to 6% in 2030 and potentially to 20% by 2035. At the same time, increasing demand for biogas production is expected, which will partly replace natural gas in some countries in the future.

In OECD Americas, biomass demand is projected to increase by about 1.2 mboe/d, reaching 4.1 mboe/d in 2050. In addition to existing ethanol production, the US is supporting efforts to increase the production of SAF from biomass. The current US Administration sees SAF supply steeply increasing from just below 16 million gallons in 2021 to 3 billion gallons by 2030.



Figure 2.12
Biomass demand by region, 2023–2050



Source: OPEC.

In the non-OECD region, the largest increase in biomass use is expected in China, which increases by 1.6 mboe/d over the outlook period to 4.5 mboe/d in 2050. It will be supported by the replacement of coal with solid biomass in existing plants, an increase in biofuels for transport, and the advanced use of biomass for biogas and electricity and/or heat generation. Traditional biomass use for residential heating is projected to decline as biomass is replaced by oil and gas.

In India, biomass use is expected to increase marginally, by around 0.2 mboe/d in the period to 2050. This mirrors an expected decline in the traditional use of biomass and its replacement by more modern energy sources. The modern uses of biomass for power generation and biofuels is expanding, resulting in modest net growth. A recent amendment to India's National Policy on Biofuels focuses on reducing the import of petroleum products and bringing forward the deadline to reach a blending target of 20% biofuel to 2025/2026 from 2030. Biofuels play an important role in India's strategy, as they also support the ambitious targets of doubling farmers' incomes and reducing air pollution.

Biomass use in Other Developing Countries is expected to increase by 2.3 mboe/d to 13.5 mboe/d in 2050, which mostly reflects an increase in the advanced use of biomass. This more than offsets a drop in traditional usage.

2.3.7 Other renewables

Other renewables (mostly wind and solar, but also geothermal and tidal) have seen record-high capacity additions in recent years. In 2023 alone, an astonishing 510 GW of renewable capacity was installed at the global level, a record-high annual addition. Almost 75% of the global capacity addition is attributed to solar PV. This is partly due to a strong decline in the cost of solar PV modules in China and rising PV production capacity. At the same time, wind

power experienced difficulties in several regions due to the higher cost of capital, which made new wind projects less competitive, with many delayed or even cancelled.

At the regional level, almost 60% of 2023 capacity additions occurred in China. Consequently, total renewable capacity climbed to nearly 3.9 TW by the end of the year. This is a doubling since 2015, mostly due to the expansion of solar and wind capacity.

In recent years, many countries have increased commitments and targets related to wind and solar capacity. This should help to not only substitute coal and/or gas in power generation and thus reduce CO₂ emissions, but also facilitate a higher degree of energy security. It is expected that the LCOE will continue to decline in the long term, albeit significantly slower than in recent years. Ongoing technological and efficiency improvements, as well as economies of scale, play an important role in declining LCOE.

Nevertheless, while the LCOE is an important factor in the competitiveness of renewables, it largely ignores many other cost components. Generally, the higher the share of renewables, the higher the cost of system integration. A rising share of intermittent energy sources in the generation mix requires significantly higher levels of balancing and ancillary services provided by dispatchable power plants (mostly thermal) and, potentially, various demand-side measures, as well as storage (e.g. batteries and/or hydrogen). Additional renewable capacity requires significant additional investment in transmission and distribution grids, as insufficient grid capacity can often lead to curtailment. Grids have to provide sufficient capacity during peak load hours from wind and solar plants and be increasingly flexible.

Thus, insufficient investment in balancing options and grid expansion may hinder further investment into power generation capacities. Thus, countries must face the real cost of wind and solar plant production and ensure sufficient infrastructure investment, if renewable growth is to be ensured. This will often depend on local power market circumstances.

Despite numerous challenges in increasing the deployment of renewable energy, the Reference Case projects strong medium- and long-term growth of other renewables across all regions. Demand is expected to increase from nearly 9.6 mboe/d in 2023 to 52.4 mboe/d in 2050, representing growth of almost 43 mboe/d, or average growth of 6.5% p.a. Other renewables show the largest incremental demand addition, as well as the fastest growth.

Table 2.13 shows the long-term outlook for other renewables by region. China is expected to see the highest incremental demand of 11.4 mboe/d. China's efforts to reach a CO₂ emissions peak by 2030 and carbon neutrality by 2060 are the main drivers behind the increase. In addition, China has become a major producer of solar panels, wind turbines, storage solutions and other related equipment. Increasing production capacities have enabled a lowering of costs through economies of scale.

India is projected to increase its other renewables demand by almost 5 mboe/d, from a level of only 0.4 mboe/d in 2025. The official target of 500 GW of installed renewable capacity (mostly wind and solar) by 2030 requires much faster deployment of renewables than has occurred in recent years if it is to be achieved.

In OPEC Member Countries, other renewables demand is projected at 6.2 mboe/d in 2050, up from only 0.2 mboe/d in 2023. This represents average annual growth of more than 14% p.a. Many countries in the Middle East, including Saudi Arabia and the UAE, have announced



Table 2.13

'Other renewables' demand by region, 2023–2050

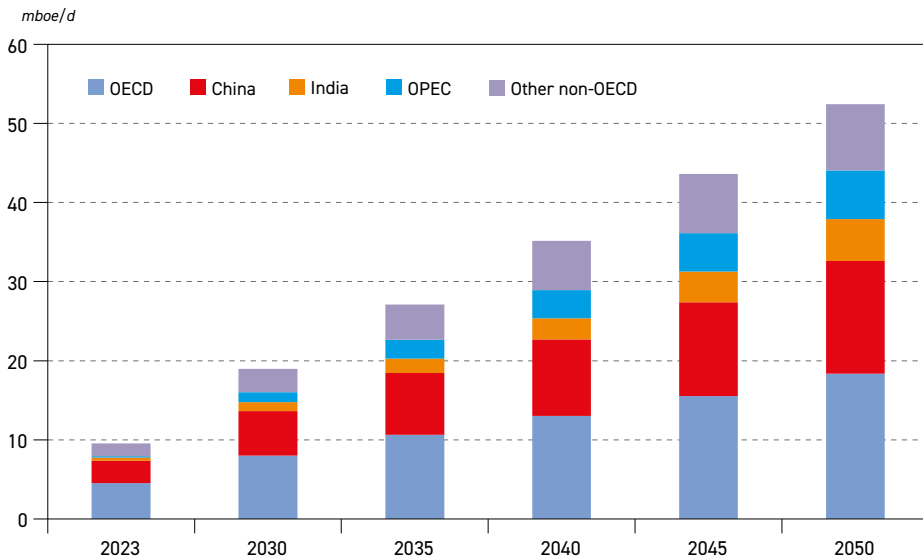
	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2023	2030	2035	2040	2045	2050			2023	2050
OECD Americas	1.8	3.3	4.5	5.6	7.0	8.5	6.7	6.0	18.6	16.1
OECD Europe	2.1	3.5	4.4	5.2	5.8	6.6	4.4	4.3	22.3	12.5
OECD Asia-Pacific	0.6	1.2	1.7	2.2	2.7	3.3	2.7	6.5	6.4	6.3
OECD	4.5	8.0	10.6	13.0	15.5	18.3	13.8	5.3	47.2	35.0
China	2.9	5.6	7.8	9.7	11.9	14.2	11.4	6.1	29.9	27.2
India	0.4	1.2	1.8	2.7	3.9	5.3	4.9	9.9	4.3	10.1
OPEC	0.2	1.2	2.4	3.6	4.9	6.2	6.0	14.3	1.7	11.8
Other DCs	1.5	2.7	3.9	5.1	5.8	5.9	4.3	5.1	15.9	11.2
Russia	0.0	0.1	0.2	0.4	0.6	0.8	0.8	14.9	0.2	1.6
Other Eurasia	0.1	0.2	0.4	0.7	1.1	1.7	1.6	12.1	0.8	3.2
Non-OECD	5.0	10.9	16.5	22.1	28.1	34.1	29.0	7.3	52.8	65.0
World	9.6	19.0	27.1	35.1	43.6	52.4	42.9	6.5	100.0	100.0

Source: OPEC.

ambitious medium- and long-term targets related to renewables (mostly PV solar). Some of the new PV projects in the Middle East are huge in size, exceeding 1 GW capacity, given the available land. Most of these projects have short payback periods, due to the competitive low cost of generation. Renewables should help diversify the power generation mix and reduce the consumption of oil in electricity generation.

Figure 2.13

'Other renewables' demand by region, 2023–2050



Source: OPEC.

Other Developing Countries (mostly Asia and Africa) are expected to increase demand for other renewables from 1.5 mboe/d in 2023 to almost 6 mboe/d in 2050. The expansion of other renewables will in some cases help address issues related to energy access and energy poverty through more local and distributed generation.

In the OECD region, other renewables are projected to increase by 13.8 mboe/d, based on strong policy support and energy security concerns. In OECD Americas alone, demand is seen increasing by 6.7 mboe/d to almost 8.5 mboe/d in 2050. The IRA supports the expansion of wind and solar power with generous tax credits in the US. Vast available resources help to increase wind and solar capacity at a much faster rate than in OECD Europe or OECD Asia-Pacific.

In OECD Europe, other renewables are projected to increase to 6.6 mboe/d in 2050, up from 2.1 mboe/d in 2023. The EU Green Deal, as well as the REPowerEU programme, seek to strongly increase the share of renewables in the medium and long term. In OECD Asia-Pacific, other renewables are set to reach 3.3 mboe/d in 2050, up from 0.6 mboe/d in 2023, mostly in Japan and Australia.

2.4 Energy intensity and consumption per capita

This section highlights the evolution and projections of energy intensity globally and in selected regions. Energy intensity is defined as the ratio of energy used per unit of GDP and is a measure used to assess the energy efficiency of an economy. When energy efficiency increases, energy intensity decreases, indicating that more economic value is obtained from each unit of energy consumed.

However, energy intensity figures and trends can vary greatly across regions and countries due to several factors. These include economic structure, level of economic development, demographics, climate and urbanization levels. These factors introduce complexities that need to be considered to gain a comprehensive understanding of the energy efficiency landscape.

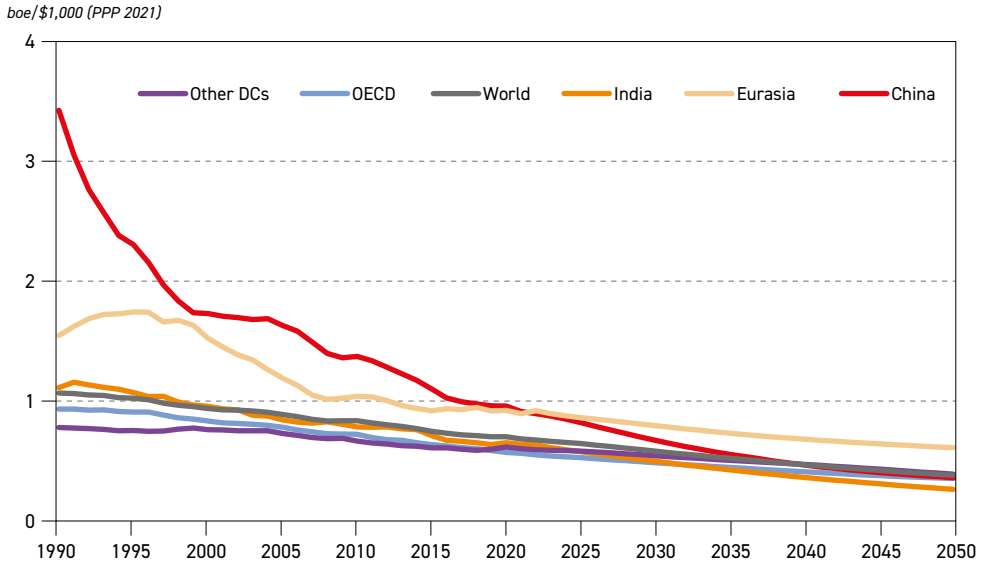
Global energy intensity trends (Figure 2.14) indicate that despite the global economy being approximately three times larger in 2023 compared with 1990, energy demand only increased by a factor of around 1.7. This demonstrates the positive impact of energy efficiency improvements achieved over this period. These improvements can be largely attributed to technological advancements (including energy efficiency), various policy interventions, as well as renewable energy deployment, such as wind and solar, which have played a crucial role in improving energy efficiency and reducing the amount of energy required to produce a unit of GDP.

At a country level, China and India have made significant improvements in terms of energy efficiency throughout the period 1990–2023. This is due to some key initiatives and strategies undertaken by their respective governments. The Chinese government, for instance, has put energy intensity reduction as one of the country's top priorities and has made significant progress in energy conservation over the past three decades.

Most OECD countries have already recorded substantial improvements in energy intensity, whereby technological progress and the growing number of energy efficiency policies have played a key role. These countries continue to prioritize energy efficiency as a critical aspect of their sustainable development goals for the future.



Figure 2.14
Evolution and projections of energy intensity in major world regions, 1990–2050



Source: OPEC.

Over the long term, energy efficiency improvements are expected to continue at a similar pace and converge in most regions. This suggests that ongoing technological developments and supportive policies will contribute to further reductions in energy intensity. Figure 2.15 illustrates energy intensity performance across selected regions. Energy intensity is expected to decline in all major regions, leading to a global reduction rate of more than 2% p.a. on average between 2023 and 2050. However, it should be noted that reduction rates fluctuate strongly from one region to another.

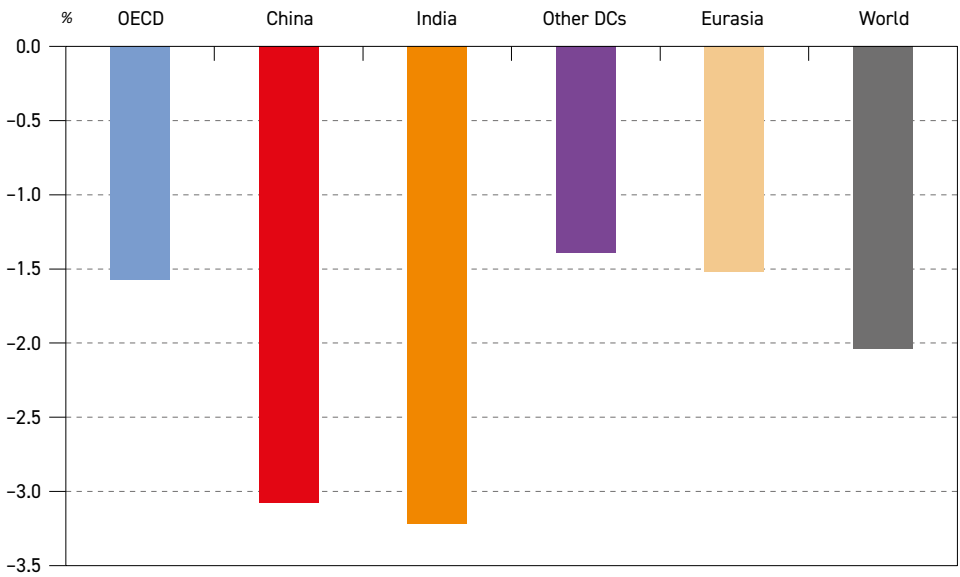
For example, India and China are expected to witness the largest energy intensity reductions, with annual average reduction rates of 3.2% and 3.1%, respectively, in this period. The main contributors are expected to be a continuing decline in coal use, which is projected to be halved by the end of the outlook period. This comes from substitution by natural gas, and in part renewables, as well as the more efficient use of primary energy.

OECD countries have made a lot of progress thus far and are using energy more efficiently than any other region. Energy efficiency improvements in this region are expected to continue at a steady rate of 1.6% p.a. throughout the outlook period.

In Other Developing Countries and Eurasia, a more gradual advancement in energy efficiency is anticipated, with improvement rates of 1.4% and 1.5% p.a., respectively. This slower pace reflects the various challenges and limitations these areas face in implementing advanced energy solutions and technologies. Factors such as economic constraints and technological accessibility can influence the ability of these regions to rapidly improve energy efficiency.

Another crucial issue at the global level is energy poverty and access to clean and affordable energy. It is important to note that energy poverty had seen significant improvements in the

Figure 2.15
Average annual rate of improvement in global and regional energy intensity, 2023–2050



Source: OPEC.

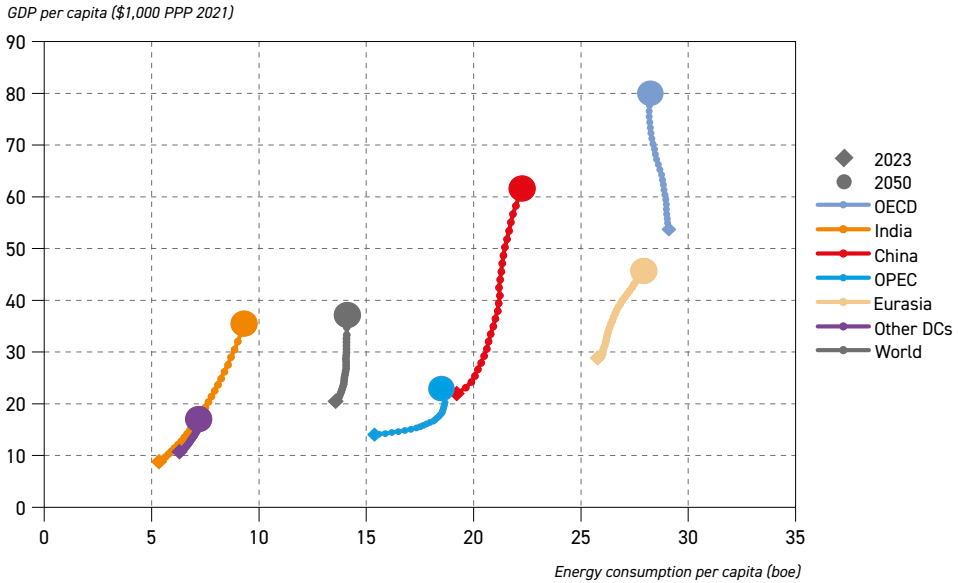
years prior to COVID-19 and the recent energy crisis. These two events had a negative impact on access to energy in developing countries, as well as energy affordability. Historically, there has been a substantial disparity in energy consumption per capita between the OECD and non-OECD regions. In the 1970s, the OECD’s average energy consumption was almost 27 barrels of oil equivalent (boe) per capita, while developing countries lagged far behind with only around 5 boe per capita. In India, where energy consumption levels were even lower, the figure was below 1.6 boe per capita.

Since the 1970s, the gap between the OECD and non-OECD regions has not narrowed significantly. However, the rapid economic expansion, especially in developing Asian countries, has had a positive impact. This growth has lifted millions of people out of energy and economic poverty, expanded the middle classes, and consequently increased access to energy. However, it is crucial to recognize that energy poverty remains a significant concern that policymakers need to urgently address (Figure 2.16).

In the long term, the non-OECD region is projected to experience continued economic growth, which will be accompanied by increasing electrification, rising income levels, urbanization and an expanding middle class. This growth trajectory is expected to be particularly evident in China and India, the two largest economies in the region.

In China, average per capita energy consumption is expected to rise, from below 19 boe in 2023 to approximately 22 boe in 2050. In India, average consumption is anticipated to increase significantly from almost 5.5 boe in 2023 to roughly 9.3 boe by 2050. India is also set to have the highest long-term energy demand growth rate among developing countries. Other Developing Countries are expected to witness a moderate improvement in energy consumption per capita, from 6.5 boe in 2023 to 7.2 boe in 2050, which is only a quarter of the energy consumption per capita of the OECD region.

Figure 2.16
Energy consumption per capita versus GDP at PPP per capita, 2023–2050



Source: OPEC.

In contrast, the OECD region, characterized by service-oriented economies, is projected to witness an ongoing decline in energy consumption per capita, a trend that has been moving forward since 2004. This decline indicates a decoupling of GDP growth and energy demand, primarily driven by advancements in technology and policy-driven energy efficiency improvements. The rising share of renewables is also contributing to this trend. The projected outlook suggests that energy consumption per capita in the OECD will drop from approximately 29 boe in 2023 to 28.2 boe in 2050. Figure 2.16 presents the relationship between energy demand per capita and GDP (income) per capita for the selected regions.

Despite optimistic projections for some regions, the global challenge of energy poverty remains acute. The persisting gap between developed and developing countries calls for a global and multilateral approach, with inclusive collaboration to the fore. Concerted efforts by policymakers around the world are essential to ensure that all have access to affordable and clean energy. Targeting 'maximum energy, minimum emissions,' the pathway forward includes managing an orderly energy transition that tackles the vital challenges of energy security, affordability and sustainability. For the future, it is crucial that investment and financing in the energy systems adopt an 'all-peoples, all-fuels and all-technologies' approach, to ensure that no one is left behind.

Oil demand



Key takeaways

- The current energy policies debate calls for energy transition pathways in which countries move in parallel, albeit at different speeds and in multiple ways that reflect their specific circumstances.
- Global oil demand is projected to reach 112.3 mb/d in 2029, representing a robust increase of 10.1 mb/d compared to 2023.
- Non-OECD oil demand is projected to increase by 9.6 mb/d between 2023 and 2029 to reach more than 66 mb/d. In contrast, OECD demand is set to drop by 0.5 mb/d over the same period.
- In the long term, global oil demand is projected to rise by almost 18 mb/d from 102.2 mb/d in 2023 to 120.1 mb/d in 2050.
- Long-term projections show a contrasting picture between continued strong demand growth in non-OECD and declining demand in OECD. While non-OECD demand is projected to increase by 28 mb/d between 2023 and 2050, OECD demand is set to drop by more than 10 mb/d.
- Extending the time horizon of this WOO to 2050 amplifies the role of India, Other Asia, the Middle East and Africa as key sources of incremental demand growth. Combined demand in these four regions is set to increase by 22 mb/d between 2023 and 2050.
- India alone is set to add 8 mb/d to its oil demand during the outlook period.
- China's oil demand is projected to increase by 2.5 mb/d over the outlook period. This demand increase is front-loaded, however, with around 2.2 mb/d materializing over the current decade.
- The largest incremental demand growth over the outlook period is projected for the petrochemicals, road transportation and aviation sectors. Oil demand in these sectors is set to increase by 4.9 mb/d, 4.6 mb/d and 4.2 mb/d, respectively.
- Road transportation demand projections indicate strong growth within the next ten years, before it stabilizes at levels above 50 mb/d for the rest of the outlook period.
- The global vehicle fleet is expected to increase from 1.7 billion in 2023 to 2.9 billion in 2050 with the fastest growth expected in the EVs segment. Nevertheless, ICE-based vehicles are set to continue to dominate the global fleet over the outlook period and still account for more than 70% in 2050.
- With respect to refined products, major long-term demand growth is expected for ethane/liquefied petroleum gas (4.2 mb/d), followed by jet/kerosene (4.0 mb/d), gasoil/diesel (3.5 mb/d), naphtha (2.8 mb/d) and gasoline (2.5 mb/d).

Last year's Outlook included a significant upward oil demand revision, compared to previous editions. This was a reflection of an ongoing shift in the narrative related to energy transitions as governments and policymakers reevaluated their sustainable energy pathways. At the fore of concerns were issues related to energy security and affordability. On the back of geopolitical tensions, there was a broad realization across many societies, especially in Europe, but also more generally in the Global North, on the need for energy security to go hand-in-hand with economic development and reducing emissions. At the same time, countries in the Global South raised their voices that energy unaffordability prevents them from improving accessibility and made it clear that these issues are central for their future energy transition pathways.

Developments since then clearly indicate that the public debate about these issues has broadened further, highlighting the need for solutions that enable the Global South to improve accessibility first, before sustainability issues are addressed. Past debate on energy transitions was guided by the concept of a 'green' energy transition, focusing almost exclusively on replacing fossil fuels by renewable energy and pushed primarily by Europe. This concept created a very narrow pathway with limited transition options that did not work even for developed countries, not to mention developing countries. Instead, the current debate calls for building pathways for the whole world where countries can move in parallel, albeit at different speeds and in multiple ways that reflect their specific circumstances.

In doing so, it is important that policymakers take the lessons learnt from past developments. One of them was the overly optimistic expectation that the cost of deploying renewable energy will continue to decline significantly with technological progress and economies of scale. A reminder is needed that this theoretical concept only works assuming that everything else remains constant. This, however, is not the case in reality as other barriers (geopolitics, inflation, trade barriers, taxes etc.) can gradually emerge, which can offset the impact of technological progress. Over the past year, there have been a number of renewable projects that have been reassessed, deferred or even canceled due to unfavourable economics.

The next large expectation is that the cost of EVs will drop significantly in the years to come, hence, considerably impacting global oil demand. The lessons learned related to renewables, however, calls for a more cautious expectation on EVs too. This is especially true when observing the recent decisions of several major car manufacturers to delay investments in increasing EV production capacity, as well as reassess their strategy targets. This shift is also visible at the policy level. Recent examples include a much softer proposal for the Euro 7 emission norm, compared to its first proposal, discussions about the US EPA emission standards for model year 2027+ vehicles, and the UK's decision to shift the sales ban on ICEs to 2035.

To be clear, the cost of EVs and renewable electricity will likely decline further, and EV sales and renewable capacity will increase in the years to come. The underlying message is about the rate of growth, a cautious warning against an overly ambitious expectation of how fast they will penetrate energy markets and substitute oil-based products. This reflects another lesson from the past years that energy policies alone, regardless of how ambitious they are, are not sufficient to drive energy transitions. In fact, realistic energy policies must meet technological readiness and working economics to be successful. If these crucial components do not go hand-in-hand, the most frequent result is energy scarcity created by policy design.

Besides continued policy discussion on the direction of energy transitions, there have been a number of other developments impacting future oil demand. Inflationary pressure has eased somewhat since the time of publishing of the last Outlook, which has allowed central banks



to put further fiscal tightening on hold and even start considering a reversal to lower interest rates. This, in turn, has brightened economic prospects in several countries and regions, at least in the medium term.

Good progress has also been made in achieving better energy efficiency across all sectors of consumption. Examples included the aviation sector, smarter grids, further replacement of traditional materials by petrochemical products, and the introduction of mobile CCUS technologies for trucks and ships. The use of AI to improve and optimize processes, especially for maintenance work in large energy facilities and distribution networks has also attracted a lot of attention although its net impact on energy demand is still to be fully determined. Remarkable growth was also achieved in the sales of EVs in China, although EV growth in other regions has been much less impressive. At the same time, however, overall vehicle sales increased after weak pandemic years, hence, supporting continued oil demand growth.

This was clearly seen during 2023 when oil demand proved to be resilient to downward revisions and finished with an annual increase of 2.6 mb/d. Relatively strong demand growth is also projected for 2024 and beyond, resulting in another upward revision to long-term global oil demand. This chapter tries to capture these demand trends at the regional, sectoral and product level, and identify critical factors that will steer future demand in the period to 2050.

3.1 Oil demand outlook by region

Following the largest annual oil demand decline in history of 9.1 mb/d in 2020 on the back of the COVID-19 pandemic, demand was on a recovery path during the years 2021–2023. This recovery broadly concluded during 2023 when oil demand increased by 2.6 mb/d, despite high energy prices, high inflationary pressure, geopolitical tensions and a slowdown in global economic growth to 3.1%, compared to 3.3% in 2022.

The strong demand growth in 2023 was the result of a combination of factors. Almost half of this demand increase took place in China. This was partly due to integral growth linked to economic development, including the correction of a misaligned link between oil demand and economic activity, and partly a recovery from the lockdowns experienced in 2022, especially in the road transportation and aviation sectors. These two factors also largely explain the 2023 demand growth in other developing countries that accounted for another 1.1 mb/d in total. Moreover, a policy shift to focus more on energy security and energy access also played a role in this group of countries.

Looking ahead, these factors will continue to play a role, although with varying impacts. Evidently, the demand recovery impact from the COVID-19 recovery will continue to diminish, with the aviation sector being the last one still effected by the scars of the pandemic. Finding a new equilibrium link between oil demand and economic activity will likely take longer, while the implications of policy shifts will increasingly play a role in the longer term.

It is important to note that a large part of the 2023 demand growth took place in developing Asia and the Middle East. Combined, these two regions accounted for 2.1 mb/d of the incremental demand. The remaining non-OECD regions contributed 0.4 mb/d, while oil demand in the OECD only increased by 0.1 mb/d. This is a clear indication that demand growth is shifting even further to non-OECD regions and the link between economic growth and oil demand in the OECD is weakening – a trend that is expected to accelerate in the years to come.

A confirmation of this trend is clearly visible in Table 3.1 and Figure 3.1, which outline oil demand prospects at the regional and global levels in the period to 2029.

Table 3.1
Medium-term oil demand in the Reference Case

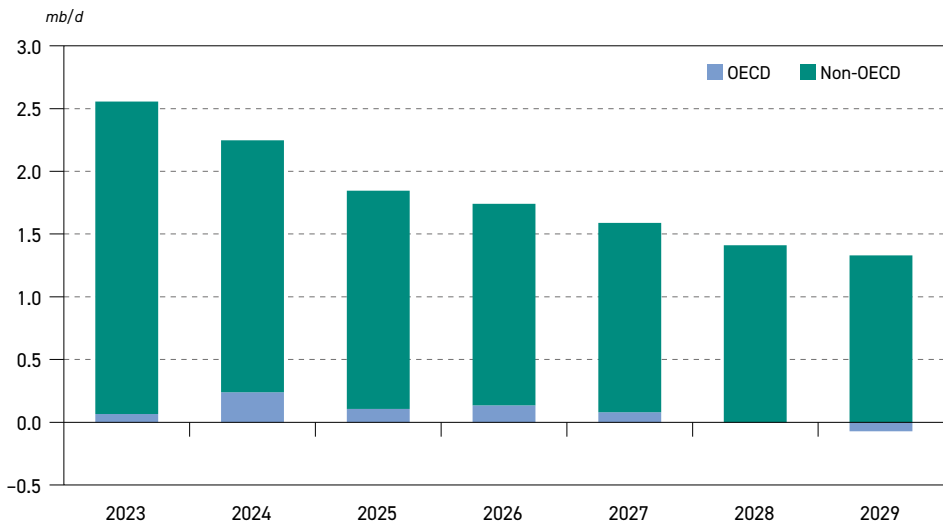
mb/d

	2023	2024	2025	2026	2027	2028	2029	Growth 2023–2029
OECD Americas	25.0	25.2	25.3	25.4	25.5	25.6	25.7	0.7
OECD Europe	13.4	13.5	13.5	13.5	13.4	13.3	13.2	–0.2
OECD Asia-Pacific	7.2	7.2	7.3	7.3	7.3	7.3	7.2	0.0
OECD	45.7	45.9	46.0	46.1	46.2	46.2	46.1	0.5
China	16.4	17.1	17.5	17.8	18.0	18.2	18.4	2.0
India	5.3	5.6	5.8	6.0	6.3	6.6	6.9	1.5
Other Asia	9.3	9.6	9.9	10.2	10.5	10.8	11.0	1.7
Latin America	6.7	6.9	7.1	7.3	7.5	7.7	7.8	1.2
Middle East	8.6	8.9	9.3	9.7	10.0	10.3	10.6	1.9
Africa	4.5	4.6	4.7	4.8	4.9	5.1	5.2	0.8
Russia	3.8	3.9	4.0	4.0	4.1	4.1	4.1	0.3
Other Eurasia	1.2	1.2	1.3	1.3	1.3	1.3	1.4	0.2
Other Europe	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.0
Non-OECD	56.6	58.6	60.3	61.9	63.4	64.8	66.2	9.6
World	102.2	104.5	106.3	108.0	109.6	111.0	112.3	10.1

Source: OPEC.

Figure 3.1 shows that, at the global level, the medium-term period will be marked by a gradual demand growth deceleration, but overall, however, demand remains robust even at the end

Figure 3.1
Annual incremental oil demand by region, 2023–2029



Source: OPEC.

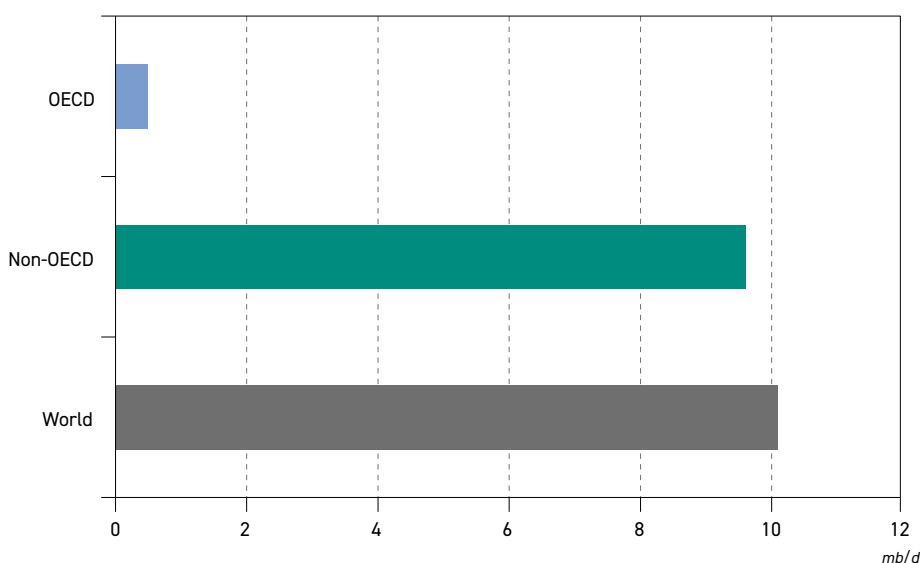


of the period. The main reason for this pattern over the medium term is strong demand growth in non-OECD countries where average annual incremental demand is projected at 1.6 mb/d. Annual demand additions in this region are set to slowly decline over the medium term, but they remain at a strong 1.3 mb/d even in 2029.

Strong non-OECD demand growth will be further supported by continuously expanding OECD demand during most years of the medium-term period. Supported by higher economic growth, oil demand in this region is expected to increase in the coming years, especially in OECD Americas. This, however, will cease sometime around 2028 when the OECD demand dynamic is expected to revert to a gradual decline. This shift will start in OECD Europe in 2026, followed by OECD Asia-Pacific in 2027. As a result, the annual OECD demand decline is expected to be approximately 0.1 mb/d by 2029. Despite this, total OECD demand by 2029 will be around 0.5 mb/d higher compared to 2023.

The overall impact of these trends is that global oil demand is set to reach 112.3 mb/d in 2029, representing a robust increase of more than 10 mb/d compared to 2023. Figure 3.2 summarizes these projections from the perspective of major regions. It shows a contrasting

Figure 3.2
Incremental oil demand by region, 2023–2029



Source: OPEC.

picture between continued non-OECD demand growth and rather stagnating demand in the OECD during the medium term. Indeed, non-OECD oil demand is projected to increase by 9.6 mb/d between 2023 and 2029 to reach a level of 66.2 mb/d, while OECD demand oscillates around a level of 46 mb/d over the same period.

Turning to long-term demand prospects, these are presented in Table 3.2. It shows that global oil demand is projected to reach a level of 120.1 mb/d in 2050, almost 18 mb/d higher than that observed in 2023. Extending the period of this Outlook to 2050 amplifies the trends set out in the second part of the medium-term period with respect to the divergent regional

Table 3.2

Long-term oil demand in the Reference Case

mb/d

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Americas	25.0	25.6	24.9	23.5	22.2	21.1	–3.8
OECD Europe	13.4	13.1	12.1	11.0	10.0	9.2	–4.2
OECD Asia-Pacific	7.2	7.2	6.7	6.1	5.7	5.2	–2.0
OECD	45.7	45.9	43.7	40.6	37.9	35.6	–10.1
China	16.4	18.6	19.0	19.2	19.1	18.9	2.5
India	5.3	7.1	8.6	10.2	11.8	13.3	8.0
Other Asia	9.3	11.2	12.3	13.1	13.8	14.5	5.2
Latin America	6.7	8.0	8.8	9.2	9.5	9.7	3.0
Middle East	8.6	10.7	11.5	12.1	12.6	13.0	4.4
Africa	4.5	5.4	6.2	7.0	7.9	8.9	4.4
Russia	3.8	4.1	4.1	4.1	4.1	4.0	0.2
Other Eurasia	1.2	1.4	1.5	1.5	1.6	1.6	0.4
Other Europe	0.8	0.8	0.8	0.8	0.8	0.7	–0.1
Non-OECD	56.6	67.4	72.7	77.2	81.1	84.6	28.0
World	102.2	113.3	116.4	117.8	118.9	120.1	17.9

Source: OPEC.

oil demand pathways of OECD and non-OECD countries. Indeed, the long-term prospect for the OECD is for a continued demand decline to levels below 41 mb/d by 2040, and then even further to below 36 mb/d at the end of the outlook period. This represents an overall demand decline of more than 10 mb/d compared to 2023.

This projected OECD demand decline is the result of a variety of factors, primarily driven by the policy setup in this region. In an effort to reduce energy-related emissions, policies have been set to foster technological development and provide incentives for their implementation, to use energy more efficiently across all sectors of consumption and to substitute oil with electricity and gas as much as possible. Important elements in these efforts is the gradual penetration of EVs in the road transportation sector, the displacement of oil-based heating systems in residential and industrial sectors, a further reduction of oil demand in the electricity sector and the penetration of alternative fuels in the marine and aviation sectors. Moreover, this region's demand decline is expected to be supported by a rather static, but ageing total population, and relatively low long-term economic growth.

It is worth mentioning that long-term OECD demand projections represent an upward revision compared to last year's Outlook. The main reason for this adjustment is a less optimistic outlook for the penetration of EVs in the region's vehicle fleet that reflect recent policy developments and the less ambitious plans of car manufacturers. Moreover, besides the road transportation sector, a softening policy setup will also impact other consuming sectors. This is likely to lead to slower oil substitution by other energy forms, hence, slightly higher oil demand compared to last year's projections.

In contrast to the OECD, oil demand in the non-OECD is set to expand over the entire outlook period. The non-OECD demand increase of 9.6 mb/d during the medium-term period will almost



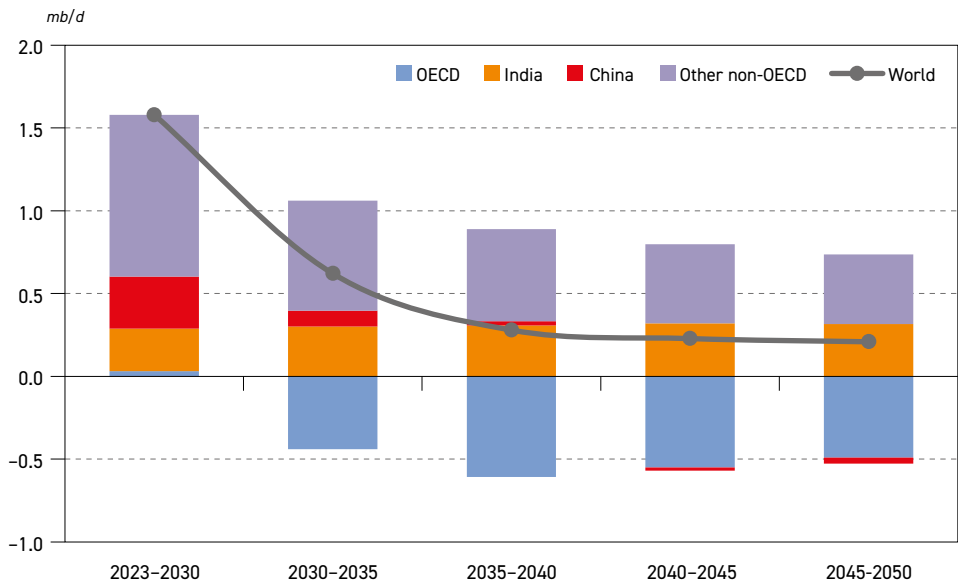
double in the long term, with the total demand increase between 2023 and 2050 amounting to 28 mb/d. The key factors contributing to this strong demand growth include robust economic growth; rising population and urbanization; a strong expansion of the middle-class and the related propensity to travel; expansion of the vehicle fleet, including commercial vehicles with a higher share of heavy-duty vehicles; expansion in the aviation sector; a shift from the traditional use of biomass to liquefied petroleum gas (LPG); transformation of the agricultural sector; and strong demand for petrochemical products.

Naturally, non-OECD oil demand growth will not be uniform across all of its sub-regions. This is highlighted in Figure 3.3, which provides details on the evolution of demand in major regions and economies. In the period to 2030, the single largest average annual demand increment is set to come from China, followed by India, both growing by around 0.3 mb/d p.a. on average. However, demand growth in China is set to be strongest at the beginning of the outlook period and it then slows relatively quickly to less than 0.2 mb/d by 2030 and below 0.1 mb/d by 2035. In contrast, demand growth in India is anticipated to gradually accelerate from the initial range of 0.2 mb/d p.a. to 0.3 mb/d p.a. by 2030 and retain this momentum for the rest of the outlook period.

The largest part of incremental demand is set to be spread among other non-OECD countries. This growth will be mainly driven by Other Asia and the Middle East during the first half of the outlook period. However, oil demand in these two regions is expected to mature afterwards and growth levels will be overtaken by India and Africa towards the end of the outlook period.

Figure 3.3 also shows an evolving profile of global annual demand increments over the outlook period. The fastest demand growth – 1.6 mb/d p.a. on average – is projected for the remaining part of the current decade. Annual growth is then expected to slow to 0.6 mb/d over the next five years and below 0.3 mb/d for the period from 2035–2040. Demand growth is then set to stabilize around 0.2 mb/d for the rest of the outlook period.

Figure 3.3
Average annual oil demand increments by region, 2023–2050



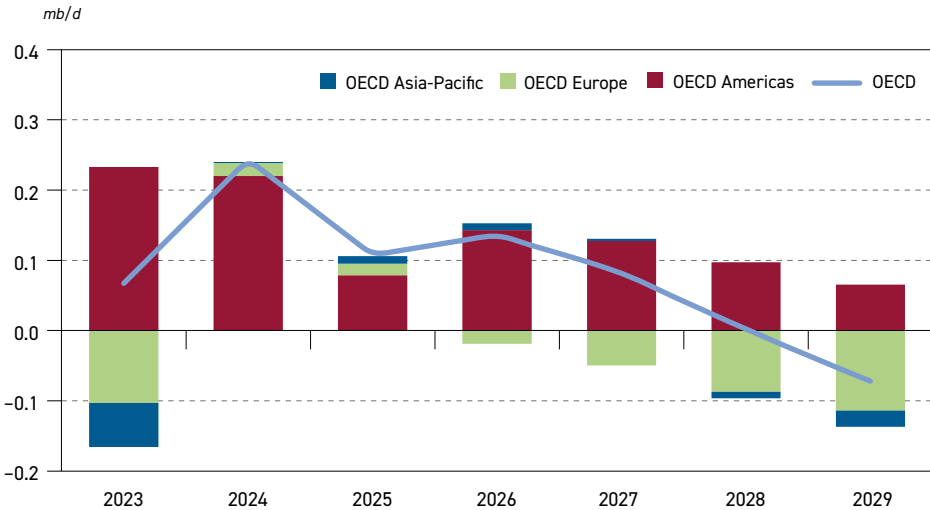
Source: OPEC.

3.1.1 OECD

Starting with medium-term prospects, average GDP growth in OECD countries is projected to improve from a rather anaemic 1.4% in 2024 to 1.8% in 2029. Among the major three regions, the fastest growth is projected in OECD Americas, in the range of 1.8% to 2.1% p.a. The other two sub-regions – OECD Europe and OECD Asia-Pacific – will likely experience growth in a lower range of 1.3% to 1.8% p.a. However, given the existing policy setup in these regions and technological progress and measures supporting improvements in energy efficiency, higher economic growth will have only a limited impact on oil demand, temporarily boosting oil consumption mainly in the OECD Americas. In the remaining two regions, improved economic growth will likely be insufficient to offset the adverse impact of these factors on future oil demand.

Therefore, as presented in Figure 3.4, slightly higher OECD Americas incremental oil demand in 2026 will temporarily push the entire region to a marginally higher level. This, however, will not prevent continued decline in the region's annual incremental demand, which is expected to turn to negative growth sometime around 2028. The overall demand change during the medium term is around 0.5 mb/d, but the reversal of the growth trend is important and has far reaching implications for the region's long-term demand.

Figure 3.4
Annual oil demand growth in the OECD, 2023–2029



Source: OPEC.

More specifically, only minimal demand changes are projected for both OECD Asia-Pacific and OECD Europe over the medium-term period. The combined demand difference between 2023 and 2029 is just -0.2 mb/d. Driven by weak demand in Japan and ongoing oil substitution in other parts of OECD Asia-Pacific, this region is set to shift to declining demand sometime around 2027. Subject to the rate of EV deployment in Europe and potential policy changes after a new EU Commission and Parliament are established, oil demand in OECD Europe is expected to start declining as soon as 2026. Regardless of the exact timing of the trend reversal in these regions, it is expected that demand changes will be relatively slow and gradual, limited to an annual change of around 0.1 mb/d for several years before any larger changes take place.

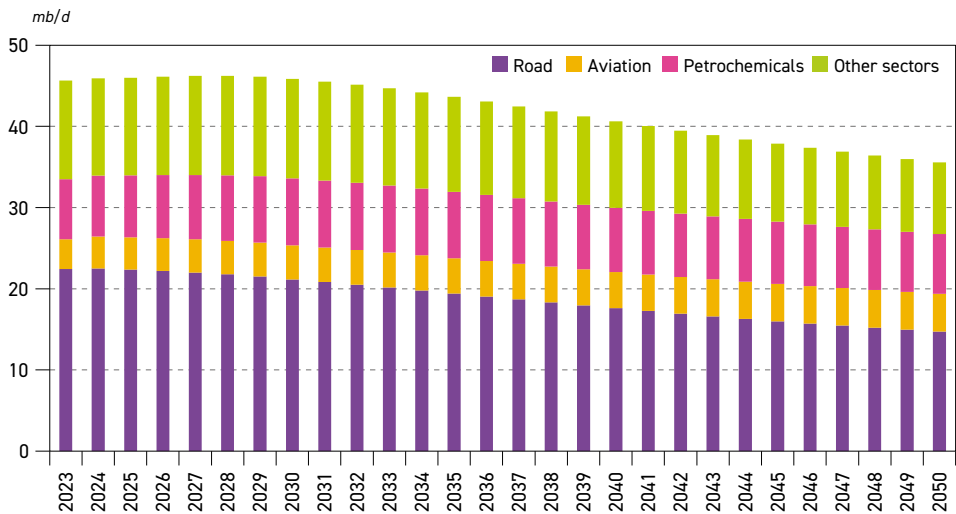


The same also applies to the demand pattern in OECD Americas, although the reversal of the trend in this region is more delayed. Current projections indicate that a turning point could materialize sometime around 2030. Similar to OECD Europe, however, this may shift depending on the result of the forthcoming US presidential election, as well as the progress achieved in the transition to electric mobility.

In the long term, OECD oil demand is set decline from 45.7 mb/d in 2023 to 42.7 mb/d in 2035 and further to 35.6 mb/d in 2050. This represents an overall demand decline of 10.1 mb/d over the outlook period. OECD Americas and OECD Europe are forecast to contribute to this demand decline by almost the same amount – around 4 mb/d each. The contribution of OECD Asia-Pacific is lower in absolute terms at 2 mb/d. In relative terms, however, due to the differences in base demand, the fastest demand decline is projected in OECD Europe with a 32% drop between 2023 and 2050. A somewhat slower decline of 28% is projected for the OECD Asia-Pacific. In the case of OECD Americas, the demand decline over the outlook period represents only 15% of the demand in 2023.

Earlier in the chapter, the key reasons for the long-term OECD demand decline were highlighted. Figure 3.5 details the impact of these factors on the region's sectoral demand. Clearly, the largest change in future oil demand is expected to take place in the road transportation sector, which is projected to decline by 7.7 mb/d between 2023 and 2050. This represents around 76% of this region's overall demand contraction.

Figure 3.5
OECD oil demand by sector, 2023–2050



Source: OPEC.

There are two main reasons for this. Bearing in mind that there is limited space for a further expansion of the vehicle fleet in this region (as detailed in section 3.2.1, the number of vehicles is set to increase by 95 million in the period to 2050), oil demand is set to be mainly driven by a changing fleet composition and expected efficiency improvements in combustion engines.

In terms of the first point, the future penetration of EVs into the car fleet is set to continue, supported by both technological progress and a favourable policy setup. The strongest policy support exists in the EU, where various incentives supporting EV sales are in place, including a ban on new ICE personal car registrations from 2035. Despite this, the most recent sales data indicate a slackening off in growth while, at the same time, there is mounting pressure from customers, carmakers and some political parties to shift or soften targets.

A similar situation can be seen in the US, which is the primary car market for OECD Americas. Here, the IRA includes strong incentives supporting new EV sales. Moreover, a recent proposal of the US EPA to tighten emission standards for new vehicle models as of 2027, if adopted, would substantially add to the pressure for a stronger shift in future sales towards EVs. There is, however, strong resistance to this proposal and it remains to be seen what version of the regulation is adopted. Compared to OECD Europe and OECD Americas, new EV registrations in the OECD Asia-Pacific are significantly lower.

Considering these policies and sales trends in recent years, as well as the range of uncertainties related to the pace of electric mobility expansion, this Outlook assumes that OECD EV ownership grows to more than 220 million in 2040 and further to around 320 million in 2050 (compared to less than 20 million in 2023). It should be noted that these projections represent a slight downward revision in the future size of the EV fleet in the OECD, a reflection of growing uncertainties and the ongoing policy debate on electric mobility. Nevertheless, the net impact of replacing more than 300 million ICE-based vehicles will be a significant component of the region's declining oil demand.

Another part of demand reduction is the result of efficiency improvements in future ICEs, as new vehicles with better fuel efficiency gradually replace older models. In this respect, technological progress is also supported by stricter emissions regulations. However, the experience in OECD countries shows that part of this improvement is offset by consumers' shift to larger vehicles (especially sport utility vehicles (SUVs)), hence, the net effect is typically lower than expected, albeit still significant.

A significant demand decline is also projected for 'Other sectors'. This aggregates industry, residential, agriculture, commercial, marine transport and electricity generation. In total, OECD oil demand in these sectors is set to decline by 3.3 mb/d over the outlook period. The largest potential for long-term demand reduction exists in the residential (–1.2 mb/d) and industrial (–0.7 mb/d) sectors. The primary means to achieve this reduction in the residential and commercial sectors includes tighter building codes for newly constructed houses, the replacement of oil-based heating systems in older buildings and better insulation. Demand in industry will mainly be affected by efficiency improvements and fuel substitution when oil-based technologies are replaced by electricity, natural gas and, at a later stage, hydrogen.

In contrast to these sectors, OECD oil demand is set to remain supported by developments in the aviation and petrochemical sectors. This especially relates to the aviation sector, which is the only one where OECD oil demand (including jet kerosene and SAF) is projected to increase over the outlook period. The overall increase is not large, projected at 1 mb/d between 2023 and 2050, but it is expected to see steady growth over a significant part of the outlook period before plateauing towards its end.

Demand developments in the petrochemical sector will be much more complex. Driven mainly by access to ethane at competitive prices, the US petrochemical industry is set to expand



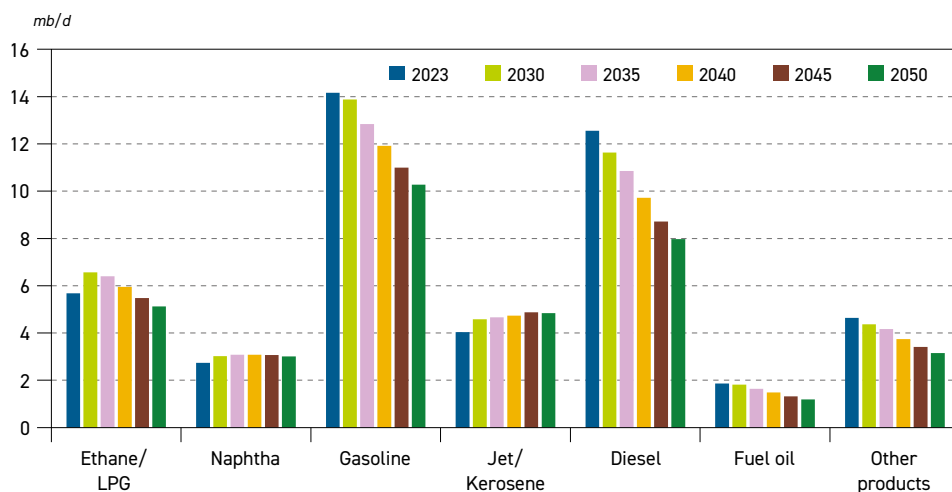
significantly during the current decade. As a result, OECD Americas oil demand in this sector increases by around 0.6 mb/d in the period to 2030. After this, however, it is unlikely that additional expansion projects will be committed, as the growth of cheap feedstock ceases. Moreover, oil used as fuel will increasingly be substituted by natural gas and electricity, which, after relatively flat demand during the 2030s, results in a gradual demand decline during the last decade of the outlook period.

A similar demand profile is also projected for OECD Asia-Pacific, although the range of changes are much smaller. Petrochemicals production in this region is set to be supported by the availability of naphtha, against a backdrop of a significant shift in refining activity in neighbouring countries and regions, especially China, India, Southeast Asia and the Middle East. In contrast to OECD Asia-Pacific, the petrochemical industry in OECD Europe is expected to gradually lose its competitiveness due to a lack of cheaper feedstock and stricter emissions regulations. Therefore, petrochemical oil demand in this region is expected to decline by 0.4 mb/d between 2023 and 2050.

The cumulative effect of these trends is that OECD oil demand in the petrochemical sector expands from 7.4 mb/d in 2023 to 8.2 mb/d in 2030, before dropping back to 7.4 mb/d in 2050.

Figure 3.6 outlines the implications of these developments on demand for refined products in OECD countries. Diesel is anticipated to face the most significant decline in the future demand mix, decreasing by 4.6 mb/d over the outlook period. This demand loss is driven by projected changes in road transport, industry, residential sector and marine transport. A similar trend is expected for gasoline, which drops to 10.3 mb/d by 2050 from its 2023 level of over 14 mb/d. The gasoline demand decline is primarily attributed to changes in the OECD vehicle fleet, influenced by the adoption of EVs and more fuel-efficient vehicles.

Figure 3.6
OECD oil demand by product, 2023–2050



Source: OPEC.

Demand for ethane/LPG and naphtha broadly mirrors developments in the petrochemical sector. Naphtha provides a baseload for petrochemicals; hence, its demand is projected to

remain relatively stable over the outlook period. In contrast, demand for ethane/LPG is driven by its availability which, especially in the case of OECD Americas, is linked to the region's tight oil production. This is projected to continue expanding over the current decade, providing additional feedstock to the petrochemical industry. However, tight oil production is set to peak around 2030, meaning that ethane availability is likely to drop in the second part of the outlook period.

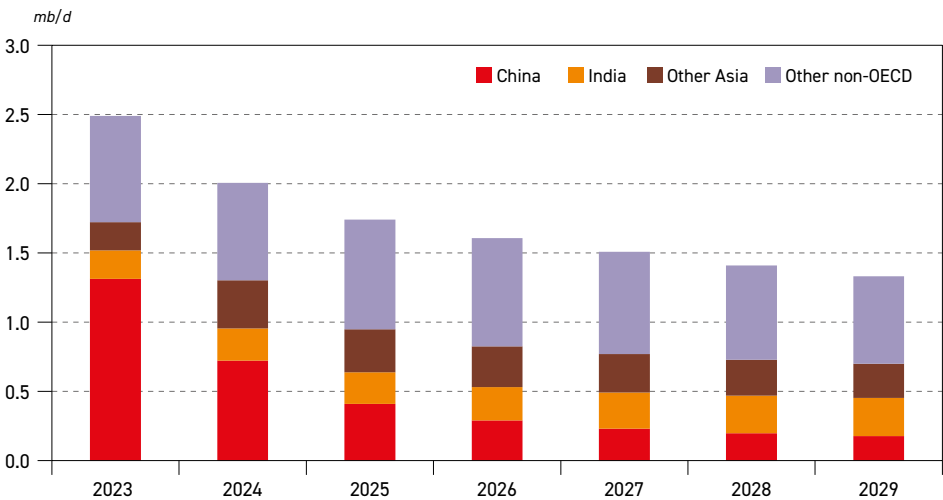
Fuel oil and 'other products' are expected to be affected by declining demand in industry (including lower refinery use), power generation and marine bunkers. The overall decline for 'other products' is anticipated to be around 1.5 mb/d, while demand for residual fuel is projected to drop by 0.7 mb/d between 2023 and 2050. The only product with increasing demand over this period is jet kerosene, reflecting increased traffic in the aviation sector.

3.1.2 Non-OECD

Non-OECD oil demand recorded strong demand growth in 2023, with an increase of 2.5 mb/d compared to 2022. This was primarily driven by the highest annual incremental demand ever observed in China. Indeed, following a decline in marginal demand growth during 2022 on the back of exceptionally low GDP growth and local COVID-19 induced lockdowns, China's oil demand climbed in all major consuming sectors during 2023, including petrochemicals, road transport, aviation and industry. The combined effect of increased economic activity and mobility led to an oil demand increase of more than 1.3 mb/d in 2023. Moreover, significant demand growth across the year was also observed in other non-OECD regions, in particular the Middle East, Other Asia and India.

As presented in Figure 3.7, however, non-OECD demand growth is expected to decelerate from the high levels in 2023 to a moderate growth that is aligned with, and justified by, market fundamentals over the medium term. This transition to lower annual increments is the result of diverging trends at the regional level.

Figure 3.7
Annual oil demand growth in non-OECD countries, 2023–2029



Source: OPEC.

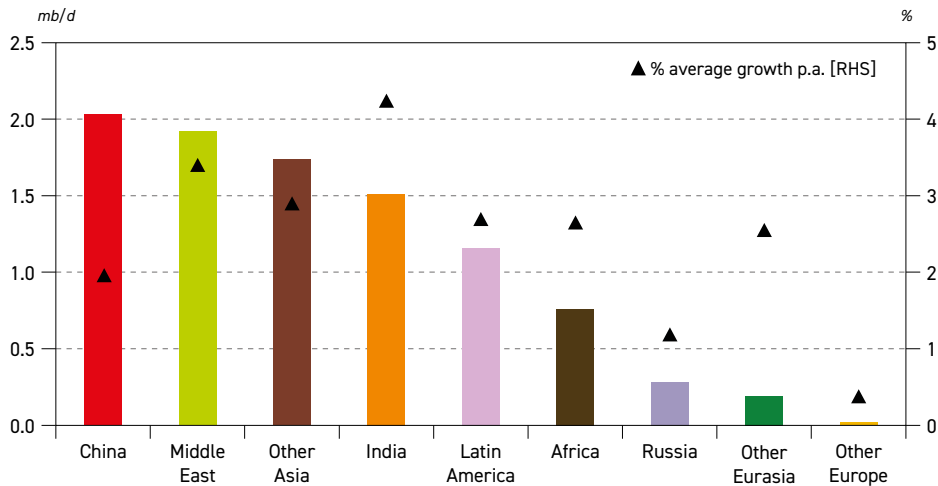


The main driver of this change is set to be slower demand growth in China, due to a number of reasons. This will be discussed in a later part of this chapter. This trend started already in 2024 with China's incremental demand expected to be around half of last year's growth at 0.7 mb/d, while annual increments are projected to decline further to around 0.2 mb/d by 2029. Some growth deceleration is also expected in the Middle East and Other Asia. However, changes in these regions is set to be much slower compared to China. To some extent, slower growth in these regions will be offset by developments in India and Africa, where demand growth is expected to accelerate during the medium-term period.

The overall effect is that non-OECD demand is projected to increase strongly by 9.6 mb/d between 2023 and 2029, driven by progressing industrialization, a fast-growing vehicle fleet, expanded production of petrochemicals, enhanced mobility and improved energy access and living standards for millions.

As presented in Figure 3.8, the largest incremental demand during this period is projected for China, at 2 mb/d, reaching a level of 18.4 mb/d in 2029. A significant demand increase is also projected in the Middle East, Other Asia and India, each contributing to medium-term non-OECD incremental demand in the range of 1.5–1.9 mb/d. Demand additions in Latin America and Africa are expected to be 1.2 mb/d and 0.8 mb/d, respectively. The lowest incremental demand is projected in Russia, Other Eurasia and Other Europe, all below 0.3 mb/d.

Figure 3.8
Non-OECD regional oil demand growth, 2023–2029



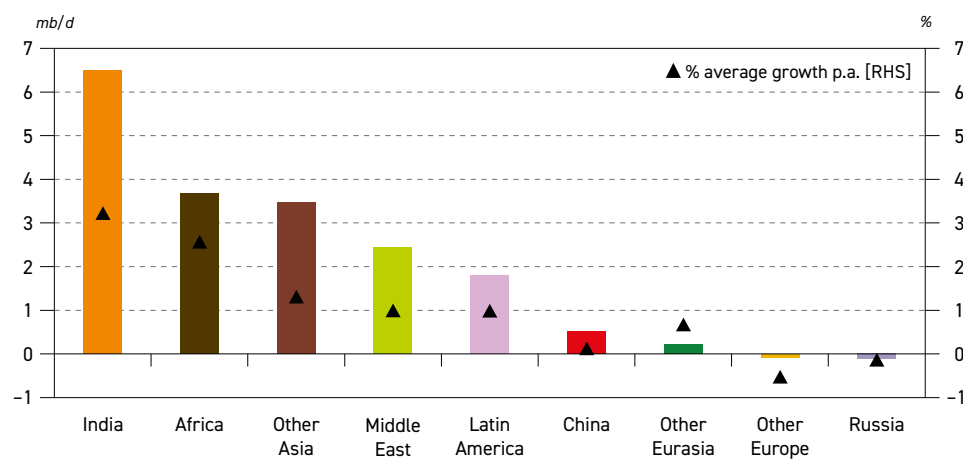
Source: OPEC.

It is important to note, however, that this order changes when considering a comparison in relative terms. In this case, India and the Middle East are the two regions with the fastest average annual growth over the medium term.

In the long term, non-OECD demand is expected to continue growing strongly, adding another 18.4 mb/d between 2029 and 2050. The increased use of oil products will help improve the living conditions for millions by providing access to affordable energy, fostering industrial growth and expanding all transportation options. Extending the time horizon of this Outlook to 2050 amplifies the role of India, Africa and Other Asia as key sources of incremental

demand in the years to come. As presented in Figure 3.9, the combined demand in these three regions is set to increase by 13.6 mb/d between 2029 and 2050, driven by economic growth, urbanization, industrialization and an expansion of the vehicle fleet. India itself adds 6.5 mb/d to its oil demand during this period, growing by 3.2% p.a., on average, followed by Africa with an average demand growth rate of 2.6% p.a.

Figure 3.9
Non-OECD regional oil demand growth, 2029–2050

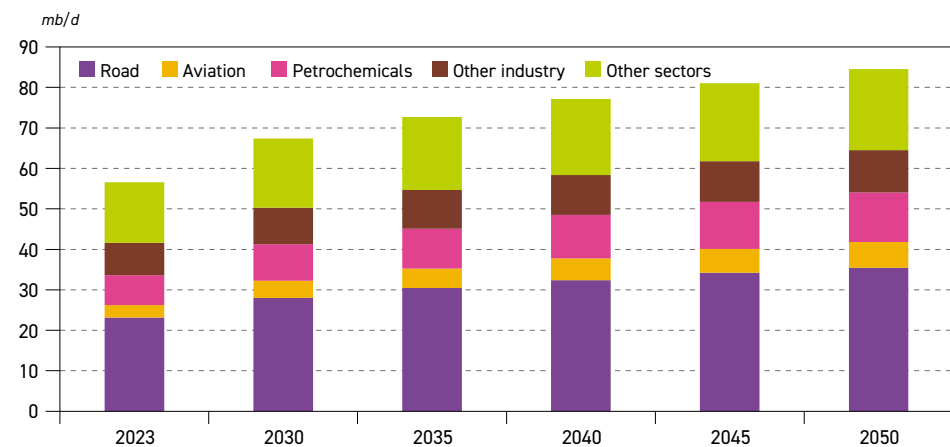


Source: OPEC.

Important demand additions are also projected for the Middle East (2.4 mb/d), Latin America (1.8 mb/d) and China (0.5 mb/d). Oil demand in the remaining non-OECD regions is forecast to plateau over the next decade and even start to marginally decline towards the end of the outlook period, therefore, leading to minimal changes in their demand level.

Figure 3.10 provides an overview of non-OECD oil demand from a sectoral perspective. It shows that developments in the road transportation sector are set to be by far the most

Figure 3.10
Non-OECD oil demand by sector, 2023–2050



Source: OPEC.



important factor driving the region's future demand. This reflects an expectation that the number of vehicles in the non-OECD more than doubles between 2023 and 2050, passing the two billion mark by 2050, with the large majority of them using gasoline, diesel and LPG as the main energy source (more details provided in section 3.2.1). Therefore, oil demand in this sector is forecast to increase by 12 mb/d over the outlook period, from 23.2 mb/d in 2023 to 35.5 mb/d in 2050.

A substantial demand increase is also projected in the petrochemical sector, mainly in Asia and the Middle East, on the back of a number of large petrochemical projects and rising demand for petrochemical products (more details included in section 3.2). As a result, oil demand in this sector is set to rise from 7.4 mb/d in 2023 to 12.3 mb/d by 2050, adding 4.9 mb/d of incremental demand over this period.

While the figures are somewhat lower, there are also significant demand increases in the non-OECD aviation, residential and agriculture sectors (at more than 3 mb/d each). An expanding middle class across all regions with an increased propensity for air travel is set to drive demand in the aviation sector. At the same time, the progressing mechanization of agriculture and the increased use of LPG in the residential sector will support growing non-OECD oil demand.

Demand additions in other sectors will likely be smaller. Nonetheless, combining demand from industry, agriculture, other transport, as well as the residential and power sectors, adds up to 7.6 mb/d of incremental regional demand between 2023 and 2050.

India

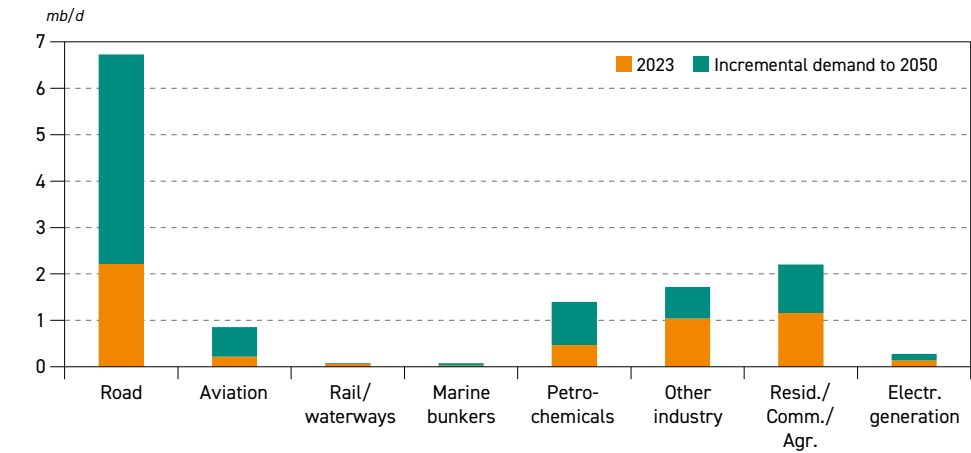
Even though India's population level is comparable to China, its current oil demand is around one-third of China's. India's oil demand is even significantly lower compared to Latin America, which is twice as less populous as India. This indicates the huge potential for future demand growth in this country, especially considering continued strong economic growth and an ever expanding population.

This Outlook assumes that India's GDP will grow by 5.9% p.a. on average between 2023 and 2050, remaining robust even towards the end of the outlook period. According to the latest estimates from UNDESA, India's population is set to increase by 242 million by 2050. With a projected population of 1.68 billion in 2050, it will be by far the most populous country in the world. Besides this significant increase, around half of India's population is below the age of 25, providing an additional boost to economic activity. As a result, India's working population is expected to expand to more than 1.1 billion by 2050.

Moreover, the expected increase in the urbanization rate will also play an important role. While India is home to several of the most populous cities in the world, its current urbanization rate is only around 34%. This is much lower when compared to developed countries, as well as many developing nations. With many policy interventions in recent years, such as the 'Smart Cities Mission' initiative, the construction of affordable rental housing complexes and the adoption of rapid transport metro systems in larger cities, India's urbanization rate is set to increase considerably during the outlook period. In turn, this will support demand growth for modern energy sources, including oil.

The potential impact of these factors on India's future oil demand at the sectoral level is presented in Figure 3.11. As mentioned earlier, total oil demand in India is set to increase by

Figure 3.11
Oil demand in India by sector, 2023 and 2050



Source: OPEC.

8 mb/d over the outlook period, rising from 5.3 mb/d in 2023 to more than 10 mb/d in 2040 and to 13.3 mb/d by 2050.

While oil demand in India is set to grow in all major consuming sectors, road transportation constitutes the primary key area where more than half of the overall demand increase is expected to materialize. This will be mainly driven by the significant expansion of the country's passenger car fleet, from less than 50 million in 2023 to more than 240 million in 2050 (excluding two-wheelers). Moreover, the number of commercial vehicles is set to more than quadruple during the period to 2050, on the back of strong GDP growth. At the same time, the penetration of EVs will likely remain subdued in India, therefore, a large majority of ICE-powered vehicles will provide support to strong oil demand growth in this sector.

The second largest demand increase is projected in the residential, commercial and agricultural sectors combined, expanding from 1.2 mb/d in 2023 to 2.2 mb/d in 2050. Part of this demand increase is linked to the extended use of agriculture machines and fertilizers. Expanding population and urbanization is set to result in the more widespread use of LPG and gasoil in the residential and commercial sectors. Part of the potential growth in these sectors, however, will likely also be met by other energy sources, such as electricity and natural gas. In particular, residential oil demand will face competition in areas where natural gas access improves, as part of the ongoing City Gas Distribution programme, which is supported by the government.

A comparable level of incremental demand – 0.9 mb/d over the outlook period – is projected in the petrochemical sector. Here oil demand is expected to grow, on average, by 4.1% p.a. between 2023 and 2050, driven by demand for a variety of petrochemical products. This comes on the back of growing construction and industrial production, an expanding agriculture sector and demand for plastics. This dynamic also manifests itself in the list of petrochemical projects that are expected to be constructed and become operational over the next few years, with the country set to account for around one third of all new projects in Asia. As a result, India's oil demand in this sector is already anticipated to increase by more than 0.2 mb/d by 2030. Incremental demand growth is set to rise to 0.9 mb/d by 2050, compared to 2023.



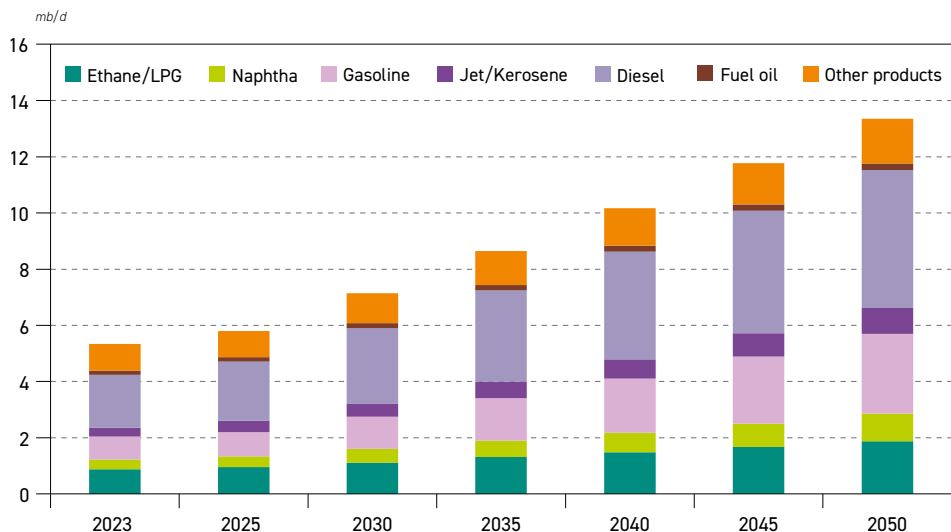
Even faster demand growth is expected in the Indian aviation sector on the back of a booming travel-ready middle class. This is clearly visible through the doubling of the number of airports over the past ten years, with four commissioned in 2023 alone. The expansion of aviation infrastructure is supported by government initiatives aimed at making air transport more affordable to the general public, such as, for example, the regional connectivity scheme known as UDAN. Reflecting these trends, Boeing's most recent market outlook expects aviation traffic in the South Asia region to grow, on average, by more than 8% p.a. over the next 20 years, requiring around 2,700 new aircraft over this period.

Accounting for improved efficiency and some use of alternative fuels, this is set to translate to average annual oil demand growth of 5.2% over the outlook period. The net result is that India's oil demand in the aviation sector increases from the current relatively low demand base of 0.2 mb/d to 0.9 mb/d in 2050.

Figure 3.12 translates these sectoral trends into demand for specific refined products. India's current oil demand composition is characterized by a relatively high share of diesel/gasoil, which accounts for around 35% of total demand. In fact, the share of diesel/gasoil is set to expand to 38% by 2040 before declining to 37% in 2050, mainly due to expanding freight transport and industrial production. Some demand growth for this product also comes from the petrochemical industry, as well as the commercial and agriculture sectors. Accordingly, diesel demand is projected to increase by 3 mb/d, from around 1.9 mb/d in 2023 to 4.9 mb/d in 2050.

A large demand increase of 2 mb/d is also projected for gasoline. This, however, will be entirely contingent on the growing number of passenger vehicles, as mentioned earlier. In a similar way, jet kerosene demand growth, which is anticipated to increase by 0.6 mb/d between 2023 and 2050, is directly linked to aviation sector developments. Demand for naphtha is set to experience a similar increase over the outlook period driven by an expanding Indian petrochemical sector. This sector will also support the increased use of ethane/LPG,

Figure 3.12
Oil demand in India by product, 2023–2050



Source: OPEC.

the demand for which, combined with the incremental use of LPG in the residential sector, is expected to increase by around 1 mb/d over the outlook period.

Another aspect specific to the Indian oil market is the relatively high demand for the group of 'other products', such as bitumen, petroleum coke, lubricants and waxes. Most of these products are used as refinery fuels, to expand road networks and to produce energy-intensive goods such as cement, aluminium and steel. Since all of these sectors are set to expand in India, related oil demand is also set to grow from 1 mb/d in 2023 to 1.6 mb/d in 2050.

The only refined product projected to remain in a narrow growth range of 0.1 mb/d to 0.2 mb/d over the entire outlook period is residual fuel oil. This is due to the fact that India has no major international bunkering hubs, and the country's electricity sector is dominated by the use of coal, renewables and natural gas.

China

Oil demand in China has experienced major growth over the last two decades. From levels lower than 5 mb/d in 2000, demand more than tripled, reaching 16.4 mb/d in 2023. During this period, oil demand in the aviation sector increased by a factor of seven; marine bunkers increased by a factor of six and demand in road transport by a factor close to five. All this materialized on the back of strong annual GDP growth in the range of 6–12%, except for the last few years that were marked by the COVID-19 pandemic.

However, recent developments indicate that the period high economic growth in China, and related high oil demand growth, is gradually winding down. It should be noted that China's extended period of high economic growth created a large industrial base (including petrochemical and refining industries), as well as a populous middle class, which will continue to support the strong sales of new vehicles, private retail product consumption and demand for travel services, including international flights. This provides a solid base for sustained oil demand in related sectors, even though economic growth is expected to decelerate.

This demand pattern is reflected in projections indicating that China's oil demand is set to grow from 16.4 mb/d in 2023 to 18.9 mb/d in 2050, representing an increase of 2.5 mb/d. Moreover, this demand increase is front-loaded, with almost 90% of it materializing during the current decade. In other words, China's oil demand continues to grow until around 2040, albeit at lower rates, before stabilizing and marginally declining towards the end of the outlook period.

There are several reasons leading to this conclusion. Firstly, China's economic growth is projected to stay at well below 5% p.a. in the medium term. Moreover, growth is expected to decelerate further to around 3% p.a. in 2040 and 2% in 2050 as the country's economy matures. Part of this slowdown can be attributed to a peaking and, subsequently, declining population, one with an ageing demographic and a shrinking labour force.

Secondly, the composition of China's economy is already shifting towards a higher share of services and less energy and oil intensive industries with a higher value-added. Examples of this are shifts to the fast-growing car manufacturing sector, the production of electronic devices and the provision of tourism services. Although this will likely provide an additional impulse to the petrochemical industry, residential and agriculture sectors, as well as to oil demand in road transportation, until the expanding penetration of EVs further curbs growth.

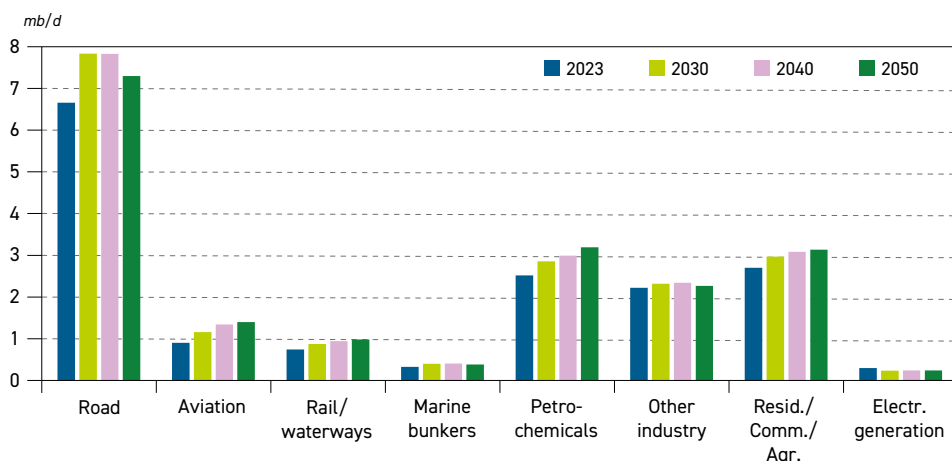


Strong growth in China's new EV registrations in recent years deserves special attention. Indeed, more than eight million electric cars were registered in China in 2023, accounting for around 25% of all new vehicle registrations. The flipside of this is the declining share of ICE-based vehicles in both new sales and the overall vehicle fleet. Moreover, HEVs are also becoming popular in China, adding to the efficiency improvements in road transportation.

As a result of these developments, the structure of the vehicle fleet in China is changing, with EVs reaching a share of 6% of the vehicle fleet in 2023 (excluding two-wheelers). This share may still seem relatively small, but the rate of penetration is growing. Naturally, this growth could slow as higher penetration levels are reached, due to much higher sales numbers being required in future years to sustain the significant growth. Nevertheless, even a decelerating EV penetration rate could potentially have an impact on China's future oil demand.

Figures 3.13 and 3.14 provide a summary of oil demand trends in China from the perspective of major refined products and consuming sectors. Oil demand in the road transportation sector accounted for more than 40% of China's total demand in 2023. Therefore, changes in the size and structure of the vehicle fleet will have large implications on its future oil demand. The size of the passenger vehicle fleet in China is projected to increase from around 315 million cars in 2023 to almost 540 million in 2050.

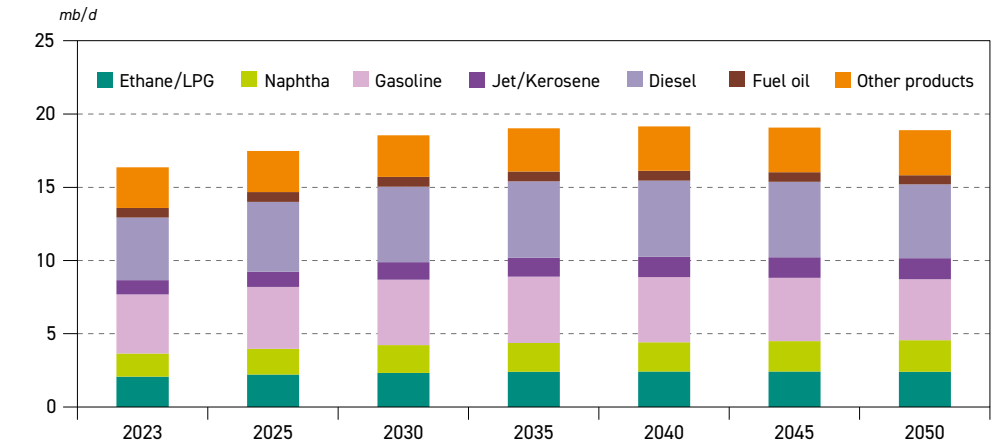
Figure 3.13
Oil demand in China by sector, 2023–2050



Source: OPEC.

However, a significant part of the potential demand growth resulting from this impressive surge will be offset by improved average efficiencies, as well as fuel substitution through electricity and natural gas. The EV expansion will play a major role in this respect as the number of EVs is expected to increase from 21 million in 2023 to almost 210 million in 2050, representing around 38% of China's passenger vehicle fleet. It is important to note that, despite the strong EVs growth, the number of ICE vehicles is set to continue growing until around 2040, and its decline during the last decade of the outlook period is moderate. This will provide continued support to Chinese oil demand in this sector.

Figure 3.14
Oil demand in China by product, 2023–2050



Source: OPEC.

Commercial vehicle growth is expected to support oil demand at an even larger scale. The number of ICE-based commercial vehicles is projected to almost double between 2023 and 2050, which, after accounting for better fuel efficiency compared to the current fleet, results in higher oil demand in this segment.

The combined effect of these developments is that China's oil demand in road transportation is set to grow until around 2035, reaching a level of almost 8 mb/d. It is then expected to plateau, before declining slowly during the last ten years of the outlook period, contributing to the overall deceleration of China's oil demand growth.

A similar demand pattern is also expected in 'other industry' (industry sector excluding petrochemicals) and marine bunkering, although overall demand changes in these two sectors are set to be relatively small. China's long-term oil demand in 'other industry' fluctuates around the level of 2.3 mb/d with a marginal decline during the last decade of the outlook period, when the departure from oil intensive industries becomes more visible. A similar range of demand oscillation is also projected in marine bunkers where growing marine traffic is more than offset by other fuels substituting oil.

In contrast to these sectors, China's oil demand is projected to continue growing in the aviation, petrochemical, agriculture and residential sectors over the entire outlook period. Among these sectors, the largest demand increase is expected to come from the petrochemical industry. Oil demand in this sector rises by 0.7 mb/d over the outlook period, from 2.5 mb/d in 2023 to 3.2 mb/d in 2050. From the perspective of feedstock, China's petrochemical industry has traditionally been naphtha-based and this will continue to be the case going forward.

Somewhat smaller incremental demand is set to materialize in the aviation sector, growing by 0.5 mb/d over the outlook period. This overall increase, however, is front-loaded, with around 55% of the growth (0.3 mb/d) materializing before 2030. In other words, robust medium-term demand growth gradually shifts to modest growth for the rest of the outlook period as China's economic expansion slows and efficiency improvements start playing an increased role.



Modest, but steady demand increases are projected in the combined residential, commercial and agricultural sector. This is largely supported by steady demand growth in agriculture. Overall incremental demand is just 0.4 mb/d between 2023 and 2050. Nevertheless, a demand level of between 2 mb/d and 3 mb/d in this sector contributes to the 'baseload' of future oil demand in China. A demand increase of around 0.2 mb/d between 2023 and 2050 is also projected for the rail and domestic waterways sector. This is not only from increased traffic on existing waterways, but also an expansion of the country's waterways network. However, part of this increase is set to be offset by reduced oil demand in the railway sector due to increased electrification.

From the perspective of major refined products, the largest demand increase in China is projected for diesel/gasoil. Demand for this product is set to increase by 0.7 mb/d between 2023 and 2050 (Figure 3.14). A large part of this increase is related to the growing number of commercial vehicles, supported by demand in agriculture and domestic waterways.

Another two products expected to experience a significant demand increase is naphtha and jet/kerosene. Since China's petrochemical industry mainly uses naphtha as a feedstock, demand for this product is set to almost entirely match demand growth in the petrochemical industry, expanding by 0.6 mb/d. The remaining demand is anticipated to be covered by ethane and LPG as feedstock.

In a similar manner, incremental demand for jet/kerosene, estimated at 0.5 mb/d between 2023 and 2050, is primarily driven by an expanding aviation sector. A minor overall demand increase is also projected for gasoline. For this product, however, initial demand gains in the period to around 2035 is broadly offset by declining demand in the second part of the outlook period, when EV penetration and efficiency improvements are expected to play an increased role.

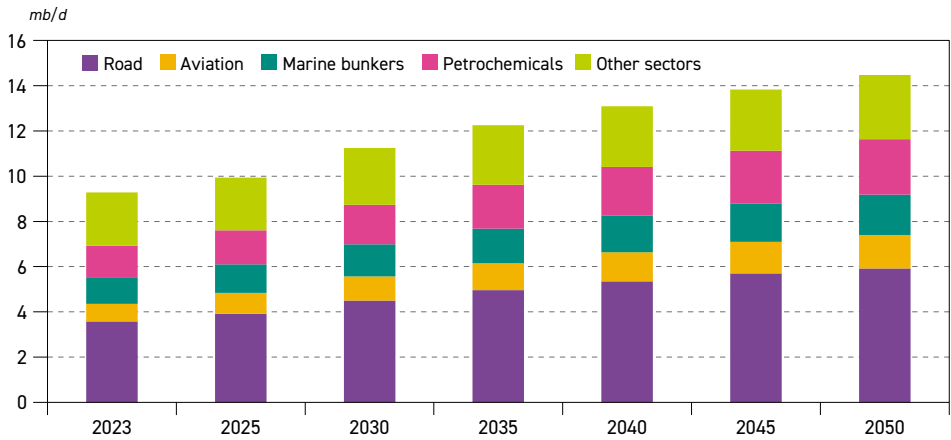
Other non-OECD Regions

With an overall demand increase of more than 5 mb/d, **Other Asia** is set to be the second largest contributor to global incremental demand over the outlook period. Similar to India, developments in this region are marked by dynamic population growth, continued urbanization, industrialization and a strong expansion of all transportation modes. At the same time, this region includes a variety of countries with specific geographic conditions and at different stages of development, which is also reflected in the projected regional GDP growth. Solid economic growth is expected over the medium term, with average GDP growth of 4.4% p.a. This decelerates to around 4% p.a. by 2035 and to 3% p.a. for the rest of the outlook period.

A combination of these factors provides strong support for oil demand in all major consuming sectors, as presented in Figure 3.15. Road transportation is likely to see an accelerated expansion of both passenger and commercial vehicle fleets. This results in oil demand in the road transportation sector growing by 2.3 mb/d between 2023 and 2050. Two other sectors with a significant oil demand increase are the petrochemical and aviation sectors, adding 1.1 mb/d and 0.7 mb/d, respectively.

An important feature of the demand structure in Other Asia is a relatively high share of marine bunkers (hence, the higher share of fuel oil in the product slate) as the region is home to several large bunkering ports, including Singapore – the world's largest bunkering port. As such, demand for marine bunkers accounts for 13% of overall regional demand.

Figure 3.15
Oil demand in 'Other Asia' by sector, 2023–2050



Source: OPEC.

This share will likely be maintained in the years to come as expected growth in the region's maritime trade is offset by efficiency improvements and the increased share of LNG as a bunkering fuel. The net result is that demand for marine bunkers in Other Asia is set to grow by 0.6 mb/d over the long term. The remaining 0.5 mb/d of incremental demand comes from the use of oil products in the residential, industry and agriculture sectors.

The other two regions with significant demand growth during the outlook period are the **Middle East** and **Africa**. Their overall projected demand increase is almost identical, estimated at 4.4 mb/d each. However, while demand growth in the Middle East is stronger during the current decade and decelerates in the second part of the outlook period, oil demand in Africa is back-loaded, becoming much stronger towards the end of the outlook period.

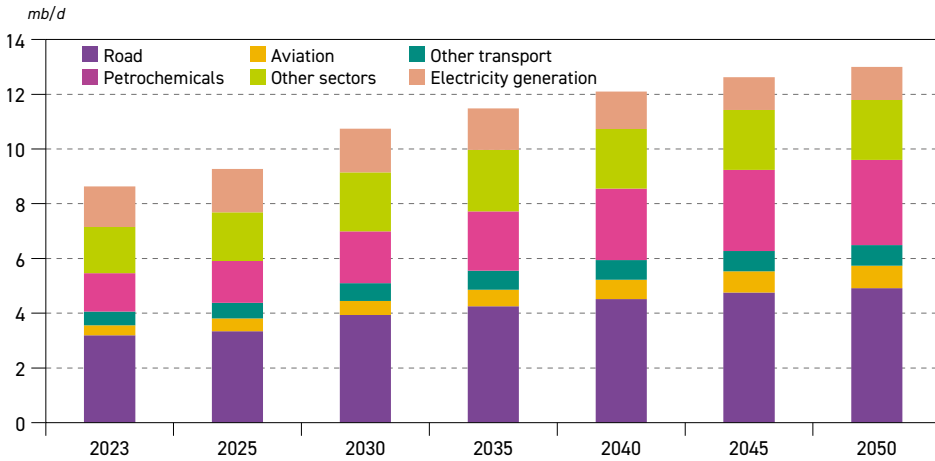
In the **Middle East**, incremental demand is expected to be largely concentrated in the road transportation and petrochemical sectors (Figure 3.16). The strong sales of new vehicles from the past few years is set to continue with an expansion of the region's vehicle fleet and result in growing oil demand, especially during the current decade. Moving forward, however, a higher share of EVs and more efficient hybrid vehicles will likely lead to decelerated growth. Nonetheless, oil demand in this sector is forecast to increase by 1.7 mb/d between 2023 and 2050.

Middle East demand in the petrochemical sector will likely grow by a comparable volume, increasing by 1.7 mb/d between 2030 and 2050. However, this growth will be more equally spread over the outlook period. Accessibility to cheaper feedstock, primarily ethane, LPG and naphtha, will provide a competitive advantage to this industry compared to other regions, which supports its sustained expansion during the entire outlook period. Significant demand growth is also projected in the aviation sector and industry, with each adding 0.5 mb/d to future oil demand. The only sector in the region expected to witness declining oil demand is electricity generation. This is mainly due to the progressing substitution of oil with natural gas, renewables and nuclear.

Turning to **Africa**, the largest potential for incremental oil demand in this region exists in the road transportation sector. This is due to Africa's relatively low vehicle ownership, although



Figure 3.16
Oil demand in the Middle East by sector, 2023–2050



Source: OPEC.

this is expected to improve over the outlook period. The vehicle fleet in the region is set to expand by around 170 million. In turn, this is set to boost sectoral oil demand, which is expected to expand by around 2 mb/d out to 2050.

The remaining part of incremental oil demand in Africa is split between the residential/agricultural (0.9 mb/d, mainly LPG and domestic kerosene), aviation (0.4 mb/d), industry (0.4 mb/d) and electricity generation (0.3 mb/d) sectors. In contrast to other regions, where oil use for electricity generation typically declines, it is set to remain on an upward trajectory in Africa due to the need for decentralized power generation in many places, especially those still lacking access to electricity. Another interesting observation for Africa relates to the limited use of oil in the petrochemical industry, which currently stands at around 0.2 mb/d. This is anticipated to increase to almost 0.4 mb/d in 2050, much lower than in other high-growth regions.

Lower, yet still significant demand growth is expected in **Latin America**. Projected GDP growth in this region is rather moderate, in the range of 2% p.a., on average. Similar to most other regions, the largest part of the incremental demand is linked to higher car ownership and mobility in the road transportation sector, where demand is projected to increase by 1 mb/d. The continued shift to cleaner fuels in the residential sector and the growing need for agricultural products accounts for an additional 0.6 mb/d over the outlook period. A similar level of demand increase is also projected in the aviation and industrial sectors, adding around 0.4 mb/d each between 2023 and 2050. The combined effect of these trends is that the region's oil demand is set to increase by around 3 mb/d, expanding from 6.7 mb/d in 2023 to 9.7 mb/d by 2050.

Oil demand growth in the remaining non-OECD regions will likely be rather constrained and even decline towards the end of the outlook period. This is the case for **Other Europe**, in particular, where overall demand between 2023 and 2050 is expected to drop by 0.1 mb/d. A slightly more positive outlook is projected for **Russia** where the net demand gain stands at around 0.2 mb/d during the same period. However, oil demand in Russia is expected to

peak sometime around 2035, at a level slightly above 4 mb/d and then plateau for the rest of the outlook period. Such a demand pattern is due to offsetting growth in petrochemicals, aviation and road transportation on the one hand, and stagnating to declining demand in other sectors.

In contrast to these two regions, some potential for further demand growth exists in **Other Eurasian** countries. Oil demand in this region is projected to expand from 1.2 mb/d in 2023 to 1.6 mb/d in 2050. This growth is set to be almost entirely driven by developments in the road transportation and industrial sectors, supplemented by a minor increase in aviation.

3.2 Oil demand outlook by sector

Discussions on regional oil demand trends clearly demonstrate that future demand heavily depends on the rate of advancement in developing regions, mainly India, Southeast Asia, Africa and the Middle East, as these regions hold the largest potential for future growth. Of course, what happens in other regions matters too, especially in OECD regions and China which, combined, currently account for around 60% of global demand and form a demand 'baseload'.

An overview of global oil demand from the perspective of major consuming sectors, as presented in Table 3.3, shows that a similar pattern exists at a sectoral level, with petrochemicals, road transportation and aviation standing out compared to others. The combined demand in these three sectors constitutes the backbone of current, as well as future oil demand. They accounted for 66% of global oil demand in 2023 and are, more importantly, projected to account for 76% of incremental global demand between 2023 and 2050.

The main reason for this trend is the lack of technologically viable and economically affordable substitution options. Natural gas and biomass will certainly increase their share in the petrochemical industry, however, strong future petrochemical product demand growth, particularly considering the significant potential in the construction sector, will provide ample room for all feedstock types. Moreover, it is important to note that oil-based products are the most suitable feedstock for a variety of petrochemicals.

In the road transportation sector, EVs and potentially fuel cell electric vehicles (FCEVs) will increasingly compete with ICE-based vehicles. While FCEVs are still far from mass adoption, due to challenges such as limited hydrogen availability and related infrastructure, EVs are becoming more competitive due to extensive direct and indirect support provided by a number of governments in key countries. However, recent developments and discussion among market participants have put a question mark on how fast they will initially penetrate new sales and, in turn, gain a significant share in the fleet composition.

This Outlook assumes that the alternative vehicles fleet increases from less than 80 million in 2023 (including EVs, FCEVs and NGVs) to almost 850 million in 2050. Nonetheless, even this significant growth in non-oil vehicles will not be sufficient to contain oil demand growth in this sector. The main reason for this is that the penetration of costly EVs will largely be concentrated in countries with higher per capita income, mainly in OECD and China, while the largest part of the vehicle fleet expansion will materialize in the developing world.



Table 3.3
Sectoral oil demand, 2023–2050

mb/d

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
Road	45.6	49.2	49.8	50.0	50.2	50.2	4.6
Aviation	6.8	8.4	9.2	9.8	10.5	10.9	4.2
Rail/waterways	2.0	2.2	2.3	2.3	2.3	2.3	0.3
Marine bunkers	4.2	4.8	5.0	5.0	5.0	5.1	0.8
Transportation	58.5	64.7	66.3	67.2	68.0	68.5	10.0
Petrochemicals	14.8	17.3	18.0	18.7	19.3	19.7	4.9
Other industry	12.9	14.2	14.8	14.6	14.6	14.7	1.8
Industry	27.7	31.5	32.8	33.2	33.9	34.3	6.6
Resid./Comm./Agr.	11.4	12.6	13.0	13.1	13.2	13.4	2.1
Electricity generation	4.6	4.6	4.4	4.3	3.9	3.8	–0.8
Other uses	16.0	17.2	17.4	17.4	17.0	17.3	1.3
World	102.2	113.3	116.4	117.8	118.9	120.1	17.9

Source: OPEC.

Finally, even less oil substitution options exist in the aviation sector. Biojet and different versions of SAFs continue to make headlines with the emergence of various theoretical production concepts and related pilot projects, but they are a distance away from being produced at the required scale and at competitive prices. Additionally, there is the substantial potential for rising air traffic, both regional and global, which makes oil demand growth in this sector inevitable.

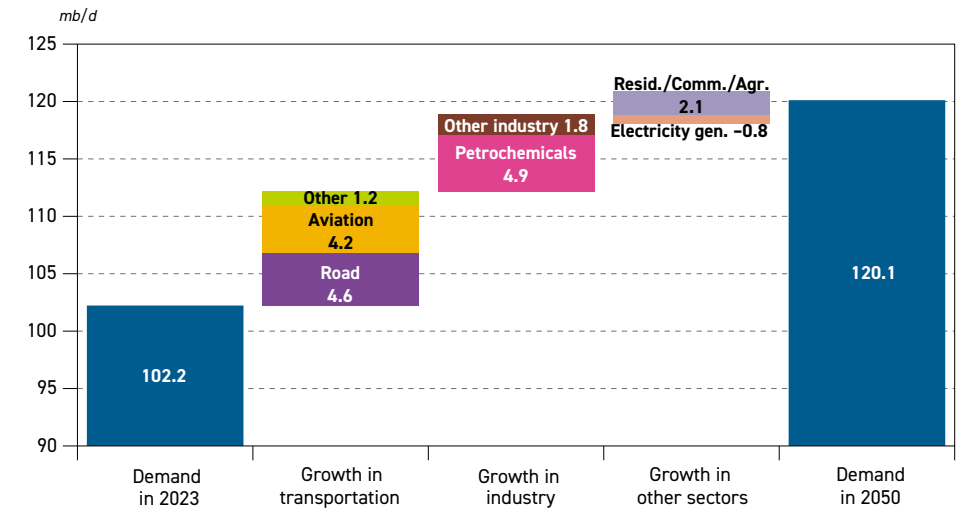
In contrast to these three sectors, more substitution options exist in other segments, especially in electricity generation, industry and the residential sector. In fact, oil already faces strong competition from natural gas and electricity in these sectors, limiting its growth potential.

More specifically, extending the outlook horizon to 2050 makes the petrochemical industry the largest contributor to incremental oil demand (Figure 3.17). This sector consumed less than 15 mb/d of oil products in 2023. The smaller part of it relates to the use of oil as a fuel, while the large majority, and an expanding part of it, relates to its use as a feedstock for a wide range of products. By 2050, petrochemical oil demand is expected to rise to 19.7 mb/d, with a large portion of this growth materializing in the Middle East and developing Asia.

The second largest demand increase is projected for the road transportation sector. Oil demand in this sector depends on the size and composition of the vehicle fleet, consumer driving habits, vehicle fuel economies that are often subject to policy measures, regional scrappage rates, as well as consumer choice when buying new vehicles (often giving preference to larger vehicles, such as SUVs). Moreover, there is a distinct pattern between personal cars and commercial vehicles, which adds to the complexity of demand modelling in this sector.

As already mentioned, the number of passenger EVs is projected to increase by more than 580 million between 2023 and 2050 leading to an oil demand plateau in this segment over the next decade, followed by a slow decline in the last decade of the outlook period. This

Figure 3.17
Oil demand growth by sector, 2023–2050



Source: OPEC.

decline, however, will be largely compensated by continued demand growth in the segment of commercial vehicles. Some penetration of EVs is also set to be achieved in this segment, especially in light-duty vehicles, but the overall EV share is expected to be relatively low. Moderate fuel substitution will also take place via natural gas, but this will be limited in respect to both regional coverage and the level of penetration.

Considering the projected increase of almost 360 million vehicles between 2023 and 2050 in the commercial vehicle fleet, oil demand in this segment is set to continue to grow. Considering both segments in aggregate, road transportation oil demand is expected to expand from 45.6 mb/d in 2023 to 50.2 mb/d in 2050.

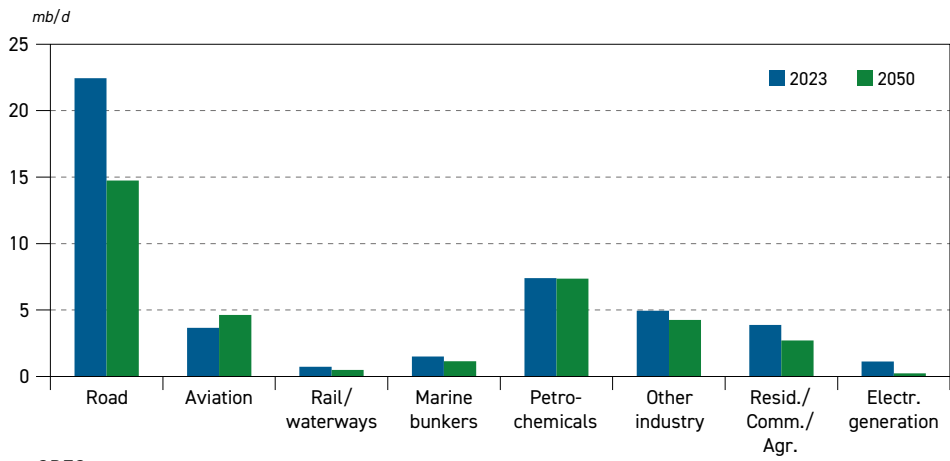
Large demand additions are also projected for the aviation sector. Driven by the propensity to travel and a rise in the middle class, especially in developing Asia and the Middle East, oil demand in this sector is set to increase by 4.2 mb/d between 2023 and 2050. This increase could potentially be even higher given the projected rise in air traffic in terms of passenger kilometres. However, improved energy efficiency and the gradual penetration of alternative fuels will likely offset part of this potential.

Demand additions in other transportation sub-sectors – marine bunkers, rail and domestic waterways – are projected to be relatively low. Expanding maritime trade will drive demand for marine bunkers, especially in Asia and the Middle East. The related demand change is expected to be around 0.8 mb/d over the outlook period. Another 0.3 mb/d is also anticipated from the combined rail and domestic waterways sector, which is primarily linked to waterways traffic in China.

Rather low incremental demand is also projected in the 'other industry', residential and agricultural sectors, despite a relatively high base demand in 2023. The overall demand increase in the 'other industry' is projected at 1.8 mb/d, mainly due to declining demand in OECD regions (Figure 3.18) where oil products are set to be increasingly substituted by



Figure 3.18
Sectoral oil demand in OECD countries, 2023 and 2050

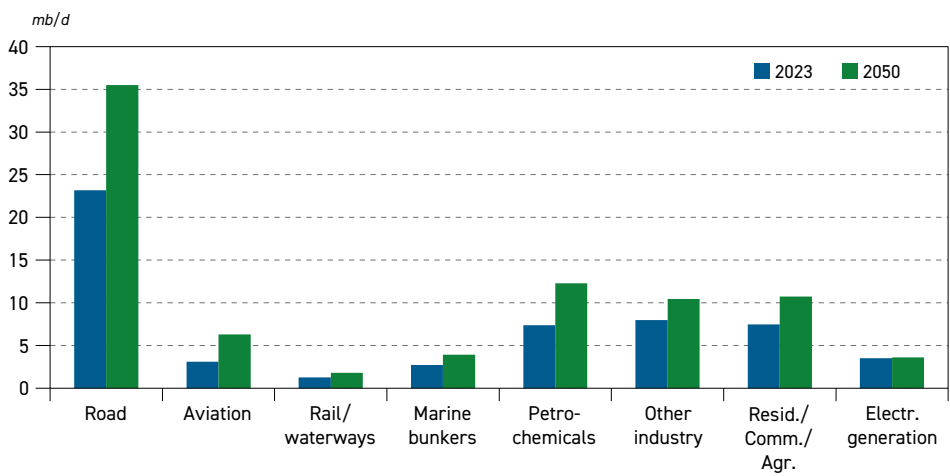


Source: OPEC.

natural gas and electricity. In non-OECD countries, strong industrialization will likely more than compensate for any oil replacement leading to 'other industry' demand in this region increasing by 2.5 mb/d over the outlook period (Figure 3.19).

3

Figure 3.19
Sectoral oil demand in non-OECD countries, 2023 and 2050



Source: OPEC.

Diverging trends between OECD and non-OECD are also clearly present in demand prospects for the residential, commerce and agricultural sectors combined. In non-OECD countries, LPG and diesel demand is set to grow, helping to improve energy access through providing much needed energy for homes and agricultural activity. This will more than offset declining demand in these sectors in the OECD where, especially in the residential sector, oil products are set to be largely replaced by electricity.

Finally, oil consumed for electricity generation in the OECD is set to be almost completely eliminated during the outlook period. It is expected to decline by around 0.9 mb/d, with the remaining volumes serving more as a back-up, or utilized in remote areas. In contrast, oil use for the same purpose in Africa is anticipated to increase by 0.3 mb/d over the outlook period.

3.2.1 Road transportation

The road transportation sector accounts for the largest part of oil demand in most countries and regions. It accounted for 45% of global oil demand in 2023, while its share over the past ten years was generally above 55% in the case of OECD Americas, around 46% in OECD Europe and about 39% in China. This underlines that developments in this sector could potentially have large implications on regional and global oil demand in the years to come.

From the global perspective, there are several critical factors steering demand in this sector. The first one is the size of the vehicle park. This Outlook assumes that the global fleet will significantly increase over the outlook period. Population growth and improving economic and social conditions, especially in developing countries, will drive the sales of new vehicles and lead to much higher car ownership compared to current levels. Moreover, a higher level of economic activity will require a higher number of commercial vehicles too.

The second factor is the changing composition of the vehicle fleet. It is clear that the electrification of road transportation is currently the most important component in this respect. The biggest uncertainty lies in how fast it will progress, and to what extent it will affect commercial vehicles. At the same time, it is important not to lose sight of other alternatives, such as natural gas and hydrogen-based vehicles.

The third factor relates to potential vehicle efficiency improvements. This could be achieved in various ways, via engine efficiency advancements; better car body designs; favouring lighter materials; and optimizing operations, especially in relation to commercial vehicles via autonomous mobility. Past experience, however, has shown that some of these improvements are typically offset by changing consumer behaviour.

This sub-section sets out to capture this interplay of often diverging trends to assess their most likely impact on regional and global oil demand in the road transportation sector.

Vehicle stock

Global vehicle sales picked up again in 2023 from the lower levels experienced during the COVID-19 pandemic in 2020-2022, reaching a level of 94.6 million units in 2023 (all figures in this section exclude two-wheelers). New registrations of passenger cars increased by more than 10% during 2023, above 80 million cars, compared to 2022.

By far the highest number of new passenger sales was reached in China. With total sales of almost 27 million cars, China accounted for around 33% of the global new sales car market in 2023. An important feature of the Chinese car market is the high share of EVs in new sales, much higher than in any other region considered in this Outlook. Indeed, new sales of EVs in China surged by around 38% in 2023 to reach 9.5 million. Moreover, China is also home to the largest market for commercial vehicles with annual sales of more than three million.



Vehicle sales in the OECD Americas, the second largest market in the world, increased by around 12% in 2023, surpassing the 20 million mark. This market, dominated by developments in the US, is characterized by its high share of SUVs and continuously low share of EVs, which account for less than 10% of new sales. Somewhat higher sales of EVs were registered in OECD Europe, reaching more than three million in 2023. This compares to new passenger car registrations of around 11 million.

Significant growth was also recorded in other regions. New vehicle sales in OECD Asia-Pacific surpassed nine million units in 2023 on the back of a 14% annual increase in its largest market, Japan. Growth in India, with a market size of almost five million, and Brazil (2.5 million) was also in the range of 10% p.a.

It is important to note that OECD and China combined account for more than 80% of global vehicle sales. The largest car markets among other non-OECD regions are India, Other Asia and Latin America, each with annual sales of around five million vehicles. It is expected, however, that these regions will gradually gain share in both new sales, and vehicle park size over the outlook period. This is clearly visible in Table 3.4, which presents the projected size of the passenger car fleet at regional and global levels. It shows that the number of passenger cars is set to increase from around 1.4 billion in 2023 to almost 2.3 billion in 2050.

Table 3.4
Number of passenger cars, 2023–2050

millions

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Americas	285.5	298.9	310.9	319.2	322.4	322.7	37.2
OECD Europe	262.7	267.3	270.4	273.3	276.2	278.9	16.2
OECD Asia-Pacific	112.2	107.1	102.9	98.2	92.9	87.3	–25.0
OECD	660.4	673.3	684.2	690.7	691.5	688.9	28.4
China	314.7	412.7	479.5	525.8	546.2	539.7	225.0
India	48.7	79.8	112.7	153.0	197.7	242.5	193.8
Other Asia	91.2	119.4	149.6	184.5	224.4	269.9	178.8
Russia	38.2	38.1	37.5	36.6	35.5	34.2	–4.0
Other non-OECD	248.8	296.1	338.4	384.4	434.9	486.5	237.6
Non-OECD	741.6	946.0	1,117.7	1,284.3	1,438.6	1,572.8	831.2
World	1,402.0	1,619.3	1,801.9	1,975.0	2,130.1	2,261.7	859.7

Source: OPEC.

In absolute terms, this represents an increase of around 860 million cars between 2023 and 2050 with this expansion almost entirely taking place in non-OECD countries. China alone is expected to add 225 million passenger cars to its fleet. Despite this impressive growth, car ownership in China will only be around 380 units per 1,000 people by 2050, much lower than the 530 and 470 units projected for OECD Americas and OECD Europe, respectively.

A somewhat smaller, yet still substantial increase of the passenger car fleet is projected in India and Other Asia, as well as a large group of countries included in Other non-OECD. The number of passenger cars in India is projected to increase by a factor of five during the outlook period, from less than 50 million in 2023 to more than 240 million in 2050. This will be

supported by sustained solid economic growth resulting in a significant increase in per capita income. A comparable fleet increase is also projected in 'Other Asia'.

In contrast to non-OECD regions, car fleets in the OECD are already fairly saturated leaving little room for further expansion. Consequently, the number of passenger cars in the OECD is set to witness marginal growth over the next decade. It then stabilizes, before slightly declining towards the end of the outlook period. Some potential for growth still exists in OECD Americas and OECD Europe. This, however, will be largely offset by declines in OECD Asia-Pacific where population levels are already on a declining trajectory. Moreover, this region's ageing population will also likely contribute to a declining passenger car fleet.

Comparing projected trends for passenger cars with those for commercial vehicles presented in Table 3.5 shows some similarities, but also some differences. Similarities include a significant expansion in the commercial vehicles fleet, as well as the fact that a large majority of this expansion materializes in non-OECD regions. Indeed, the total number of commercial vehicles is projected to more than double between 2023 and 2050, rising from 270 million in 2023 to 630 million in 2050. In relative terms, this represents even faster growth compared to passenger vehicles.

Table 3.5
Number of commercial vehicles, 2023–2050 *millions*

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Americas	41.6	45.7	50.9	56.9	63.8	71.7	30.1
OECD Europe	45.1	51.4	57.5	63.7	70.0	76.4	31.3
OECD Asia-Pacific	25.6	26.5	27.5	28.4	29.5	30.7	5.1
OECD	112.2	123.7	135.9	149.0	163.2	178.8	66.5
China	32.6	43.5	53.6	64.1	73.9	83.3	50.8
India	21.9	33.1	44.3	59.0	75.7	94.1	72.1
Other Asia	31.8	42.5	52.1	62.0	71.8	81.3	49.5
Russia	5.8	6.0	6.1	6.3	6.4	6.5	0.6
Other non-OECD	68.1	86.2	105.0	128.7	156.4	188.3	120.2
Non-OECD	160.2	211.3	261.1	319.9	384.2	453.4	293.2
World	272.5	335.0	397.0	468.9	547.4	632.2	359.7

Source: OPEC.

While more than 80% of this increase, representing 293 million units, is projected for the non-OECD, significant growth is also expected in OECD countries as commercial vehicles are largely linked to economic activity and provide freight services at all levels, from the transport of raw materials, the exchange of components and product delivery to final consumers. This is the main reason why projections indicate significant increases in the number of commercial vehicles, especially in India, Other Asia, Middle East and Africa.

Vehicle fleet composition

The growing sales of EVs in recent years have increasingly affected the composition of the global vehicle fleet, although noticeable changes are still limited to the passenger car fleet in China, Europe and to some extent the US. At the global level, new sales of EVs reached



around 13.6 million units in 2023, representing around 14% of global vehicle sales and almost 17% of global passenger car sales.

While this global number is starting to look meaningful, it is important to note that 94% of new sales were in just three regions, namely China, OECD Europe and the US. China alone accounted for 60% of global EV sales in 2023, largely supported by various incentives provided by the government to both car manufacturers and buyers. Although the level of governmental support is lower in European countries and the US, it still exists.

Road transportation electrification is a significant element of EU efforts to reduce emissions. Accordingly, various plans to support (directly or indirectly) transition to EVs are in place in this region, including a strategy to ban the sales of ICEs by 2035 (with exceptions being made in the case of synthetic fuels). Policies supportive of EVs also exist in the US. Besides policy measures at the state level, the US IRA includes provisions supporting the expansion of EVs across the automotive supply chain, starting from charging infrastructure, battery production, car manufacturers and consumers.

These policy measures, and similar ones in other countries, such as the UK and Norway, were instrumental in expanding the required infrastructure, technological development and deployment, as well as in driving EV sales numbers in 2023. The flip side of these measures is that they are costly for governments and different levels of governmental support in major regions has created unfair competition among car manufacturers.

Considering the still relatively low EV sales in the US, the efficiency of expenses/income losses related to the IRA are subject to extensive discussions. A similar debate is ongoing in the EU, where strong opposition has formed that is pushing for a re-assessment of the EU's policy on electric mobility as part of an even wider discussion on re-thinking the EU Green Deal. Recent farmers' protests in many EU countries, proposals to significantly soften the EURO 7 emission standard and the ending of direct EV subsidies in Germany (following a decision of the German constitutional court that ordered the government to reduce the budget deficit) are just a few examples. It is worth mentioning that eliminating EV subsidies in Germany resulted in a significant reduction in EV sales during the 1Q24.

Moreover, generous support provided to Chinese EV manufacturers resulted in an overcapacity issue in China with local producers looking for export options to foreign markets, especially Europe and the US. In response, the EU Commission opened an anti-subsidy investigation against Chinese carmakers at the end of 2023 that aimed to introduce additional taxes in an effort to protect its own automotive industry. Consequently, a substantial increase of import tariffs was introduced in June 2024. In a similar vein, the US quadrupled import duties on Chinese EVs and batteries effective as of 1 August 2024.

Furthermore, expectations of a delayed introduction of new battery technologies and slower cost reductions than previously assumed, raises the question as to how fast road transportation electrification will progress, and equally important, how fast it will be picked up in developing countries where little progress has been achieved so far. This is one of the reasons why the global penetration of EVs was just 2.4% in 2023, despite the significant growth in China and Europe.

Despite a minor downward revision to the future size of the EV fleet in this Outlook, reflecting the current debate and investment plans of major car producers, the global EV fleet is on track for an increase of 650 million units between 2023 and 2050, from a base of around 40

million in 2023 to 690 million in 2050. OECD countries and China are set to play a major role in this expansion, accounting for close to 530 million EVs in 2050. Making a comparison on a single country basis, China is seen leading the way with almost 210 million EVs by the end of the outlook period. In all cases, EVs are set to grow much faster in the passenger car segment compared to commercial vehicles (Table 3.6).

Table 3.6
Number of electric vehicles, 2023–2050

millions

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Americas	5.6	29.5	58.7	91.0	122.5	141.6	136.0
OECD Europe	12.1	54.3	86.0	108.6	128.5	141.1	129.0
OECD Asia-Pacific	0.8	5.6	14.2	24.2	32.4	37.5	36.7
OECD	18.4	89.5	158.9	223.9	283.3	320.2	301.8
China	21.3	85.0	130.2	165.3	191.7	208.0	186.6
India	0.3	2.7	7.7	14.9	22.6	31.5	31.2
Other Asia	0.4	5.6	17.0	31.9	47.3	62.2	61.7
Russia	0.1	0.5	1.6	3.3	5.0	6.7	6.7
Other non-OECD	0.3	3.0	10.2	22.9	39.9	63.4	63.1
Non-OECD	22.4	96.8	166.8	238.4	306.5	371.8	349.4
World	40.9	186.3	325.7	462.2	589.8	692.0	651.2

Source: OPEC.

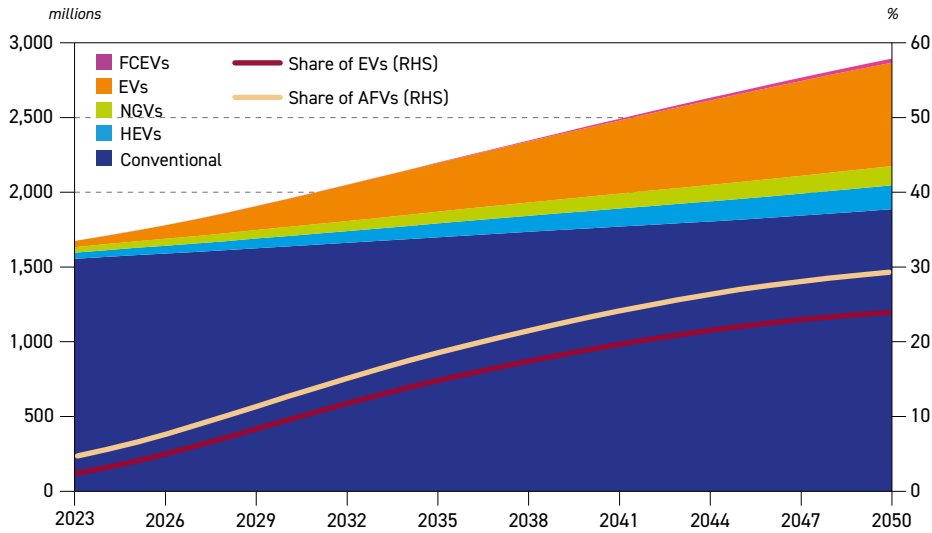
In addition to the strong growth projected for EVs, NGVs are also expected to expand, but at a far lower rate. The size of the NGV fleet is set to rise from less than 40 million vehicles in 2023 to almost 80 million in 2035 and then 130 million in 2050 (Figure 3.20). However, the expansion of this type of vehicle will likely be limited to Asian and Latin American countries, while NGVs are expected to almost disappear from European roads. The advantage of NGVs is that they can also partly penetrate the commercial segment as ICE-based vehicles can be adapted to run on natural gas.

The smallest expansion over the outlook period is projected for hydrogen-based fuel cell vehicles. This technology has the potential to offer an alternative pathway to road transportation electrification in efforts to reduce emissions. However, due to the higher costs and limited availability of hydrogen, this Outlook does not assume a mass expansion of FCEVs. The number of these vehicles might reach some 20–30 million by the end of the outlook, with most coming in the last decade. This means that compared to other vehicle types, the market will remain rather niche.

Figure 3.20 shows the implications of these trends for ICE-based vehicles, which are projected to increase from 1.6 billion in 2023 to two billion in 2050, hence, retaining their leading role in the global fleet with a share of 70% in 2050. Moreover, this share is even more dominant in the category of commercial vehicles, with an 83% level at the end of the outlook period. Needless to say, this large number of ICE-based vehicles will provide a solid base for the sustained use of oil in this sector. Another important conclusion from this analysis is that due to the large existing base of ICEs in the global fleet, the transition to alternative powertrains will likely take decades, not years.



Figure 3.20
Global fleet composition, 2023–2050



Source: OPEC.

Outlook for oil demand in road transportation

As already discussed, oil demand in road transportation is subject to the results of a complex interplay of regional changes in the size of the vehicle fleet, shifts in the composition of these vehicles, changing consumer driving habits and assumed changes in fuel efficiency. The net effect of these factors at a regional level is summarized in Table 3.7.

Table 3.7
Oil demand in the road transportation sector by region, 2023–2050

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Americas	13.7	13.1	12.3	11.5	10.9	10.3	–3.3
OECD Europe	6.3	5.8	5.1	4.4	3.7	3.2	–3.1
OECD Asia-Pacific	2.5	2.3	2.0	1.7	1.4	1.2	–1.3
OECD	22.4	21.2	19.4	17.6	16.0	14.7	–7.7
China	6.7	7.8	8.0	7.8	7.6	7.3	0.6
India	2.2	3.2	4.1	5.0	5.9	6.7	4.5
Other Asia	3.6	4.5	5.0	5.4	5.7	5.9	2.3
Latin America	3.3	3.7	4.0	4.1	4.3	4.3	1.0
Middle East	3.2	3.9	4.3	4.5	4.8	4.9	1.7
Africa	2.1	2.5	2.8	3.2	3.6	4.1	2.0
Russia	1.2	1.3	1.2	1.2	1.2	1.1	–0.1
Other Eurasia	0.6	0.7	0.7	0.8	0.8	0.8	0.2
Other Europe	0.4	0.4	0.4	0.4	0.4	0.4	0.0
Non-OECD	23.2	28.0	30.4	32.4	34.2	35.5	12.3
World	45.6	49.2	49.8	50.0	50.2	50.2	4.6

Source: OPEC.

The overall demand pattern in this sector is set to be characterized by continued strong demand growth over the current decade before demand stabilizes at levels above 50 mb/d for the rest of the outlook period. In fact, this sector is projected to experience the largest demand increase among all major sectors during the current decade, adding 3.6 mb/d between 2023 and 2030. An increasing number of EVs, combined with better future car fuel efficiency, will largely offset the potential demand growth stemming from an expanding vehicle fleet during the rest of the outlook period. This pattern results in an overall demand increase of 4.6 mb/d between 2023 and 2050.

At the same time, road transportation is the sector with the most remarkable demand variations at the regional level. On the one hand, oil demand in this sector is expected to triple in India and double in Africa over the outlook period. On the other, it is set to decline by 3.3 mb/d in OECD Americas and more than 3 mb/d in OECD Europe over the same period.

Driven by a fast expanding vehicle fleet, in combination with a relatively slow penetration of alternative vehicles, oil demand in this sector in India is projected to increase by a staggering 4.5 mb/d, from just 2.2 mb/d in 2023 to 6.7 mb/d in 2050. Somewhat lower incremental demand, but still significant, is projected for Other Asia and Africa, expanding by 2.3 mb/d and 2 mb/d, respectively. An important feature of road transportation oil demand in these three regions is that growth shows almost no signs of deceleration over the entire outlook period. A significant demand increase is also projected for the Middle East, at 1.7 mb/d between 2023 and 2050, although this region shows some signs of decelerating long-term growth.

A different demand pattern is expected in China. Road transportation oil demand in this country is set to expand by more than 1 mb/d during the current decade, which is the largest incremental demand among all regions. However, the penetration of EVs is anticipated to be large enough to curtail further demand growth. Despite this, China's road transportation sector is expected to be by far the most important oil consumer in Asia, even by the end of the outlook period. It will also be the second largest consumer globally, behind only OECD Americas.

Demand increases in the remaining non-OECD regions will be more limited. Some growth in the road transportation sector is expected in Latin America (1 mb/d between 2023 and 2050) and Other Eurasia (0.2 mb/d), while demand in Russia and Other Europe is projected to remain in a very narrow range around current consumption levels. Nevertheless, impressive demand growth in other regions results in total non-OECD road transportation demand increasing by 12.3 mb/d between 2023 and 2050 to reach a level of more than 35 mb/d in 2050.

Turning to the prospects for OECD demand, this will be largely impacted by a gradual increase in the EV fleet to 320 million by 2050, as well as ICE efficiency improvements. The combined effect of these factors is projected to lead to a drop in demand of 7.7 mb/d over the outlook period. The largest part of this decline is projected for OECD Americas, at 3.3 mb/d, mainly due to it being the largest demand base in the grouping (hence, it sees the largest impact from efficiency improvements). Demand declines in OECD Europe and OECD Asia-Pacific are also expected to be significant, projected at 3.1 mb/d and 1.3 mb/d, respectively. In fact, in relative terms, the demand drop in these two regions is set to be even faster than in OECD Americas.



3.2.2 Aviation

After a severe drop in aviation traffic during the COVID-19 pandemic, the aviation industry experienced almost a full recovery during 2023, when passenger traffic increased by around 40% compared to 2022 reaching a level slightly below 2019. Moreover, due to higher ticket prices, passenger flight revenues had already surpassed pre-pandemic levels helping airlines further consolidate and improve profitability.

Despite remaining below 2019 levels in 2023, a full recovery is expected in 2024. After this, annual demand growth is expected to decelerate to reflect undistorted market fundamentals. Nonetheless, the expected demand increase over the medium term is still significant, with overall demand projected to reach 8.3 mb/d in 2029, compared to 6.8 mb/d in 2023.

It is worth noting that demand growth during this period is set to be much faster in non-OECD countries, compared to the OECD. Driven mainly by developing countries in Asia, the overall medium-term demand increase in the non-OECD is anticipated to be around 1 mb/d, twice as much as the OECD. This will lead to a complete elimination of the demand gap in the aviation sector between these two major regions. While the difference was around 1 mb/d in 2019, regional demand is expected to reach parity by 2029.

These medium-term regional demand trends are set to be even more pronounced in the long-term. Stronger economic growth in developing countries and the related rising share of the middle class – a source of passenger flight sales – is forecast to drive aviation traffic and oil demand to significantly higher levels. However, part of the potential demand increase is expected to be offset by higher fuel efficiencies in modern aircraft, higher load factors and route optimization.

While the impact of these measures on future oil demand can be reasonably quantified, a large uncertainty relates to recent initiatives from the ICAO and the IATA. In October 2022, ICAO member states adopted the LTAG for international aviation to achieve net zero CO₂ emissions by 2050. More specific steps to achieve this vision were outlined in 'The Net Zero Roadmaps' by the IATA. The latter foresees that the required emissions reduction will be achieved via three main means: reduction in aircraft energy use (through more efficient aircraft that use less energy); change in fuel and a reduction of its carbon footprint (using net zero and true-zero fuel alternatives, with SAF expected to be the main alternative); and recapturing of all the CO₂ that could not be avoided.

The main component of this ambitious plan to reduce the industry's emissions is the substitution of jet/kerosene by SAF, electricity and hydrogen. According to the strategy proposed by the IATA, SAF is expected to eliminate 65% of emissions generated in this sector, and electricity and hydrogen, combined, should help reduce another 13% of emissions. While it is expected that small electric aircraft could start entering the market in the current decade, it is unlikely that this type of aircraft will play a significant role in displacing future oil demand in the period to 2050. Even less optimism can be placed on the assumption that the expanded use of SAF will progress fast enough to replace more than half of the aviation sector's oil demand by 2050.

Taking into consideration the associated uncertainties, current estimates suggest that oil demand in this sector is set to rise from 6.8 mb/d in 2023 to 10.9 mb/d by 2050, making this sector the third largest contributor to future incremental demand. Moreover, unlike several other consuming sectors, global aviation demand is anticipated to continue growing over the entire outlook period. Even in the long term, annual increments are projected at around 0.1 mb/d (Table 3.8).

Table 3.8
Oil demand in the aviation sector by region, 2023–2050

mb/d

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Americas	1.8	2.1	2.2	2.3	2.4	2.4	0.6
OECD Europe	1.3	1.5	1.5	1.5	1.5	1.5	0.2
OECD Asia-Pacific	0.5	0.6	0.7	0.7	0.7	0.7	0.2
OECD	3.7	4.2	4.3	4.5	4.6	4.6	1.0
China	0.9	1.2	1.3	1.3	1.4	1.4	0.5
India	0.2	0.3	0.4	0.6	0.7	0.9	0.6
Other Asia	0.8	1.1	1.2	1.3	1.4	1.5	0.7
Latin America	0.3	0.4	0.5	0.6	0.6	0.7	0.4
Middle East	0.4	0.5	0.6	0.7	0.8	0.8	0.5
Africa	0.3	0.4	0.4	0.5	0.6	0.7	0.5
Russia	0.2	0.3	0.3	0.3	0.3	0.3	0.0
Other Eurasia	0.0	0.1	0.1	0.1	0.1	0.1	0.0
Other Europe	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-OECD	3.1	4.2	4.8	5.3	5.9	6.3	3.2
World	6.8	8.4	9.2	9.8	10.5	10.9	4.2

Source: OPEC.

From a regional perspective, the largest incremental demand is expected to come from Other Asia, followed by India, China, the Middle East and Africa. Noticeable additions are also projected for Latin America, which is expected to contribute 0.4 mb/d. In contrast to these regions, only marginal demand additions are expected for Eurasia and Other Europe (0.1 mb/d combined). The cumulative effect of these regional increases is that non-OECD demand in this sector is expected to rise by 3.2 mb/d over the outlook period.

In addition to the non-OECD, aviation demand in the OECD is also projected to grow, rising from 3.7 mb/d in 2023 to 4.6 mb/d in 2050. In fact, the aviation sector is the only segment where OECD demand by 2050 is higher compared to the base 2023 demand. The largest part of this incremental demand comes from OECD Americas (+0.6 mb/d between 2023 and 2050), with demand growth in the other two OECD regions much lower.

Moreover, OECD demand growth in this sector is set to decelerate in the second part of the outlook period. The underlying assumption for this projection is that the OECD represents a mature market where growth is constrained by infrastructure capacity, and population growth will largely cease.

3.2.3 Petrochemicals

The outlook for oil demand in the petrochemical industry will be shaped by several key trends and challenges in the period to 2050. Supportive of demand growth is an expected substantial demand increase for petrochemical products on the back of projected growth in GDP, population and income levels, as well as a broadening of the areas with extended use of these products, especially the construction sector.

This growth potential will be partly offset by regulations and actions related to environmental concerns, such as the push to increase recycling, bans on single-use plastics, agreements to



end plastic pollution and new technologies to substitute oil- and gas-based plastics. However, technological developments and innovative approaches could also enable the use of oil-based feedstock in this sector in the long run. Technologies include CCUS and electrically heated steam crackers, such as the project developed in Germany by BASF, Sabic and Linde, which could significantly reduce CO₂ emissions from petrochemical operations.

Considering these offsetting trends and uncertainties surrounding petrochemicals, Table 3.9 presents oil demand expectations in this sector. At the global level, oil demand is projected to increase by 4.9 mb/d throughout the outlook period, rising from 14.8 mb/d in 2023 to 19.7 mb/d in 2050. This makes the petrochemical industry the single largest contributor to global incremental demand over the outlook period.

Table 3.9

Oil demand in the petrochemical sector by region, 2023–2050

mb/d

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Europe	1.8	1.8	1.8	1.6	1.5	1.4	–0.4
OECD Asia-Pacific	2.0	2.1	2.1	2.1	2.1	2.1	0.1
OECD	7.4	8.2	8.2	7.9	7.7	7.4	0.0
China	2.5	2.9	2.9	3.0	3.1	3.2	0.7
India	0.5	0.7	0.8	1.0	1.2	1.4	0.9
Other Asia	1.4	1.7	1.9	2.2	2.3	2.5	1.1
Latin America	0.3	0.4	0.5	0.5	0.5	0.5	0.2
Middle East	1.4	1.9	2.2	2.6	3.0	3.1	1.7
Africa	0.2	0.2	0.2	0.3	0.3	0.4	0.2
Russia	1.0	1.2	1.2	1.2	1.2	1.2	0.1
Other Eurasia	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Europe	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-OECD	7.4	9.0	9.8	10.8	11.6	12.3	4.9
World	14.8	17.3	18.0	18.7	19.3	19.7	4.9

Source: OPEC.

Moreover, it is important to note that demand in this sector steadily grows over the entire outlook period. The rate of growth is set to be higher during the current decade, and remains in the range of 0.1 mb/d annual growth even towards the end of the outlook period when GDP and population growth decelerate.

Significant differences are also projected in respect to regional developments. Indeed, oil use in petrochemicals is projected to grow strongly in the non-OECD, increasing by 4.9 mb/d between 2023 and 2050. In contrast, OECD oil demand in this sector is projected to increase over the next ten years, before declining at the end of the forecast period to the same level observed in 2023, at around 7.4 mb/d.

Given the regional breakdown in this Outlook, the largest incremental demand in this sector is projected in the Middle East, estimated at a staggering 1.7 mb/d over the outlook period. Driven by the local availability of feedstock at a competitive cost, there is a large number of global-scale petrochemical projects in different stages of development in this region.

In February 2024, QatarEnergy and Chevron Phillips Chemical started a \$6 billion project in Ras Laffan Industrial City, Qatar, which will include the largest ethane cracker in the Middle East with a processing capacity of 2.1 million tonnes p.a. (mtpa). In Saudi Arabia, Aramco and TotalEnergies awarded EPC contracts worth \$11 billion to seven different firms for the construction of a giant petrochemical complex in Jubail, Saudi Arabia, in June 2023. This project is expected to be operational by 2027. Additionally, Aramco and SABIC are proceeding with the first crude oil-to-chemicals petrochemical plant in Yanbu, Saudi Arabia, which will be integrated with an existing refinery.

Other petrochemical projects are currently under development in IR Iran, the UAE and Oman, including a steam-cracking project between OQ, SABIC and KPI in Duqm, Oman. These projects will support the region's oil demand for petrochemicals over the medium term. Moreover, a continuation of this trend is expected in the long term too.

Another region with a fast-developing petrochemical industry is non-OECD Asia. Demand additions of 1.1 mb/d, 0.9 mb/d and 0.7 mb/d are anticipated in Other Asia, India and China, respectively. Combined, these three regions are set to account for 55% of this sector's global incremental demand. This growth will be driven by economic and population expansion, as well by well-established processing/manufacturing industries in the region.

These regions are also marked by strong demand prospects in the current decade on the back of a number of large projects currently under construction or under development, especially in China. For example, a joint venture between SABIC and the Fujian Energy and Petrochemical Group started the construction phase of SABIC Fujian Petrochemical Complex in February 2024. The project, with an expected ethylene capacity of 1.8 mtpa is scheduled to be commissioned in 2026. India, Indonesia and Malaysia also see partnerships with Middle Eastern national oil companies as an opportunity to expand their petrochemical industries.

Some petrochemical capacity expansion is also expected in Russia and other non-OECD regions. In Russia, oil consumption in the petrochemical sector is expected to increase sharply over the next 3–4 years. In the long term, however, demand is anticipated to stabilize at a level of 1.2 mb/d. Oil demand for petrochemicals in other non-OECD regions – Africa and Latin America – is expected to witness only a slight demand increase, each in the range of 0.2 mb/d.

Given the ample supply of ethane at competitive prices, large petrochemical projects are also under construction in OECD Americas, especially in the US. These will support oil demand growth in the period to 2030 when it is expected to peak at a level of around 4.3 mb/d. Demand is set to plateau sometime after 2030 and revert to a declining trajectory due to falling ethane supply in the second part of the outlook period. In turn, this will likely enable the resurgence of more competitive naphtha cracking. Nevertheless, oil demand in the petrochemical sector of OECD Americas is expected to drop by 0.5 mb/d between 2030 and 2050.

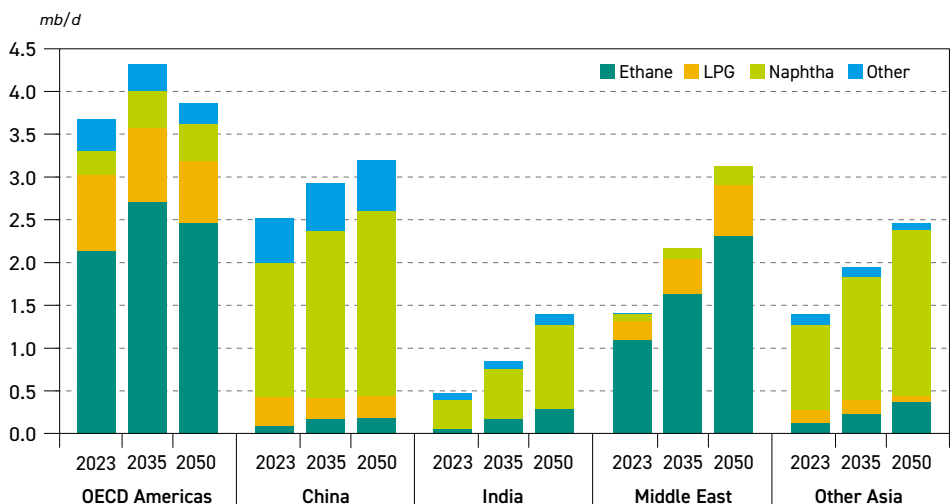
With the exception of the S-Oil Shaheen naphtha cracker in Ulsan, South Korea, which is expected to be operational in 2026, there are no major projects in the other two OECD regions. Therefore, oil demand in OECD Europe for the petrochemicals sector is projected to experience a continued decline over the outlook period, from around 1.8 mb/d in 2023 to 1.4 mb/d in 2050. The main reasons for this decline include relatively low economic

growth, rising production costs, as well as stricter recycling rules and emission policies leading to industry rationalization.

A broadly similar demand trend is expected in OECD Asia-Pacific, with a minor distinction given the above-mentioned project in South Korea, as well as several smaller projects, which leads to stable sectoral oil demand in this region for a longer period. The combined effect of these developments is that OECD oil demand in this sector is expected to initially grow to around 8.2 mb/d by 2030, before declining to 7.4 mb/d in 2050.

Figure 3.21 summarizes these developments from the perspective of major refined products. At the global level, naphtha accounts for the largest share of total demand in this industry (44% in 2023), followed by ethane (26%) and LPG (17%). Looking ahead, naphtha is expected to also provide the largest incremental demand (2.7 mb/d) during the outlook period given the large increases in Asian countries. As a result, naphtha is set to increase its share to 48% in 2050.

Figure 3.21
Regional demand in the petrochemical sector by product, 2023–2050



Source: OPEC.

3.2.4 Other sectors

Current oil consumption in the combined **residential, commercial, and agricultural sector** of more than 11 mb/d globally indicates the widespread use of oil products in this sector. This includes diesel to power agriculture machinery; gasoil for heating homes; LPG and kerosene for cooking and lightning; diesel for off-grid electricity production; asphalt and bitumen for the expansion of road infrastructure; as well as a variety of oil products to produce fertilizers, pesticides and other petrochemicals. The implication is that future oil demand will depend on the different trajectories observed within each subsector and is heightened by distinct regional consumption patterns.

For instance, regional policy setups, such as incentives in the US, Europe, and some parts of Asia, negatively affect oil demand in the residential sector by encouraging the substitution

of oil with electricity. However, there are still regions where people lack access to clean cooking fuel, which will likely increase the demand for oil, particularly LPG. Additionally, strong economic growth in many developing countries, such as India, will help improve the living standards of millions and further boost oil demand in these sectors.

Moreover, regional considerations, such as differences in heating *versus* cooling requirements, play a significant role in shaping demand trends. Increased agricultural mechanization in developing countries will also support oil demand growth. Despite calls to reassess reliance on agriculture machinery and adopt practices that mitigate soil compaction it is unlikely that a large number of these machines will be replaced by other technologies (e.g. drones) without compromising food security and quality.

Table 3.10 tries to capture the overall impact of these trends by providing an assessment of future oil demand at the regional and global levels. It indicates that global oil demand in this sector is expected to sustain steady growth over the outlook period, with the overall incremental demand estimated at 2.1 mb/d between 2023 and 2050.

Table 3.10
Oil demand in the residential/commercial/agricultural sector by region, 2023–2050 *mb/d*

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Americas	1.6	1.8	1.9	1.7	1.3	1.2	–0.4
OECD Europe	1.5	1.5	1.3	1.2	1.2	1.1	–0.4
OECD Asia-Pacific	0.8	0.8	0.7	0.6	0.5	0.4	–0.3
OECD	3.9	4.1	3.9	3.5	3.0	2.7	–1.2
China	2.7	3.0	3.0	3.1	3.1	3.1	0.4
India	1.2	1.4	1.6	1.8	2.0	2.2	1.0
Other Asia	0.8	0.9	0.9	0.9	0.9	1.0	0.1
Latin America	0.9	1.1	1.2	1.3	1.4	1.5	0.6
Middle East	0.5	0.6	0.6	0.6	0.6	0.6	0.1
Africa	0.7	0.8	0.9	1.1	1.4	1.6	0.9
Russia	0.4	0.4	0.4	0.4	0.4	0.4	0.0
Other Eurasia	0.2	0.2	0.2	0.2	0.2	0.2	0.0
Other Europe	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Non-OECD	7.5	8.5	9.1	9.6	10.2	10.7	3.2
World	11.4	12.6	13.0	13.1	13.2	13.4	2.1

Source: OPEC.

However, OECD demand is projected to decline towards the back end of the outlook period as stricter policy measures, such as those outlined in the EU's 'Fit for 55' and 'REPowerEU' package, as well as the IRA in the US, are expected to accelerate oil displacement in these sectors.

For example, the EU's 'Fit for 55' package incorporates targeted regulations aimed at reducing energy and oil consumption in new construction projects through stricter building codes, renovations and retrofitting in existing buildings, such as adopting heat pumps and PV technologies, encouraging the purchase of more efficient appliances, and prioritizing district



heating. This could be magnified even further with the introduction of the Emission Trading System (ETS II), which includes some provisions regarding the residential sector.

Moreover, tighter building codes promoting energy efficiency play an increasing role in non-OECD countries too. However, the effects of population growth, urbanization, and the increasing middle class in this region are anticipated to outweigh the energy savings yielded by these regulations.

The largest demand growth in this sector is projected in India and Africa, each expected to increase by around 1 mb/d over the outlook period. In India, this growth is primarily driven by demand for LPG, kerosene for cooking and lighting, and diesel for agricultural purposes. However, the expanding utilization of natural gas, facilitated by the extension of City Gas Distribution networks to cover over 70% of the population in India, may constrain this potential growth.

Sub-Saharan Africa similarly holds substantial potential for oil demand growth, especially through a transition from solid biomass to oil-based products, such as LPG. Additionally, oil finds applications in off-grid electricity generation for household lighting, heating and cooling in remote rural settlements. Similar factors are expected to influence oil demand in Latin America.

While slower growth is projected in other non-OECD regions, the combined effect will see non-OECD demand increasing from 7.5 mb/d in 2023 to 10.7 mb/d in 2050. From the perspective of specific products, the increased residential use of LPG (with an estimated increase of 1.8 mb/d between 2023 and 2050) is set to be a predominant driver of this growth, followed by diesel utilized in agriculture and for off-grid electricity generation (0.5 mb/d).

Oil used for **marine bunkers** is expected to be exposed to strong competition over the next three decades. Since the size of the global economy is set to more than double in the period to 2050, international maritime trade, as well as coastal traffic and related energy demand in this sector is set to expand significantly. This, however, does not necessarily translate to a significant oil demand increase. To the contrary, it is expected that a large portion of incremental energy demand will be captured by alternative energy sources, in particular, natural gas and its derivatives.

This is already becoming visible in the order book for new vessels as nearly 50% of orders are for pure LNG or dual-fuelled engines, signalling a significant shift towards natural gas. Additionally, methanol-fuelled ships are gaining traction with a rising share in the order book. Engine manufacturers are also exploring the development of ammonia-fuelled engines, particularly for deep-sea shipping, providing another viable alternative to oil.

Other options, such as hydrogen and electricity are also being considered as potential energy sources in this industry's quest for sustainability. Considering the long lifespan of most vessels, however, achieving a significant market penetration with these engines over the next 25 years seems unlikely. Nevertheless, their gradual penetration will likely put a cap on potential oil demand growth and further delink the rate of expanding maritime trade from oil consumption.

It is important to note that this shift to alternative powertrains in the shipping industry is, to a large extent, driven by efforts to reduce emissions. In July 2023, International Maritime Organization (IMO) member states adopted the 'Strategy on Reduction of GHG Emissions from

Ships' outlining a common ambition to achieve netzero greenhouse gas (GHG) emissions from international shipping by around 2050. To support this ambitious strategy, IMO also introduced additional measures to improve the industry's fuel efficiency, which – besides oil substitution – should constitute another important contributor to reducing emissions.

However, what could prove to be supportive to the extended use of oil products in the shipping industry is a new technology of on-board carbon capture units – similar to on-board scrubbers to capture SO_x emissions – developed by Aramco. This could represent a major step forward in reducing CO₂ emissions and mitigating risks for shipowners, and could be utilized in both existing and newly built ships.

Considering these uncertainties and the impact of regional GDP developments on maritime trade, Table 3.11 provides a summary of oil demand for marine bunkers in the period to 2050. Driven by expanding international trade, oil demand is set to continue increasing in the current decade, but this growth is expected to slow sometime after 2030. This is due to the expanding number of vessels with alternative powertrains and a higher impact of energy efficiency measures.

Table 3.11
Oil demand in the marine bunkers sector by region, 2023–2050

mb/d

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Americas	0.5	0.5	0.5	0.5	0.5	0.4	0.0
OECD Europe	0.8	0.8	0.7	0.7	0.6	0.6	–0.2
OECD Asia-Pacific	0.2	0.2	0.2	0.2	0.2	0.2	–0.1
OECD	1.5	1.5	1.4	1.3	1.2	1.1	–0.4
China	0.3	0.4	0.4	0.4	0.4	0.4	0.1
India	0.0	0.0	0.1	0.1	0.1	0.1	0.0
Other Asia	1.2	1.4	1.5	1.6	1.7	1.8	0.6
Latin America	0.3	0.4	0.4	0.5	0.5	0.5	0.2
Middle East	0.5	0.6	0.6	0.6	0.6	0.6	0.2
Africa	0.1	0.2	0.2	0.2	0.2	0.3	0.1
Russia	0.1	0.2	0.2	0.2	0.1	0.1	0.0
Other Eurasia	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Other Europe	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Non-OECD	2.7	3.3	3.5	3.7	3.8	3.9	1.2
World	4.2	4.8	5.0	5.0	5.0	5.1	0.8

Source: OPEC.

Therefore, the overall change between 2023 and 2050 is limited to 0.8 mb/d with the bulk of this incremental demand (0.6 mb/d) materializing in the current decade. After 2030, demand for marine bunkers continues to grow, albeit in a narrow range of 4.8–5.1 mb/d.

With future economic growth driven mainly by Asian countries, the centre of gravity of international maritime trade is set to shift further towards Asia. Moreover, several large bunkering ports are located in this region, as well as in the Middle East. These factors are expected to drive demand for marine bunkers in the non-OECD over the entire outlook period, with regional demand increasing by 1.2 mb/d. The largest demand increases are projected in Other Asia (0.6 mb/d) followed by the Middle East and Latin America, adding 0.2 mb/d each.



Shifting trade towards non-OECD regions will also have implications for OECD demand in this sector. This is expected to remain relatively stable at around 1.5 mb/d during the current decade, before the penetration of non-oil-based vessels, efficiency improvements and environmental regulations start biting into oil demand. The demand decline is not anticipated to be large, but steady across all OECD regions.

'Other industry' (industry sector excluding petrochemicals) has a relatively high oil demand base of almost 13 mb/d and is subject to certain policy measures and regulations. In the OECD, this set of measures has significantly contributed to a gradual oil substitution in this sector, initially by natural gas and more recently also by electricity. For example, the industrial use of oil in OECD Europe stood at around 3.5 mb/d during the 1970s. However, it declined to levels below 2 mb/d in 2010s and further to 1.4 mb/d in recent years.

This trend is expected to continue over the future outlook period although demand changes in OECD Europe and OECD Asia-Pacific are projected to be relatively small as remaining demand in these regions is concentrated in hard-to-abate industry segments. However, there is a higher potential in OECD Americas, especially given the availability of natural gas in the US at competitive prices, as well a high potential for efficiency improvements. In brief, OECD oil demand in 'other industry' is projected to continue declining over the outlook period to reach a level of 4.3 mb/d by 2050, from 5 mb/d in 2023 (Table 3.12).

Table 3.12

Oil demand in the 'other industry' sector by region, 2023–2050

mb/d

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Americas	2.8	3.1	3.1	2.8	2.6	2.4	–0.4
OECD Europe	1.4	1.4	1.4	1.3	1.3	1.2	–0.1
OECD Asia-Pacific	0.8	0.7	0.7	0.6	0.6	0.6	–0.2
OECD	5.0	5.2	5.2	4.7	4.5	4.3	–0.7
China	2.2	2.3	2.4	2.3	2.3	2.3	0.0
India	1.0	1.2	1.3	1.5	1.6	1.7	0.7
Other Asia	0.9	1.1	1.2	1.2	1.2	1.3	0.4
Latin America	1.0	1.2	1.3	1.3	1.4	1.4	0.4
Middle East	1.2	1.5	1.6	1.6	1.6	1.6	0.4
Africa	0.6	0.7	0.8	0.8	0.9	1.0	0.4
Russia	0.6	0.6	0.6	0.6	0.6	0.6	0.0
Other Eurasia	0.2	0.3	0.3	0.3	0.3	0.3	0.1
Other Europe	0.1	0.2	0.2	0.2	0.2	0.1	0.0
Non-OECD	8.0	9.0	9.6	9.8	10.1	10.4	2.5
World	12.9	14.2	14.8	14.6	14.6	14.7	1.8

Source: OPEC.

The demand outlook for this sector in non-OECD countries has a somewhat different narrative. Naturally, industry electrification, the increased use of natural gas and policy measures to reduce emissions will impact non-OECD industrial oil demand. However, expanding industrialization and the limited availability of alternative fuels in many of these countries will more than offset the impact of potential fuel substitution and efficiency gains.

This will especially be the case in India. Driven by a fast economic expansion and sustained support to the country's industrialization, India's oil demand in this sector is projected to increase by 0.7 mb/d between 2023 and 2050. With this expansion, India will be the largest contributor to future demand growth in this sector. Africa, the Middle East, Latin America and Other Asia are also expected to expand for the same reason, each growing by around 0.4 mb/d over the same period.

Somewhat lower demand changes are also projected in the remaining non-OECD regions, namely China, Other Eurasia, Russia and Other Europe, which combined add another 0.2 mb/d. From the perspective of refined products, changes in demand in this sector typically impact demand for diesel, residual fuel and LPG.

Oil demand prospects in the smallest segment of the transportation sector – **rail and domestic waterways** – largely depends on developments in two critical areas: domestic waterways in China and rail transportation in OECD Americas. Currently, China is the largest oil consumer in this sector, with annual demand of around 0.7 mb/d, around 0.6 mb/d of which is linked to domestic waterways and less than 0.1 mb/d to diesel consumption in rail transport. This reflects the fact that a large part of China's railway system is already electrified and the country has the longest system of navigable waterways in the world.

Planned waterway network expansions are expected to lead to an increase in related oil demand while, at the same time, continuous railway electrification will give demand a slight push in the opposite direction. The net effect of these diverging trends is incremental demand growth in China of 0.2 mb/d between 2023 and 2050 (Table 3.13). In addition to China, some minor demand expansion is also projected in the remaining non-OECD regions, such as Other Asia, Latin America and the Middle East.

Table 3.13

Oil demand in the rail and domestic waterways sector by region, 2023–2050

mb/d

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Americas	0.5	0.5	0.5	0.5	0.4	0.3	–0.2
OECD Europe	0.1	0.1	0.1	0.1	0.1	0.1	0.0
OECD Asia-Pacific	0.1	0.1	0.1	0.1	0.1	0.1	0.0
OECD	0.7	0.7	0.7	0.6	0.5	0.5	–0.2
China	0.7	0.9	0.9	0.9	1.0	1.0	0.2
India	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Other Asia	0.1	0.2	0.2	0.2	0.2	0.2	0.1
Latin America	0.1	0.2	0.2	0.2	0.2	0.2	0.1
Middle East	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Africa	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Russia	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Other Eurasia	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Europe	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-OECD	1.3	1.5	1.6	1.7	1.7	1.8	0.6
World	2.0	2.2	2.3	2.3	2.3	2.3	0.3

Source: OPEC.



In the case of OECD Americas, the demand split in this sector is in favour of rail transportation, which accounted for around 0.3 mb/d out of 0.5 mb/d consumed in this sector in 2023. In contrast to China, however, in the absence of major expansion plans in either of these subsectors, future oil demand is set to be mostly affected by improved engine efficiencies and the substitution of oil with electricity, especially in the rail sector. The displacement of oil by LNG in waterways traffic could also be expected. Consequently, OECD Americas oil demand in this sector is set to decline by around 0.2 mb/d between 2023 and 2050. For the same reasons, demand in other OECD regions is also anticipated to marginally decline.

Finally, Table 3.14 presents oil demand projections in electricity generation in the period to 2050. It shows that global demand in this sector is set to decline by 0.8 mb/d, falling from 4.6 mb/d in 2023 to 3.8 mb/d in 2050. The primary reason for this decline is the almost complete elimination of oil used for electricity generation in the OECD. This is projected to decline by around 1 mb/d over the outlook period and reach a level of just 0.2 mb/d by 2050. By then, virtually no oil will be used in large power plants. The use of oil is expected to be basically restricted to electricity generation within the refinery gates, the use of diesel aggregates in remote places and for emergency back-up purposes.

Table 3.14
Oil demand in the electricity generation sector by region, 2023–2050

mb/d

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
OECD Americas	0.4	0.2	0.1	0.1	0.1	0.1	–0.3
OECD Europe	0.3	0.1	0.1	0.2	0.1	0.1	–0.2
OECD Asia-Pacific	0.4	0.4	0.3	0.2	0.1	0.1	–0.4
OECD	1.1	0.7	0.5	0.5	0.3	0.2	–0.9
China	0.3	0.1	0.2	0.2	0.2	0.2	–0.1
India	0.1	0.2	0.2	0.2	0.2	0.3	0.1
Other Asia	0.4	0.4	0.4	0.4	0.3	0.3	–0.1
Latin America	0.5	0.6	0.6	0.6	0.6	0.6	0.1
Middle East	1.5	1.6	1.5	1.4	1.2	1.2	–0.3
Africa	0.5	0.7	0.8	0.8	0.8	0.8	0.3
Russia	0.2	0.2	0.2	0.1	0.1	0.1	0.0
Other Eurasia	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Europe	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-OECD	3.5	3.8	3.8	3.8	3.5	3.6	0.1
World	4.6	4.6	4.4	4.3	3.9	3.8	–0.8

Source: OPEC.

Turning to non-OECD prospects, projections show a mixed picture with diverging regional trends. Demand in some regions, such as the Middle East, China, Other Asia and Russia, is projected to decline on the back of the power sector shifting more towards renewable electricity and natural gas. In contrast to these regions, oil used for electricity generation will likely increase in Africa, India and Latin America. The largest increase (0.3 mb/d) is projected for Africa due to the need to improve access to electricity and provide a back-up in case of shortages and disruptions from on-grid electricity.

3.3 Oil demand outlook by product

This section of the chapter aims to provide some insights into future demand trends from the perspective of specific refined products. As presented in Table 3.15 and Figure 3.22, the largest demand increase among all major products is projected for ethane/LPG. The combined demand for these two products is set to grow from 13.4 mb/d in 2023 to 17.5 mb/d in 2050. The large part of this demand growth relates to the use of ethane as a petrochemical feedstock, mainly in OECD Americas and the Middle East.

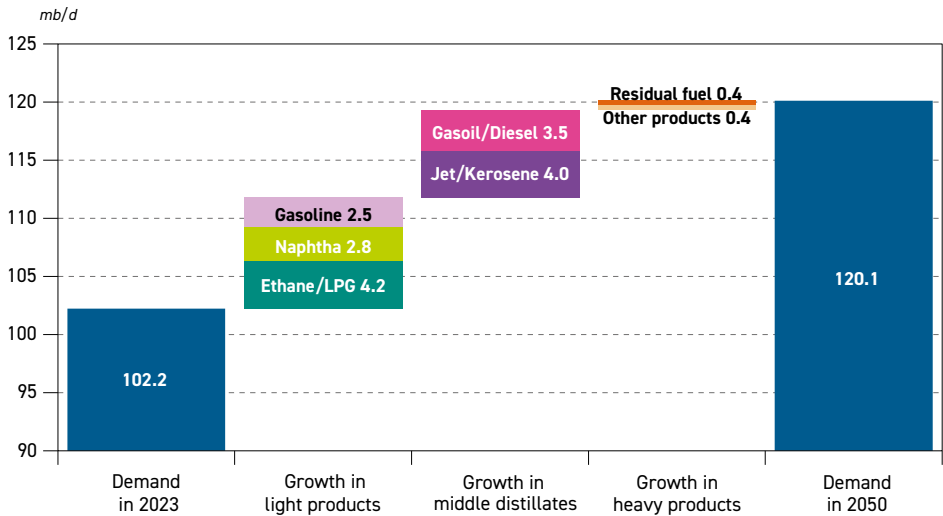
Table 3.15
Global oil demand by product, 2023–2050

mb/d

	2023	2030	2035	2040	2045	2050	Growth 2023–2050
Ethane/LPG	13.4	15.7	16.4	16.9	17.2	17.5	4.2
Naphtha	6.6	7.8	8.2	8.7	9.1	9.4	2.8
Gasoline	27.1	29.2	29.5	29.6	29.6	29.6	2.5
Light products	47.0	52.7	54.1	55.1	55.9	56.6	9.6
Jet/Kerosene	7.5	9.2	9.9	10.5	11.2	11.5	4.0
Gasoil/diesel	29.0	31.3	32.1	32.2	32.2	32.5	3.5
Middle distillates	36.5	40.6	42.0	42.7	43.4	44.1	7.5
Residual fuel	6.8	7.7	7.7	7.6	7.3	7.2	0.4
Other products	11.8	12.3	12.5	12.4	12.3	12.3	0.4
Heavy products	18.7	20.0	20.2	19.9	19.6	19.5	0.8
World	102.2	113.3	116.4	117.8	118.9	120.1	17.9

Source: OPEC.

Figure 3.22
Demand growth by product category between 2023 and 2050



Source: OPEC.

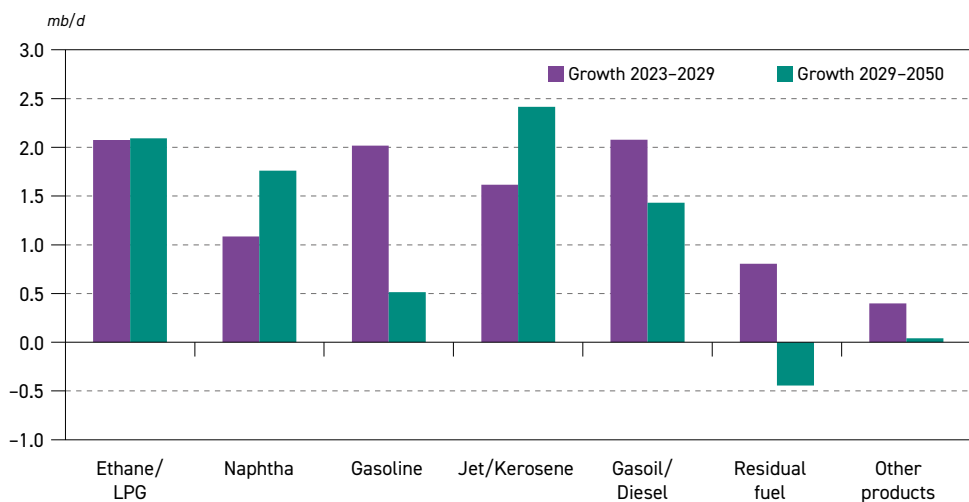


Compared to ethane, the use of LPG is spread across a wider range of regions and sectors, including the residential, industrial and petrochemical sectors. From the regional perspective, the largest demand growth for LPG demand is expected in Africa, India and Latin America. Despite the higher incremental demand of ethane, it is crucial to note that current demand for LPG is more than double that for ethane. This ratio is expected to drop over time, but LPG demand is set to remain almost 80% higher even at the end of the outlook period.

The strong projected demand growth in the petrochemical sector, especially in Asia, is set to lead to increased naphtha demand too. At the global level, demand for naphtha is projected to grow by 2.8 mb/d between 2023 and 2050, with the largest increment projected for Other Asia (0.9 mb/d). Moreover, China and India are expected to contribute around 0.6 mb/d each. In contrast, naphtha demand in OECD Europe is expected to decline by 0.1 mb/d, with only moderate increases projected in other regions.

Somewhat lower incremental demand is projected for gasoline. Its global demand is expected to increase by 2.5 mb/d during the outlook period, rising from 27.1 mb/s in 2023 to 29.6 mb/d in 2050. As presented in Figure 3.23, however, almost the entire demand increase for this product is set to materialize in the medium term, with only minor demand growth projected in the later part of the outlook period. This demand pattern results from varying dynamics in the expansion of the global vehicle fleet, and the EV fleet, in particular.

Figure 3.23
Growth in global oil demand by product



Source: OPEC.

In the medium term, a large number of the additional vehicles are set to use gasoline-based powertrains, hence, driving gasoline demand higher. In time, however, the growing number of EVs are anticipated to gradually slow gasoline demand growth and even lead to its stabilization at levels below 30 mb/d.

In terms of middle distillates, overall demand growth for these products (including jet kerosene, domestic kerosene and diesel/gasoil) is somewhat lower than for light products,

estimated at 7.5 mb/d during the outlook period. The major growth driver in this category is the expansion of the aviation sector affecting future demand for kerosene, which is expected to grow from 7.5 mb/d in 2030 to 11.5 mb/d in 2050. It is noteworthy, however, that the overall increase in kerosene demand is slightly lower than the incremental demand in the aviation sector. This is because demand for domestic kerosene is set to slightly decline, therefore, part of the kerosene volume can be expected to 'shift' from the residential sector to aviation.

Future diesel/gasoil demand is set to be driven by a different set of factors as consumption of this product is spread across most major sectors. The largest demand base for diesel is in the road transportation sector, mainly in commercial vehicles. With the number of commercial vehicles set to expand, diesel demand in this segment is also expected to grow. Additional demand growth is projected in industry and the agricultural sectors, especially in developing countries. Part of this incremental demand, however, will likely be offset by declines in the shipping industry and in the residential and commercial sectors.

Finally, demand for the heavy part of the refined barrel (consisting of residual fuel oil, bitumen, petroleum coke, waxes, lubes, still gas and crude oil used for direct burning) is projected to remain in a relatively narrow range of 19–20 mb/d during a large part of the outlook period. Within this group, higher demand for residual fuel is set to be driven by an expanding industrial sector in non-OECD countries and fuelling vessels in maritime transportation. However, its use in electricity generation is set to decline, therefore, the overall demand increase for fuel oil is limited to 0.4 mb/d between 2023 and 2050.

Even more complex changes are set to steer demand for the group of 'other products'. In this respect, some demand growth is projected for bitumen, lubes and waxes, especially in developing countries. The direct use of crude oil is expected to see a declining trajectory in the power sector, but should increase in the petrochemical industry with the wider adoption of crude-to-chemicals technology. With the expansion of cracking and coking capacity in the downstream sector, the availability of petroleum coke will likely decrease, leading to declining consumption.

The projected net effect is that global demand for these products will increase by around 0.7 mb/d within the next 10 to 15 years, after which it is expected to be on a declining path in the second part of the outlook period.



Liquids supply



Key takeaways

- In line with methodology introduced in OPEC's May 2024 Monthly Oil Market Report (MOMR), the WOO will henceforth show supply outlooks and balances that primarily reflect DoC and non-DoC liquids supply.
- Non-DoC liquids supply in the medium term is projected to increase from 51.7 mb/d in 2023 to 58.8 mb/d in 2029, or by 7.1 mb/d. This outlook is driven by supportive fundamentals, including a healthy outlook for continued oil demand growth, but also a robust list of upstream project developments.
- Once again, the largest medium-term source of non-DoC liquids supply growth is the US, where total output is set to rise by 2.3 mb/d in the 2023–2029 period, or from 20.9 mb/d to 23.2 mb/d. Other significant supply increments in this timeframe come from Brazil (1 mb/d), Canada (0.6 mb/d), Qatar (0.5 mb/d), Argentina (0.3 mb/d) and Norway (0.2 mb/d).
- Tight oil is the main driver behind US growth, with combined tight crude and unconventional NGLs supply rising from 13.7 mb/d in 2023 to 16.7 mb/d in 2029. US tight oil is projected to peak around the end of the decade, but continue producing in an extended plateau above 16 mb/d for the 2030s. Long term, it declines to average 14.8 mb/d by 2050. US tight oil supply patterns, due to their relative size, lead to more or less concurrent peaks in US and, in turn, total non-DoC liquids supply.
- Long-term non-DoC liquids supply grows from 51.7 mb/d in 2023 to 57.3 mb/d in 2050, or by 5.5 mb/d. Despite the US production decline over this time horizon, this is more than offset by higher output in Latin America, Canada, the (non-DoC) Middle East and global refinery processing gains. Other regions see only modest change.
- In terms of supply trends by type of liquid, a long-term decline in non-DoC crude supply of 3.0 mb/d is more than offset by increases in all other liquids. NGLs are projected to expand by 2.8 mb/d in the 2023–2050 period; other liquids, including Canadian oil sands, by 2.7 mb/d; biofuels by 2.2 mb/d; and global refinery processing gains by 0.9 mb/d.
- DoC liquids supply is projected to grow from 50.3 mb/d in 2023 to 53.8 mb/d in 2029. After non-DoC liquids supply peaks in the early 2030s, DoC liquids supply by contrast keeps expanding, rising to 62.9 mb/d by 2050. This means that the DoC's share in global liquids supply increases from 49% in 2023 to 52% in 2050.
- Oil sector investment needs remain significant to reliably meet projected oil demand growth. Total cumulative investment requirements between 2024 and 2050 are estimated at \$17.4 trillion, or around \$640 billion p.a. on average (all in US\$2024). The bulk of this is required in the upstream, where total investment needs are estimated at \$14.2 trillion, or around \$525 billion p.a. Downstream and midstream investment needs over the long term are projected to be \$1.9 trillion and \$1.3 trillion, respectively.

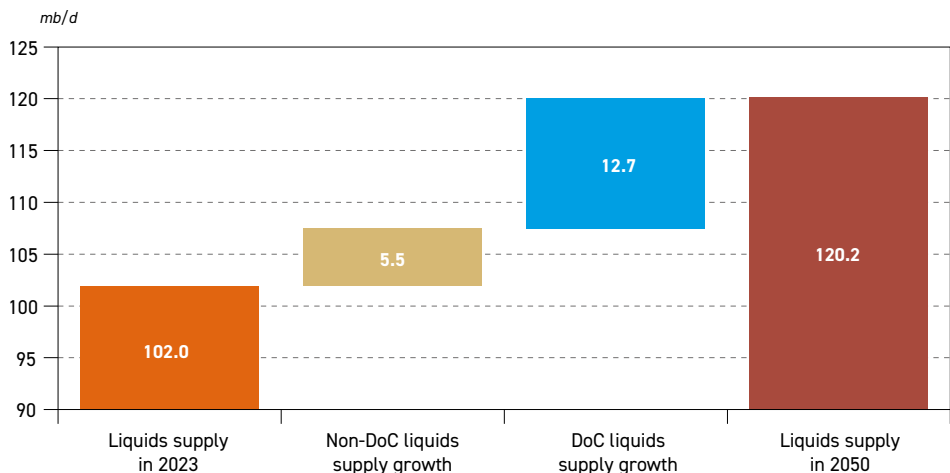
This chapter describes the outlook for liquids supply from 2023 to 2050. As in previous WOOs, the medium-term projections for 2023 to 2029 and the longer-term outlook are discussed separately, due to the different methodologies employed. The medium-term view relies on a bottom-up approach, identifying upstream project start-ups, their progress and the underlying decline in mature fields, while the long-term outlook is based on an assessment of the available resource base and other factors. US and other tight oil are also modelled and discussed separately, as are non-crude liquids. This year's WOO has extended the time horizon out to 2050 for the first time. Also, following Angola's decision to leave OPEC, liquids supply data has been revised throughout to reflect current membership.

In line with methodology introduced in OPEC's May 2024 MOMR, the WOO will henceforth also show supply outlooks and balances that primarily reflect DoC and non-DoC liquids supply. The countries participating in the DoC are: Algeria, Azerbaijan, Bahrain, Brunei, Congo, Equatorial Guinea, Gabon, IR Iran, Iraq, Kazakhstan, Kuwait, Libya, Malaysia, Mexico, Nigeria, Oman, Russia, Saudi Arabia, Sudan, South Sudan, the United Arab Emirates and Venezuela.

4.1 Global liquids supply outlook

Against projections for continued strong oil demand growth and a broader picture of healthy fundamentals, the outlook for liquids supply growth remains robust. In the medium term, non- DoC liquids supply is projected to grow from 51.7 mb/d in 2023 to 58.8 mb/d in 2029, or by 1.2 mb/d on average p.a. In this period, non-DoC liquids supply is driven primarily by increases in the Americas, with rising output in the US, Brazil and Canada, but there are also significant increments from Qatar, Argentina and Norway. In the early 2030s, aggregate non-DoC liquids supply peaks at 59 mb/d and then begins to decline modestly, falling to 57.3 mb/d by 2050 (Figure 4.1 and Table 4.1).

Figure 4.1
Composition of global liquids supply growth



Source: OPEC.



Table 4.1

Long-term global liquids supply outlook

mb/d

	2023	2030	2035	2040	2045	2050	Change 2023-2050
US	20.9	23.0	22.1	21.1	20.2	19.4	-1.5
<i>of which: tight oil</i>	13.7	16.7	16.5	16.1	15.5	14.8	1.1
Canada	5.7	6.4	6.4	6.7	7.0	7.5	1.8
<i>of which: oil sands</i>	3.2	3.6	3.8	4.1	4.5	5.0	1.7
OECD Americas	26.6	29.4	28.5	27.8	27.2	26.9	0.3
OECD Europe	3.7	3.9	3.9	3.9	4.0	4.1	0.4
OECD Asia-Pacific	0.4	0.5	0.5	0.5	0.5	0.5	0.1
Latin America	7.0	9.2	10.1	10.6	10.7	10.5	3.6
Middle East	2.0	2.7	2.7	2.7	2.7	2.7	0.7
Africa	2.2	3.0	2.9	2.8	2.6	2.5	0.2
China	4.5	4.6	4.5	4.4	4.4	4.3	-0.2
India	0.8	0.9	0.9	0.9	0.8	0.8	0.0
Other Asia	1.6	1.6	1.5	1.4	1.4	1.3	-0.3
Other Eurasia	0.5	0.4	0.4	0.4	0.3	0.3	-0.2
Global refinery processing gains	2.5	2.8	3.0	3.2	3.3	3.4	0.9
Non-DoC liquids	51.7	59.0	58.9	58.5	57.8	57.3	5.5
Total DoC liquids	50.3	54.5	57.6	59.4	61.1	62.9	12.7
World	102.0	113.5	116.5	117.8	119.0	120.2	18.2

Source: OPEC.

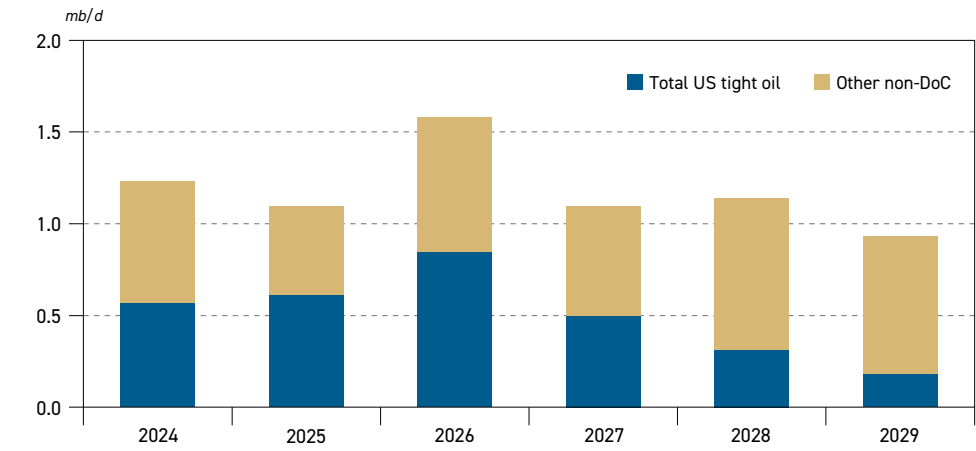
DoC liquids supply is projected to expand from 50.3 mb/d in 2023 to 53.1 mb/d in 2029. After non-DoC liquids supply peaks in the early 2030s, DoC liquids supply by contrast remains on an upward trend, rising to 62.9 mb/d by 2050. This means that the DoC's share in global liquids supply rises from 49% in 2023 to 52% in 2050.

4.2 Drivers of medium-term and long-term liquids supply

Following a strong rebound in non-DoC liquids supply post-COVID 19, especially in the US, the medium term is projected to see healthy growth, with total non-DoC liquids supply increasing from 51.7 mb/d in 2023 to 58.8 mb/d in 2029, or by 7.1 mb/d. The rise continues to be driven first and foremost by the US, which is set to increase by 2.3 mb/d, making up one-third of the non-DoC increment in this period (Figure 4.2). As shown in Figure 4.3, this is complemented by rising supply in Brazil (1 mb/d), Canada (0.6 mb/d), Qatar (0.5 mb/d), Argentina (0.3 mb/d) and Norway (0.2 mb/d). As in previous reports, tight oil is the main reason behind increasing US supply, rising by 3 mb/d in this period, but this growth is partly offset by conventional production declines.

Higher medium-term non-DoC liquids supply also stems from an upward revision to the 2023 baseline, with US production notably having exceeded expectations compared to the WOO 2023. Near-term projections are also higher, and a re-assessment of medium-term upstream project start-ups indicates a longer list of sanctioned field developments. Supported by a solid fundamentals outlook, and buoyed by cash to spend, companies have committed to more upstream investments in Canada, Brazil and the US, among others.

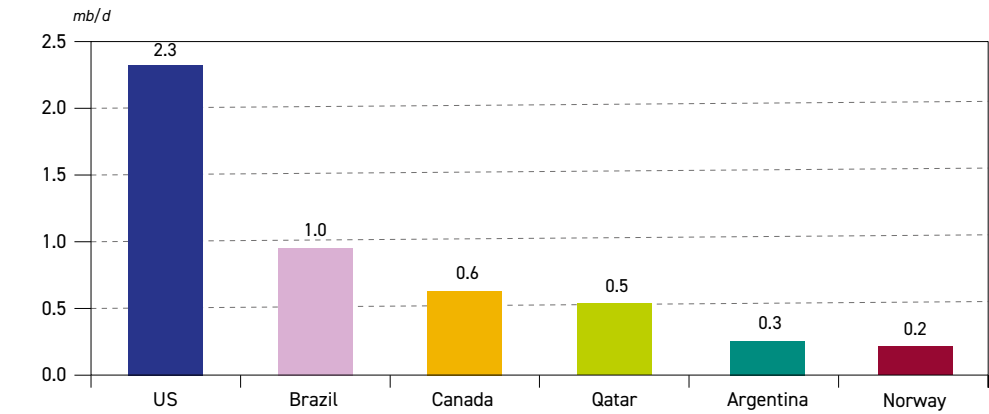
Figure 4.2
Composition of non-DoC annual medium-term liquids supply growth



Source: OPEC.

The longer-term outlook for non-DoC liquids supply has also been revised up compared to the WOO 2023. In part, this is a carry through from medium-term adjustments, but it is also a reflection of US tight oil projections that show a longer plateau. Recent discoveries and

Figure 4.3
Select contributors to non-DoC total liquids change, 2023–2029



Source: OPEC.

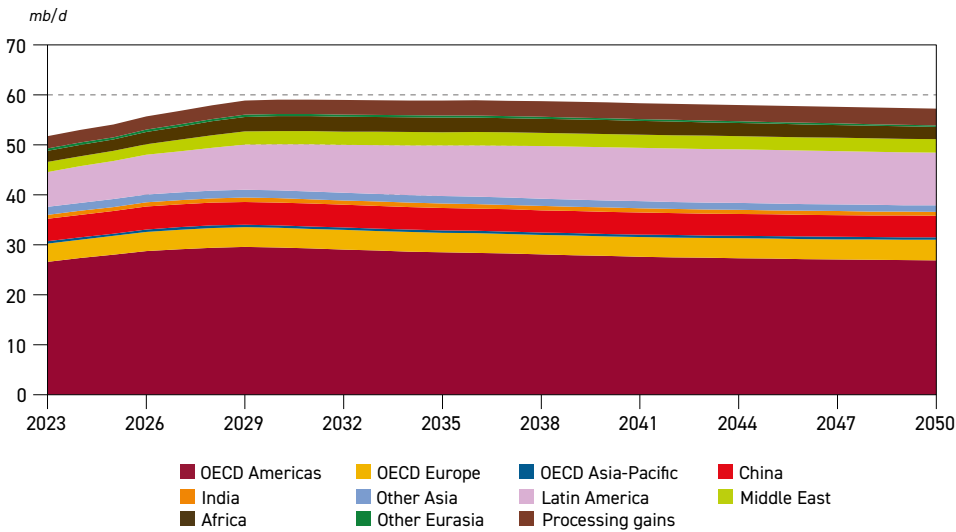
investment plans for frontier producers in Latin America and Africa have also resulted in upward revisions in these regions. Lastly, prospects for tight oil – in the US, but also in Argentina – have improved, and the same goes for biofuels, including SAF, due to firmed-up mandates in various regions.

As a result, non-DoC liquids supply, after peaking at 59 mb/d in the early 2030s, is set to see an extended plateau throughout the 2030s, before sliding to 57.3 mb/d by 2050. Thus, non-DoC liquids, despite declining post-2030, grows by 5.5 mb/d over the entire outlook horizon from 2023 to 2050.



Combined with the upward-revised demand outlook, DoC liquids are projected to rise from 50.3 mb/d in 2023 to 53.8 mb/d in 2029, and then further to 62.9 mb/d by 2050. In market share terms, this indicates an increase from 49% in 2023 to 52% by 2050.

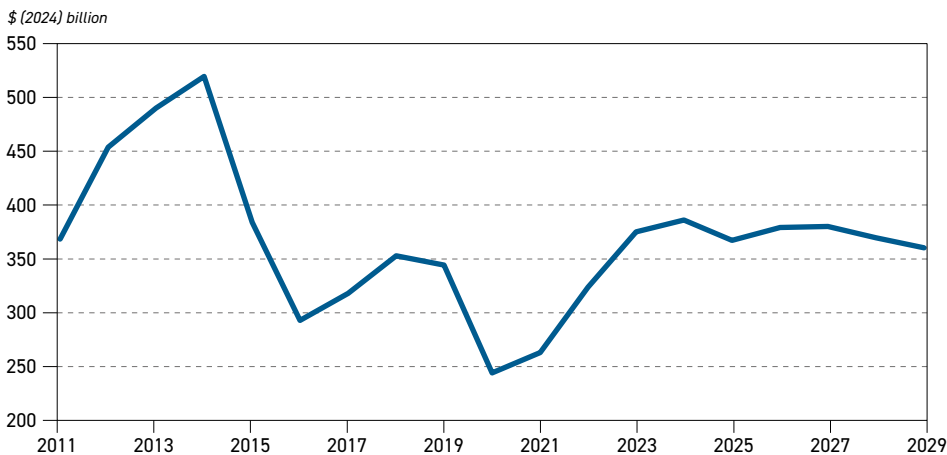
Figure 4.4
Long-term non-DoC liquids supply outlook



Source: OPEC.

Besides the outlook for continued robust demand growth, greater optimism and commitment regarding oilfield start-ups are also reflected in the outlook for upstream investment. According to Rystad Energy, upstream investment (capex) in oil only, is now projected to grow by a modest 3% in 2024, and then remain around \$375 billion p.a. in the period until 2029. This represents a substantial upward revision from Rystad Energy's assessment one year ago (Figure 4.5).

Figure 4.5
Global upstream (oil only) capital expenditure



Source: Rystad Energy.

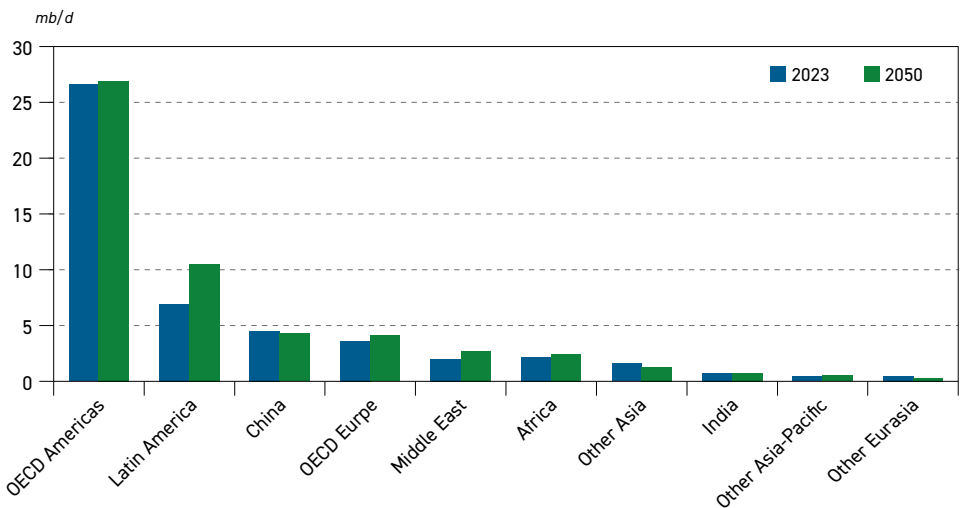
Another reason behind robust medium-term growth may be upstream producers' increased focus on shorter-cycle projects that quickly deliver returns. Examples include US and other tight oil, but also smaller tie-back developments that benefit from existing infrastructure in mature producing regions, as well as efforts at debottlenecking. This is driven by companies' increased focus on returns, which in turn leads to reluctance to invest in higher-breakeven projects, even as they work to reduce costs and develop fields as fast as possible. Another factor may be a flurry of investment decisions made in the wake of the energy crisis in 2022, the fruit of which will be seen within this report's medium-term time horizon.

4.3 Breakdown of liquids supply outlook by main regions

Regionally, as in previous outlooks, medium-term non-DoC liquids supply growth is overwhelmingly concentrated in OECD Americas and Latin America, which together make up three-quarters of incremental supply in this period, or 2.7 mb/d and 2.1 mb/d, respectively. Excluding DoC Members, Africa is projected to grow by 0.7 mb/d, the Middle East by 0.6 mb/d and OECD Europe by 0.3 mb/d. Most other regions see fairly flat production over this period.

In the long term, Latin America's contribution to non-DoC liquids supply is even more pronounced, with projected output set to rise by 3.6 mb/d from 2023 to 2050. The Middle East, OECD Europe and OECD Americas are expected to see long-term supply rises of 0.7 mb/d, 0.4 mb/d and 0.3 mb/d, respectively. By contrast, Other Asia, China and Other Eurasia will see modest declines.

Figure 4.6
Non-DoC liquids supply outlook by region



Source: OPEC.

US

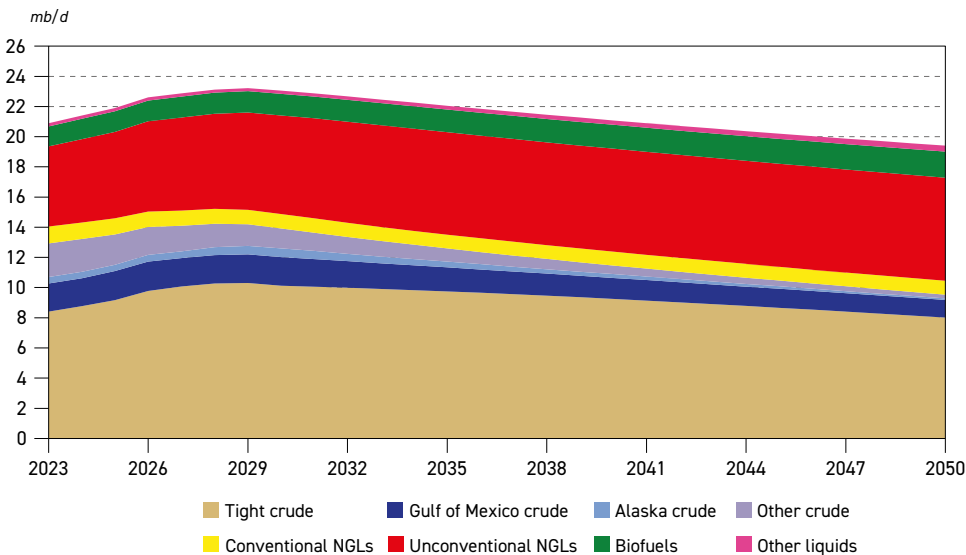
The US remains not only the world's largest oil and liquids producer, but also the strongest medium-term growth centre, with its total liquids supply, including crude oil, NGLs, tight oil, biofuels and other liquids, projected to grow from 20.9 mb/d in 2023 to 23.2 mb/d in 2029, or by 2.3 mb/d. This growth is overwhelmingly driven by tight oil, both tight crude and unconventional NGLs, while conventional onshore crude oil declines modestly and biofuels see a small uptick.



Despite what many in the US oil and gas industry see as a hydrocarbons-hostile administration, in terms of numbers, US liquids supply growth in 2023 was at 1.6 mb/d, which is on par with the 2017 to 2019 pre-pandemic annual average achieved in volumetric terms. Notwithstanding a refocusing on returns over growth, US tight oil producers have concentrated on efficiency gains. This covers extending well lengths, including laterals, clustering well-heads and drilling pads geographically, utilizing sensing and other technology advances and, to some extent, achieving cost reductions. However, production growth is clearly slowing, with average annual increments around 0.4 mb/d expected for the medium term.

Supply growth is overwhelmingly concentrated in tight oil, with tight crude increasing by 1.9 mb/d in the 2023–2029 period, and unconventional NGLs by another 1.1 mb/d (the outlook for US and other tight oil will be discussed in more detail in section 4.4.1). Meanwhile, non-tight crude is expected to decline in the medium term, albeit with mixed trends. In the Gulf of Mexico (GoM), offshore crude oil production will stay relatively flat at 1.9 mb/d over the medium term, as a string of new fields come on stream, offsetting a decline in existing assets. These new projects include the 80 tb/d Anchor and Whale fields in 2024, followed by Shenandoah and Shenzi North in 2025, with 40 tb/d and 25 tb/d, respectively. The Ballymore field start-up is set to add 75 kb/d in 2026. Lastly, in 2028/29, the sizeable Kaskida (100 tb/d), Sparta and Tiber (each 80 tb/d) are expected to be brought on stream. However, thereafter, GoM production is expected to decline again, falling to an average production of 1.2 mb/d by 2050.

Figure 4.7
US total liquids supply outlook



Source: OPEC.

Alaskan crude production is due to have something of a medium-term renaissance, growing from 0.4 mb/d in 2023 to 0.6 mb/d in 2029, as the Pikka (80 tb/d), Liberty (40 tb/d) and the large Willow (180 tb/d) fields start up. In the long term, however, Alaskan crude production is projected to decline to 0.1 mb/d by 2050. Other conventional crude output, all onshore and long in decline, is set to continue to shrink, falling from 2.2 mb/d in 2023 to 1.4 mb/d in 2029, and further to 0.2 mb/d by 2050.

With elections in 2024 and the possibility of a change in US administrations, the outlook for upstream-related policies is uncertain. Nonetheless, some of the policies implemented by the Biden administration are likely to raise costs for the upstream sector, which could potentially discourage some investment in the long term, particularly in higher-cost, more mature areas, including non-shale onshore acreage.

For instance, in April 2024, the Biden administration raised royalty rates on oil and gas drilling on public lands, which make up a share of just over 10% of total oil and gas produced in the US, for the first time in a century. Rates have been raised to 16.67% from 12.5%, in line with a change already mandated by the IRA, which among other things tried to strike a balance between encouraging renewable investment, while not excessively discouraging investment in hydrocarbons. Leasing costs will also rise in an attempt to avoid 'speculative leases', which are leases held by investors but not actively developed within a certain timeframe. Minimum bond requirements, which are used to pay for cleaning up sites after they are no longer produced, will also be raised. Previously, the Biden administration had implemented a fee on methane emissions, incentivizing greater efforts to capture these.

In terms of US biofuels and other liquids, both are set to experience growth by 2050, at 0.4 mb/d and 0.2 mb/d, respectively. Essentially, they are stimulated by mandates for road transport biofuels and various kinds of aviation fuels, whether biological or synthetic.

In sum, US liquids supply is expected to rise from 20.9 mb/d in 2023 to a peak of just over 23 mb/d at the end of the decade, before plateauing and declining slowly to average 19.4 mb/d by 2050.

Table 4.2
US total liquids supply outlook

mb/d

	2023	2030	2035	2040	2045	2050	Change 2023–2050
US tight oil	13.7	16.7	16.5	16.1	15.5	14.8	1.1
of which: tight crude	8.4	10.1	9.7	9.3	8.7	8.0	–0.4
of which: unconventional NGLs	5.3	6.5	6.8	6.8	6.8	6.8	1.5
US Gulf of Mexico crude	1.9	1.9	1.6	1.4	1.3	1.2	–0.7
US Alaska crude	0.4	0.6	0.4	0.3	0.2	0.1	–0.3
US other crude	2.2	1.3	0.9	0.6	0.4	0.2	–2.0
US other NGLs	1.1	1.0	0.9	0.9	0.9	0.9	–0.2
US biofuels	1.3	1.4	1.5	1.6	1.7	1.7	0.4
US other liquids	0.2	0.2	0.2	0.3	0.3	0.4	0.2
Memo item: US total crude	12.9	13.9	12.6	11.5	10.5	9.5	–3.4
Memo item: US total NGLs	6.4	7.5	7.7	7.7	7.7	7.7	1.3
Total US liquids production	20.9	23.0	22.1	21.1	20.2	19.4	–1.5

Source: OPEC.

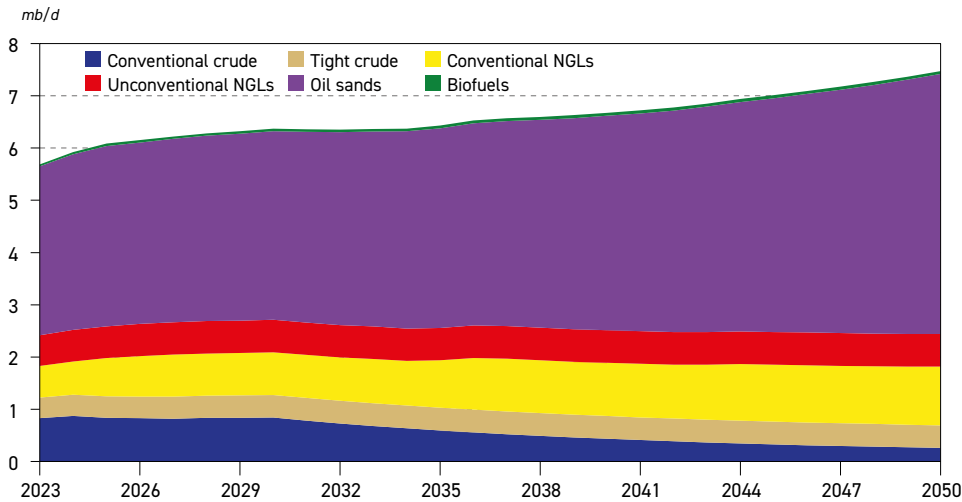
Canada

Canadian total liquids supply is set to rise from 5.7 mb/d in 2023 to 6.3 mb/d in 2029, making it the third-largest source of non-DoC supply growth. Incremental supply is projected to come primarily from rising oil sands output, which is set to expand from 3.2 mb/d in 2023 to 3.6 mb/d in 2029. NGLs supply is another source of growth, with output rising from 1.2 mb/d in 2023 to 1.4 mb/d 2029, as gas production increases.



Other sources of supply, including conventional and tight crude, are projected to stay flat in this period. This is despite the start-up of some sizeable conventional offshore fields on the country's east coast. These include West White Rose, due to come on stream in 2026, with a capacity of 75 tb/d. The even larger 180 tb/d Bay du Nord field is now slated to start production in 2028. These sources of incremental supply, however, are set to be offset by declines elsewhere, particularly mature producing areas on- and offshore.

Figure 4.8
Canada total liquids supply outlook



Source: OPEC.

Liquids production from oil sands is set to continue growing beyond the medium term, with output rising from 3.6 mb/d in 2029 to 5 mb/d in 2050. Constraints in export infrastructure, which in previous years had threatened to limit output growth, may now be somewhat alleviated by the recent start-up of the expanded Trans Mountain pipeline. The line, which pumps crude oil from Alberta's oil sands to a location near Vancouver in British Columbia, has been undergoing work to expand its capacity from around 300 tb/d to 900 tb/d in the future, significantly boosting Albertan producers' capacity to export barrels to the West Coast and on to US or Asian refiners.

NGLs supply is also set to keep growing, both conventional and unconventional, rising from 1.2 mb/d in 2023 to 1.7 mb/d in 2050. Conventional crude, however, is expected to continue its decline, falling to 0.3 mb/d by 2050.

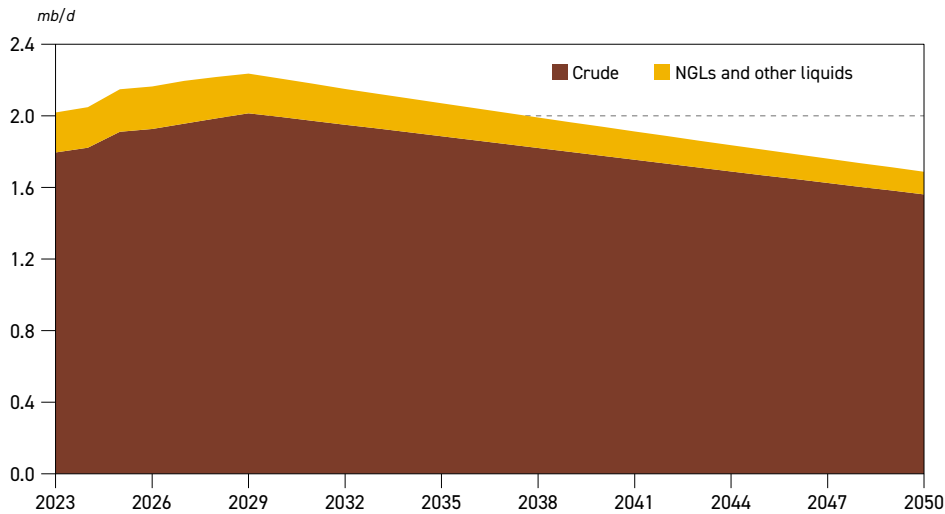
Norway

Norway's liquids supply is projected to see medium-term growth, rising from 2 mb/d in 2023 to 2.2 mb/d in 2029, as the large Johan Castberg field comes on stream during 2024, adding 200 tb/d. The super-giant Johan Sverdrup, which has driven Norway's output growth in recent years, is now producing at a capacity of around 750 tb/d. From 2027, another 80 tb/d will be added at the Yggdrasil field, adding to some smaller tiebacks at existing fields.

Norway's producers have been particularly successful at maintaining production, even at some highly mature field complexes, by relatively quickly adding smaller tiebacks and benefiting from the extensive infrastructure already in place. Another boost has come from a flurry of final investment decisions (FID) made due to tax breaks temporarily put in place in the wake of the COVID-19 pandemic, which have now expired.

In the absence of any larger new fields on the horizon, however, Norway's production is set to decline in the long term. The future of fields such as Ringvei West or Wisting, the latter in the challenging Barents Sea on Norway's northernmost coast, is uncertain, given high costs and many oil companies, especially the supermajors', shifting focus to newer frontiers on the Atlantic Rim in Latin America or Africa. Thus, Norway's total liquids supply is projected to decline gradually from 2030, sliding to 1.7 mb/d by 2050.

Figure 4.9
Norway total liquids supply outlook



Source: OPEC.

UK

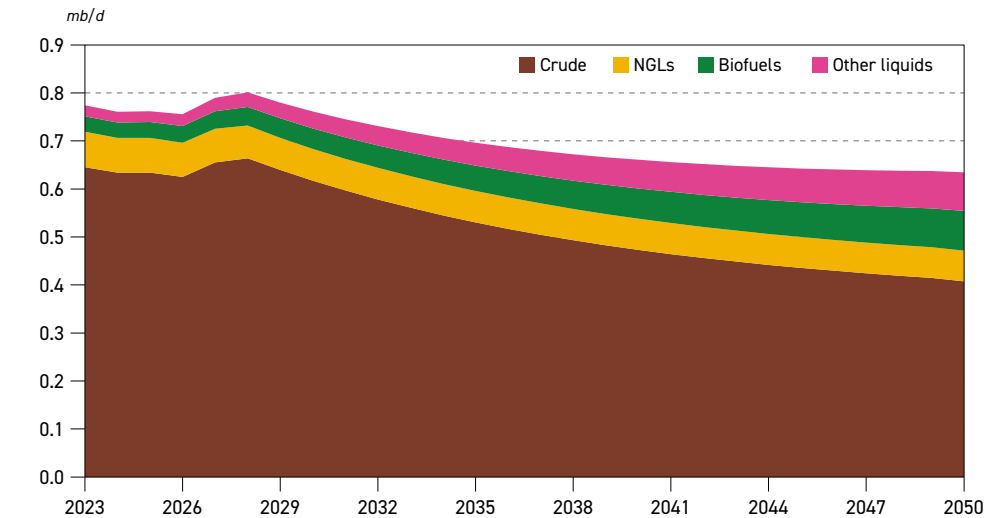
By contrast, the UK is projected to see flat production in the medium term, with total liquids averaging 0.8 mb/d in this period. Its pipeline of new fields is more modest, the largest due to come on stream in the next six years being Rosebank, adding around 65 tb/d from 2027 after finally receiving its FID in late 2023 following delays.

Against a backdrop of a shrinking resource base, operators argue that the government's Energy Profits Levy, a windfall tax that was introduced in 2022 and since been extended, is punitively high, disincentivizing new upstream investments. Moreover, the new government elected in July 2024 has suggested that it plans to raise the headline tax rate on oil and gas profits from the current 75% to 78% and also remove the investment allowances currently in place.

As a result, UK crude supply is projected to continue its slow decline, sliding from an average of 0.6 mb/d in the medium term to 0.4 mb/d in 2050. To some extent, this is offset by the prospect of a modest increase in biofuels and synthetic aviation fuel. In aggregate, UK liquids supply is set to slide from 0.8 mb/d in 2023 to 0.6 mb/d in 2050.



Figure 4.10
UK total liquids supply outlook



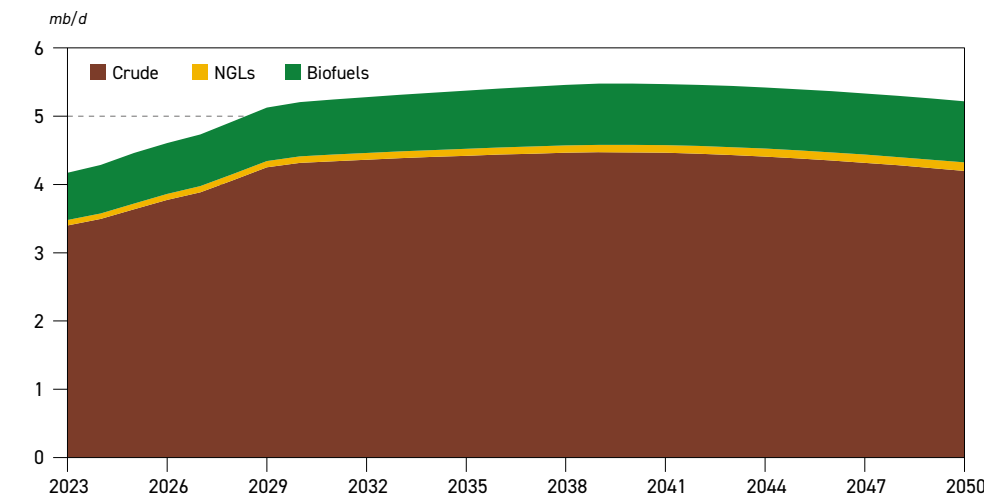
Source: OPEC.

Brazil

Brazil is set to be the second-largest source of non-DoC medium-term liquids supply growth, with total output projected to rise from 4.2 mb/d in 2023 to 5.1 mb/d in 2029. Incremental supply remains focused on the ultra-deepwater offshore pre-salt areas, with a long list of fields and associated floating production, storage and offloading (FPSO) vessels due to come on stream in the coming years.

4

Figure 4.11
Brazil total liquids supply outlook



Source: OPEC.

These include the next development stages of the large Mero and Buzios field complexes that are set to contribute significant production capacity. Mero 3 and 4, each with 180 tb/d of capacity, are expected to see first oil in 2024 and 2025, respectively. Buzios 6 through 10, with nameplate capacity in the range of 180–225 tb/d, are also due to come on stream between 2025 and 2028. Other notable capacity additions are the Bacalhau field (220 tb/d), due in 2025, to be followed in 2029 by Bacalhau Norte, adding another 220 tb/d. In sum, new capacity of around 2.3 mb/d is due to come online in the medium term.

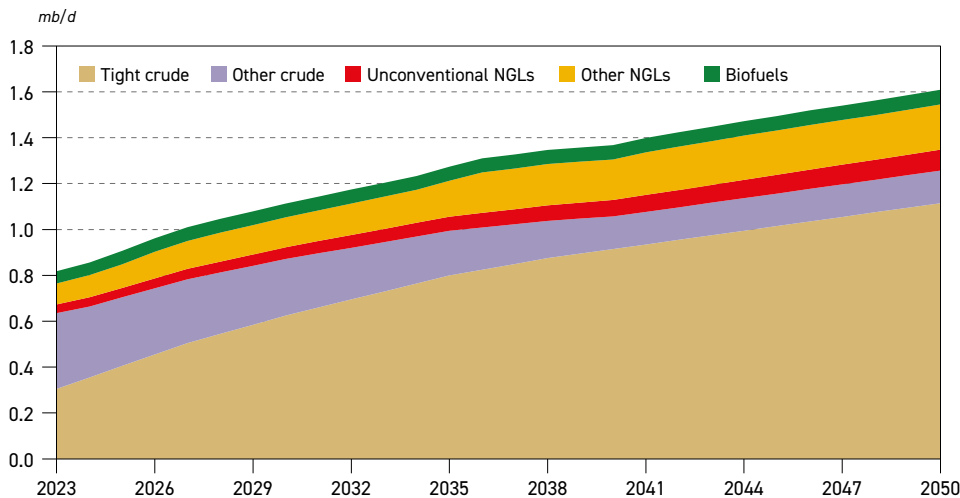
Beyond the medium term, supply growth is expected to slow, as much of the prime pre-salt resources will have been tapped. Having said that, offshore exploration in Brazil has ramped up, including in the less-explored equatorial margin on the country’s northern coast. Even so, slower crude oil output growth, coupled with more modest increases in fuel ethanol production, is expected to see Brazil’s total liquids supply rise from 5.1 mb/d in 2029 to a projected peak of around 5.5 mb/d in the late 2030s, after which it dips back to around 5.2 mb/d in 2050.

Argentina

Argentina is another source of significant non-DoC supply growth, with output projected to expand from 0.8 mb/d in 2023 to 1.1 mb/d in 2029. This is predominantly driven by an expected near doubling of tight crude from 0.3 mb/d to 0.6 mb/d, as output in the Vaca Muerta basin ramps up.

Export capacity out of the landlocked region also continues to increase. After the 115 tb/d crude pipeline to Chile’s Pacific coast was re-started in 2023, the Vaca Muerta Norte line added another 160 tb/d in the same year. National oil and gas producer Yacimientos Petrolíferos Fiscales (YPF) is currently planning a Vaca Muerta Sur pipeline and port to boost tight crude exports into the Atlantic Basin markets. This line, initially conceived for 400 tb/d, could be expanded to 800 tb/d at a later stage. Gas infrastructure, including for exports, is also being increased, potentially providing another fillip for oil expansion.

Figure 4.12
Argentina total liquids supply outlook



Source: OPEC.



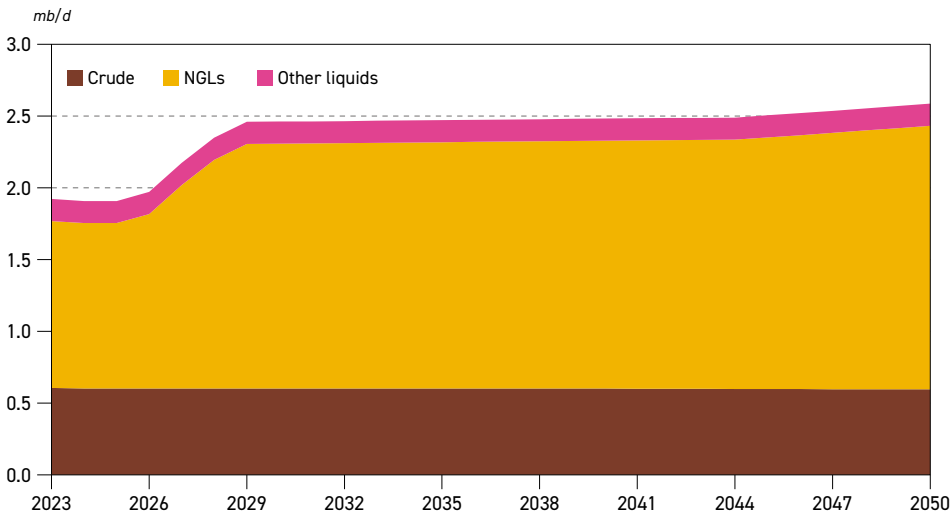
The new Milei government has ambitious plans to liberalize the economy, including privatizing some state-owned companies, and possibly YPF. This, and other reforms, have the potential to shape the country's energy scene, though they could face significant resistance in Congress. For the time being, the base case for Argentina's continued strong liquids supply growth rests on tight oil from the Vaca Muerta. Beyond the medium term, the country's tight oil production is expected to double again, from 0.6 mb/d in 2029 to 1.2 mb/d in 2050. This is mostly tight crude, with around 0.1 mb/d projected to be from unconventional NGLs.

In sum, Argentina's liquids supply is set to expand from 0.8 mb/d in 2023 to 1.6 mb/d in 2050. Given the huge resource base in the Vaca Muerta, still largely untapped and roughly on par with the hugely prolific Permian Basin in the US, as well as the country's largely unexplored offshore acreage, Argentina's supply outlook has significant upside potential.

Qatar

Qatari liquids supply is projected to increase from 1.9 mb/d in 2023 to 2.5 mb/d in 2029, as significant NGL volumes are added from 2026/27 due to the massive planned gas production expansion in the country's North Field. While crude output is expected to stay relatively steady at around 0.6 mb/d, NGLs supply is set to rise from 1.2 mb/d in 2023 to 1.7 mb/d in 2029. Qatari liquids supply in the long term is expected to plateau around 2.5 mb/d, albeit with potential to the upside, depending on expectations for global gas demand and possible further expansions of the country's gas and export infrastructure.

Figure 4.13
Qatar total liquids supply outlook



Source: OPEC.

Africa

Liquids supply in Other Africa, which excludes DoC producers, is projected to rise sharply, from 2.2 mb/d in 2023 to 2.9 mb/d in 2029. Output in Angola rises modestly, from 1.1 mb/d in 2023 to 1.2 mb/d in 2029, as production at the Agogo-Ndungu and Cameia-Golfinho blocks

start up in 2025 and 2027, respectively. Elsewhere, output from mature producers, including Chad, Egypt, Ghana and South Africa, is expected to remain relatively steady.

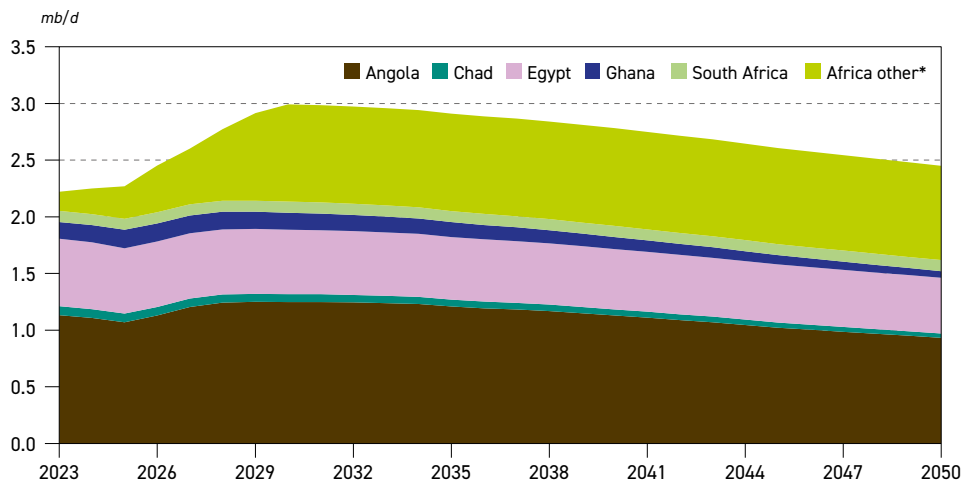
Much focus, however, is on new producers, including (in the order of production starting up) Senegal, Uganda and Namibia. Senegal, with the 100 tb/d first stage of its Sangomar project, is set to see first oil in the course of 2024. Sangomar phase 2 could add another 40 tb/d at a later stage. Uganda should see first oil produced at its Lake Albert development, when the 190 tb/d Tilenga field comes on stream in 2026. From 2027, the smaller Kingfisher field, with around 40 tb/d of capacity, should be added. Both are dependent upon the East African Crude Oil Pipeline, which is being built from landlocked Uganda to the Tanzanian coast.

The country attracting most attention recently has been Namibia, which historically has no meaningful oil or gas production. Starting in early 2022, however, several large discoveries have meant that Namibia will likely become an oil and gas producer before the end of the decade.

Shell made the first discovery, Graff, in early 2022, followed by Jonker, in early 2023. Galp and other international oil companies are also active in Namibia. Nonetheless, it was TotalEnergies' discovery of the Venus field, in early 2022, which put Namibia firmly on the map. It is thought to be the largest offshore field ever discovered in Sub-Saharan Africa, with estimated recoverable reserves of around 3 billion boe, and potentially far more.

Current projections are for Venus to start up from 2028, with expectations for it to rise to 250 kb/d in its initial phase. Other major discoveries, including Graff, Jonker, La Rona, Resedi, Mopane and Venus 2, may come thereafter. Graff is considered to be the next field most likely to be sanctioned, which could add 100 kb/d from 2030. Further stages of Venus are also quite likely, especially if the field does indeed turn out to be as prolific as expected.

Figure 4.14
Non-DoC Africa total liquids supply outlook



* Africa other includes Cameroon, Namibia, Senegal, Tunisia, Uganda and smaller producers, and excludes African OPEC producers.

Source: OPEC.



In sum, Namibia's liquids production is estimated to start in 2028, before rising to 250 kb/d by 2030. If the main fields mentioned are given the go-ahead, production could reach around 500 kb/d by the mid-2030s, and potentially more beyond. Much depends, however, on whether Venus proves to be a success.

What is clear is that Namibia has joined a small group of countries with significant prospects around the Atlantic Rim, including Brazil, underexplored offshore parts of Argentina, and now also Suriname – all of which also enjoy a significant degree of interest from the larger majors. Moreover, the Orange Basin, which the Venus discovery is in, extends into South African waters and has also enjoyed a resurgence in exploratory activity.

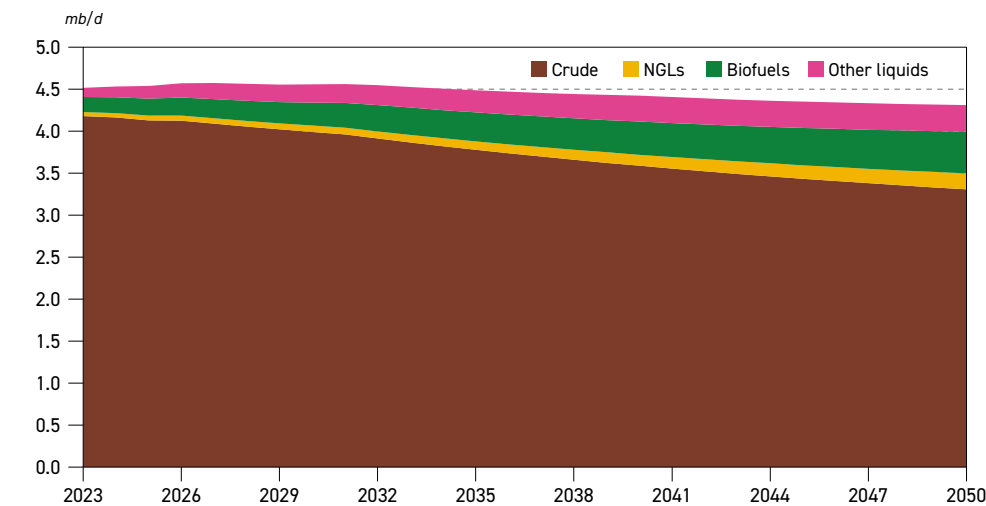
China

China, which has been successful in ramping up crude production in recent years, despite its large, mature base, is projected to see a fairly flat liquids supply profile in the medium and long term. Crude output is actually expected to decline modestly in the 2023–2029 period, despite the start-up of a handful of fields, including Laxi, Shidong 1, Huizhou 26-6 and Jinhua zhen, among others, which collectively add around 100 tb/d. The decline in (conventional) crude production is offset, however, by modest increases in tight crude and NGLs, biofuels and other liquids. It should also be noted that the government is maintaining pressure on the state-owned oil and gas giants to keep investing in order to help maintain production.

In sum, Chinese liquids supply rises from 4.5 mb/d in 2023 to 4.6 mb/d in 2029. Thereafter it is expected to plateau at an average of 4.5 mb/d for the 2030s, before declining modestly to 4.3 mb/d by 2050. As in the medium-term period, the trend is for a decline in crude supply, partly offset by increases in non-crude liquids.

4

Figure 4.15
China total liquids supply outlook



Source: OPEC.

4.4 Breakdown of liquids supply by type of liquids

In contrast with the medium-term period, long-term non-DoC crude supply is set to decline, from 31.5 mb/d in 2023 to 28.5 mb/d in 2050. This is largely due to US crude supply (including tight crude) peaking, as well as maturity in many other producing regions. By contrast, supply of all other types of liquids continues to increase. Other liquids, including Canadian oil sands, refinery additives, very small volumes of oil shale (kerogen) and synthetic fuels, is set to increase from 4.2 mb/d in 2023 to 6.8 mb/d in 2050. Of this, some 1.8 mb/d is growth in Canadian oil sands supply.

Non-DoC biofuels supply is also projected to increase, as policy requirements in some parts of the world mandate a rising share of transport fuels, in particular, to be met by blending in biofuels. Biofuels volumes are set to increase from 3.1 mb/d in 2023 to 5.2 mb/d in 2050. NGLs and refinery processing gains are also expected to increase in the long term, by 2.7 mb/d and 0.9 mb/d, respectively.

Table 4.3

Non-DoC liquids supply outlook by type

mb/d

	2023	2030	2035	2040	2045	2050	Change 2023–2050
Crude	31.5	35.2	33.7	32.0	30.3	28.5	–3.0
NGLs	10.6	12.6	13.0	13.2	13.2	13.4	2.8
Biofuels	3.1	3.7	4.2	4.7	4.9	5.2	2.2
Other liquids	4.2	4.7	5.0	5.5	6.1	6.8	2.7
Processing gains	2.5	2.8	3.0	3.2	3.3	3.4	0.9
Total non-DoC	51.7	59.0	58.9	58.5	57.8	57.3	5.5

Source: OPEC.

4.4.1 Tight oil: US and other developments

Tight oil remains an important part of the global liquids supply picture. In particular, much of the medium-term growth in non-DoC liquids supply stems from US tight oil, which is set to increase by 3 mb/d. However, its projected peak thereafter and subsequent decline mean that over the entire 2023–2050 timeframe, net growth is lower, at 1.1 mb/d. The most significant newcomer is Argentina, where output from the prolific Vaca Muerta basin is projected to boost the country's tight oil supply from 0.3 mb/d in 2023 to 1.2 mb/d in 2050. Canada, already a significant producer of tight oil volumes, sees quite flat production in the long term at around 1.1 mb/d. In sum, non-DoC tight oil increases from 15.2 mb/d in 2023 to 17.5 mb/d in 2050.

Table 4.4

Non-DoC tight oil outlook

mb/d

	2023	2030	2035	2040	2045	2050	Change 2023–2050
US	13.7	16.7	16.5	16.1	15.5	14.8	1.1
Canada	1.0	1.1	1.1	1.1	1.1	1.1	0.1
Argentina	0.3	0.7	0.9	1.0	1.1	1.2	0.9
China	0.1	0.2	0.2	0.3	0.3	0.4	0.2
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total tight oil	15.2	18.6	18.7	18.4	18.0	17.5	2.3

Source: OPEC.



US

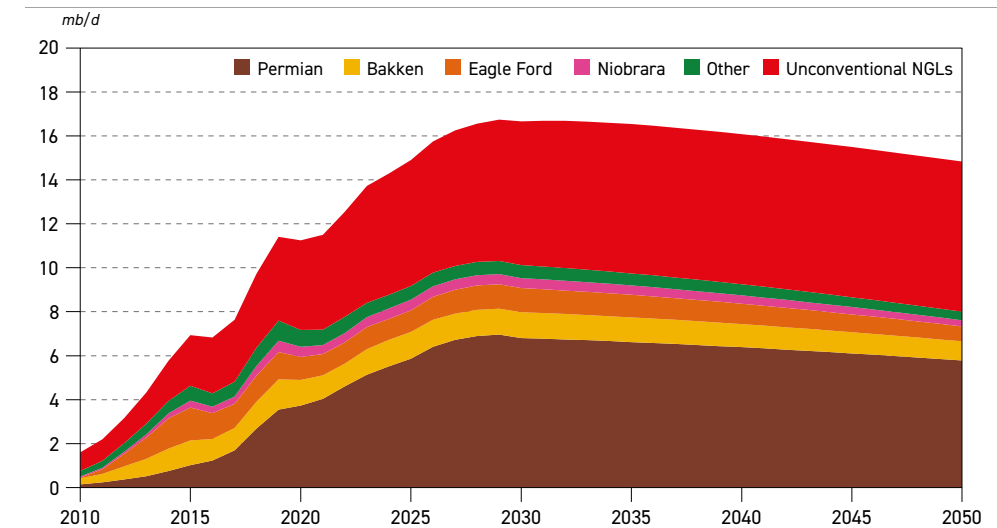
US tight oil supply remains a key driver of near- and medium-term non-DoC liquids supply. Even as growth continues to slow, annual increments in the medium term are set to average 0.5 mb/d, providing over 40% of total non-DoC growth in this period. US tight crude output is dominated by the Permian basin, where production is set to grow from 5.1 mb/d in 2023 to 7 mb/d in 2029, which is expected to be its peak. The Eagle Ford in southern Texas is also projected to see growth, from 1 mb/d in 2023 to 1.1 mb/d in 2029. The Bakken, Niobrara and other basins meanwhile are set to see relatively flat medium-term production profiles.

Tight oil producers remain focused on their bottom line, but with much of the key basins' prime acreage already tapped, efforts to increase efficiency gains in the broadest sense continue. Demonstrably, despite a decline in drilling rigs from around 600 to 500 over the course of 2023, US crude output has nonetheless risen by over 1 mb/d. Continued advances in drilling, well and lateral lengths, pad drilling, acquisition of contiguous territory, and the application of AI on drilling, completion and other aspects of operations, are all making a difference.

Moreover, the trend towards the continued consolidation of tight oil producers may also play a role. The past year has seen announcements of major acquisitions – ExxonMobil purchasing Pioneer, Chevron looking to take over Hess, and Occidental buying CrownRock – to name just the largest ones. Some argue that the supermajors, in particular, are likely to keep growing US tight oil production more steadily, as they have the cashflow and a longer-term perspective – and crucially, as their US footprints make up a growing and increasingly important pillar of their upstream operations globally. These companies may also have the ability to apply technology advances, cost-cutting principles and efficiency gains more aggressively than smaller, less-specialized producers.

US unconventional NGLs remain an important contributor to growth and overall volumes, both in the medium and long term. From 5.3 mb/d in 2023, volumes rise to 6.4 mb/d in 2029,

Figure 4.16
US tight oil supply breakdown



Source: OPEC.

thereafter reaching a peak of around 6.8 mb/d in the early 2030s as increases in natural gas production are expected to slow. In the long term, US unconventional NGLs' rise serves to partly offset US crude oil declines (tight and conventional).

4.4.2 Other non-crude liquids supply

Other non-crude liquids are projected to make significant contributions to non-DoC liquids supply. Besides the aforementioned increases in NGLs and refinery processing gains, biofuels and other liquids are also set to see strong incremental gains in the long term. Non-DoC biofuels are projected to increase from 3.1 mb/d in 2023 to 5.2 mb/d in 2050, with gains in both fuel ethanol and biodiesel. Blending mandates, in order to improve the sustainability of fuels, and ambitions to recycle waste liquids, such as cooking fuels, fats and oils, as well as agricultural by-products, will continue to drive this trend.

Growth in other liquids, from 4.2 mb/d in 2023 to 6.8 mb/d in 2050, is primarily driven by the projected increase in Canadian oil sands, which rise from 3.2 mb/d in 2023 to 5 mb/d in 2050. Of increasing importance, however, are synthetic aviation fuels. These are expected to rise from currently very modest volumes to 1 mb/d by 2050, with considerable upside potential.

Table 4.5

Long-term non-DoC biofuels and other liquids supply outlook

mb/d

	2023	2030	2035	2040	2045	2050	Change 2023–2050
Fuel ethanol	1.9	2.2	2.4	2.7	2.7	2.8	0.9
Biodiesel	1.2	1.5	1.8	2.0	2.2	2.4	1.2
Global biofuels	3.1	3.7	4.2	4.7	5.0	5.3	2.2
Canadian oil sands	3.2	3.6	3.8	4.1	4.5	5.0	1.7
Gas-to-liquids (GTL)	0.3	0.3	0.3	0.3	0.3	0.3	0.0
Coal-to-liquids (CTL)	0.3	0.3	0.3	0.3	0.3	0.3	0.1
Synthetic aviation fuel	0.0	0.1	0.3	0.5	0.7	1.0	1.0
Other*	0.4	0.4	0.4	0.3	0.3	0.3	–0.1
Total 'Other liquids'	4.2	4.7	5.1	5.5	6.1	6.8	2.7
Non-DoC total	7.3	8.4	9.3	10.2	11.1	12.1	4.8

* Including kerogen, extra-heavy crude, MTBE and other refinery additives.

Source: OPEC.

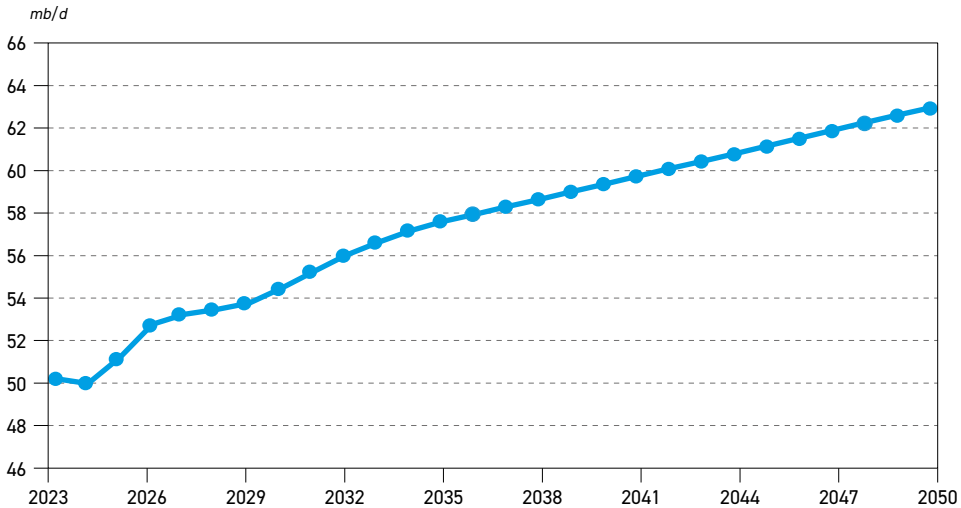
The aviation sector, which faces greater technical challenges to substitute hydrocarbon-based fuels with other propulsion systems, for instance electric or hydrogen, is banking on both biological-based aviation fuels, in other words 'biojet' fuel, but also on synthetic fuels made from hydrogen and CO₂. In turn, some governments are discussing mandates similar to those blending biofuels into road transport fuels. The EU, for instance, has plans to mandate a 2% share of SAF blended into aviation jet fuel from 2026, for flights originating in the EU. This would later rise to 6% by 2030, 20% by 2035, and eventually 70% by 2050. However, considerable doubts as to the feasibility of these targets remain, given the substantially higher cost of producing both biological-origin and synthetic aviation fuels, and the only very modest volumes currently being produced.



4.5 DoC liquids

Total liquids supply in DoC countries is expected to rise from 50.3 mb/d in 2023 to a temporary plateau around 53 mb/d to 54 mb/d in the latter part of the 2020s (Figure 4.17). Non-DoC liquids supply is set to peak around 2030, while DoC liquids expands again, to eventually average 62.9 mb/d in 2050. This represents an increase of 12.7 mb/d over the entire 2023–2050 timeframe. In market share terms, this implies an increase from 49% in 2023 to 52% in 2050.

Figure 4.17
DoC total liquids



Source: OPEC.

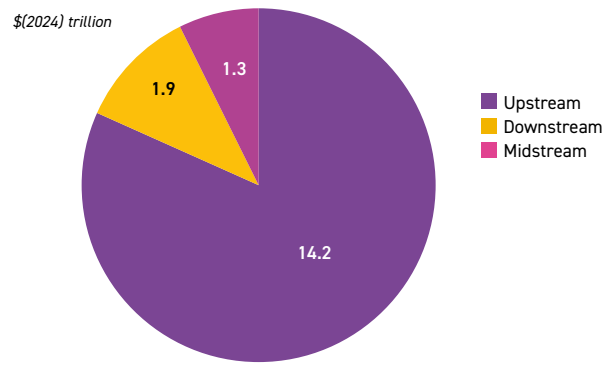
4.6 Upstream investment requirements

Cumulative oil-related investment requirements are assessed at \$17.4 trillion over the entire 2024–2050 period (Figure 4.18). This substantial challenge needs to be overcome in order to meet expanding oil demand, also taking into account natural declines in existing fields.

The upstream sector, which accounts for the bulk of investment needs, is projected to require \$14.2 trillion in the 2024–2050 outlook period, or \$525 billion p.a. (all in US \$2024). This is a substantially higher figure than projected in the WOO 2023, attributable to higher long-term and cumulative oil production volumes, not least due to the extension of the outlook timeframe from 2045 to 2050. Additionally, a higher share of liquids supply is expected to come from higher-cost producing regions. Besides the upstream sector, estimated investment requirements in the downstream and midstream sectors are calculated at \$1.9 trillion and \$1.3 trillion, respectively, for the 2024–2050 period.

Broken down into key producer groupings, this indicates that the US and Canada, which already make up nearly 60% of annual investment requirements, at around \$240 billion, will need to further raise investments to just over \$270 billion p.a., in order to enable projected supply growth in the medium term. In the longer term, however, their required investment and relative share of global capital expenditure will decline, as their collective supply peaks and other producers play a larger role.

Figure 4.18
Cumulative oil-related investment requirements by segment, 2024–2050

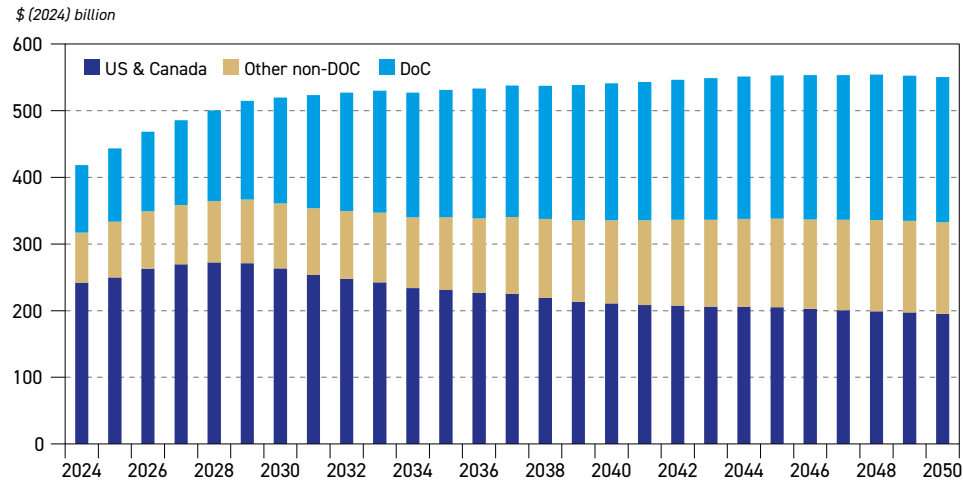


Source: OPEC.

Meanwhile, the DoC producers' share of required upstream investments will need to approximately double, from \$101 billion in 2024 to \$218 billion in 2050, reflecting the group's increasing share of global liquids supply. This means that the DoC's share of global upstream investment requirements will rise from around 25% in 2024 to nearly 40% in 2050.

Other non-DoC producers, in other words excluding the US and Canada, will also need to up their investment from around \$75 billion p.a. currently to \$137 billion p.a. by 2050. This represents a market share increase from 18% to 25%.

Figure 4.19
Annual upstream investment requirements, 2024–2050



Source: OPEC.





Key takeaways

- The downstream market stabilized to a large degree in 2023 and early 2024, supported by the commercial start-up of several plants, which increased the available refining capacity in the international downstream market.
- In the medium term, around 6.3 mb/d of refining capacity additions are projected at the global level. The majority of new additions are set for the Asia-Pacific (3.2 mb/d), Africa (1.4 mb/d) and the Middle East (1.2 mb/d). Capacity additions in other regions are minor and mostly limited to the expansion of existing refineries.
- In the long term (2024–2050), global refining additions are projected at 19.2 mb/d, including creep capacity expansions. Similar to oil demand growth, additions are frontloaded, with a significant slowdown in the rate of additions after 2040.
- The majority of long-term additions (almost 90%) are located in the Asia-Pacific, the Middle East and Africa. This continues the historical trend of refining capacity migrating from developed to developing countries and is in line with oil demand trends.
- The medium-term balance shows a tighter downstream market relative to 2023 due to strong oil demand growth. The estimated deficit of potential refining capacity relative to required refining capacity is set to peak at around 1.5 mb/d in 2027 and narrow to around 1.25 mb/d in 2029. The largest deficits are projected for the Asia-Pacific, while surpluses are expected in Europe, as well as the US & Canada.
- Global refinery utilization rates are expected to increase from around 80% in 2023 to above 83% from 2027 to 2029, supported by rising oil demand and medium-term refinery closures.
- In the long term, refinery runs are expected to increase to almost 90 mb/d in 2030 from around 81.8 mb/d in 2023. The growth will be slower in the post-2030 period, with global runs reaching 93 mb/d in 2040 and almost 94 mb/d in 2050. The US & Canada, Europe, as well as the developed countries in Asia-Pacific, are set to decline from 2030 onwards. This is more than offset by strong increases in developing regions, such as the Asia-Pacific, the Middle East, Africa and Latin America.
- About 1 mb/d of refinery closures are expected in the medium term, which is significantly lower compared to recent closures since 2020. In the long term, further closures of between 4 mb/d and 5 mb/d are required if refinery utilization rates are to be kept at sustainable levels.
- Secondary capacity additions over the outlook period are significant, with 19.4 mb/d of desulphurization, 10.8 mb/d of conversion capacities and 6.1 mb/d of octane units.
- Total required downstream sector investments are projected at \$1.9 trillion. More than \$600 billion is required for refinery capacity expansions, while the rest is required for continuous maintenance and replacement of existing capacity.

This chapter presents the downstream oil outlook for the period 2024–2050. It is fully consistent with the Reference Case assumptions, including projections on oil demand (Chapter 3) and liquids supply (Chapter 4). It examines various market drivers and factors that may influence the future global refining sector, highlighting challenges, uncertainties and opportunities. Similar to chapters 3 and 4, the analysis is conducted in two different timeframes, namely the medium term (2024–2029) and long term (2024–2050).

This chapter initially focuses on recent developments in the downstream sector. This is followed by an updated assessment of the current 'base' capacity by major region (as of January 2024) that is the basis for all medium- and long-term projections. It is important to note that these projections are conducted according to two substantially different methodologies.

Firstly, in the medium term, refining capacity additions are assessed based on a thorough review of refinery projects and their progress by major downstream region. Based on the probability assessment, the medium-term global and regional outlook for both primary and secondary capacity is produced. Secondly, based on global and regional oil demand and supply trends, long-term refining capacity additions (i.e. requirements for additions) are projected.

Moreover, the analysis in this chapter shows how the downstream market balance is anticipated to evolve in the medium and long term. This provides insights into regional market balances and respective utilization rates.

There are also discussions and forecasts for recent and near-term refinery closures. In the medium term, projections are based on announcements (firm closures) and an assessment of potential closures by 2029. From 2030, the Reference Case makes no explicit forecasts on closures. However, it does provide an indication of required refinery closures based on market balances and projected utilization rates.

In addition, this chapter examines medium- and long-term secondary capacity additions. This includes projections for fluid catalytic cracking (FCC), coking and hydrocracking, desulphurization capacity and octane units. Based on these secondary capacity additions and the projected demand by product, the potential medium-term market balance is highlighted.

Finally, this chapter provides an outlook for global and regional investment requirements related to medium- and long-term capacity additions to the year 2050, as well as investments for continuous maintenance and replacement.

5.1 Existing refinery capacity

5.1.1 Recent developments in the downstream sector

After the shock of 2022, the downstream market stabilized somewhat during 2023. Recent start-ups and the ramp-up of mega refineries in the Middle East, Africa and Asia have helped to ensure stable refined product flows. Around 1.4 mb/d of refining capacity reached commercial operation during 2023 and more is scheduled in 2024 and 2025. These additions are expected to more than offset announced refinery closures over the same period.

Despite market stabilization, downstream markets remain in flux. New mega-projects are poised to alter the international downstream market. For instance, the start-up of the Dangote

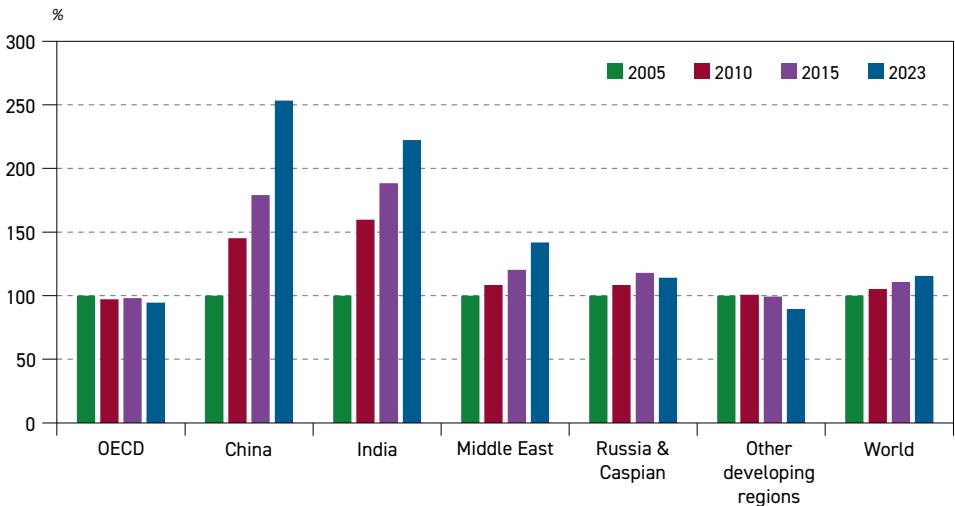
refinery in Nigeria and the upcoming commercial start of the Dos Bocas refinery in Mexico could significantly affect the gasoline market in the Atlantic basin. Although both regions import significant volumes of gasoline from the international market, this could change when these two refineries reach full operation. This in turn could negatively affect refineries in the US and especially Europe, as gasoline markets in these regions are stagnating.

Furthermore, the downstream market and related trade dynamics are still strongly influenced by geopolitics. The EU embargo on Russian crude and product exports has altered interregional oil flows, with EU refiners increasing crude oil imports from regions such as the US and Middle East. EU product imports of non-Russian origin also increased, especially from India, the US and the Middle East. Recently commissioned plants in the Middle East have also started exporting diesel to the EU, including Jizan in Saudi Arabia and Duqm in Oman.

Turning to broader downstream trends, global refinery throughputs have continued their growth. In 2023, global runs increased by roughly 1.5 mb/d relative to 2022, following the increase in oil demand that materialized mostly in developing regions, predominantly in China and to some extent in Other Asia-Pacific and the Middle East. At the same time, runs in other regions were either stable, y-o-y, or experienced a minor decline relative to 2022.

This reflects a continuation of historical trends. Figure 5.1 shows global and regional refinery throughput since 2005 by major region (in percentages and indexed to 2005). Global refinery throughputs increased roughly 16% in the period 2005–2023. However, the increase was unequally distributed across regions.

Figure 5.1
Refinery throughputs, indexed to 2005



Source: OPEC.

Three distinct regional patterns can be observed in Figure 5.1. The first pattern relates to OECD countries, where refinery throughputs declined roughly 5% between 2005 and 2023. This occurred mostly in Europe and developed Asia, where oil demand for major refinery fuels has been stagnating or decreasing, triggering significant refinery closures since 2005. This was only partly offset by refinery run increases in OECD Americas, mostly the US, where

the increasing availability of domestic oil supported the competitiveness of the US refining sector and encouraged product exports.

The second pattern is visible in the Middle East, China, India and to some extent Russia and the Caspian, where refinery runs have increased significantly since 2005 in line with rising demand and/or increasing product exports. This was especially the case in China, where refinery throughputs have increased by an astonishing 250% since 2005. In the Middle East, the strategy of several countries to replace crude oil by product exports also encouraged rising refinery throughputs. In Russia & Caspian, the availability of domestic crude oil feedstock favoured rising runs and product exports to international markets.

Finally, in other developing regions (including Latin America, Africa and non-OECD Europe), refinery runs declined by more than 10% in the period 2005–2023. This was despite rising oil demand in most of these regions. Old and ageing refineries, insufficient downstream investments, as well as rising competition from refineries in developed regions (especially the US), as well as the Middle East and China, were the main reasons for this development.

Looking to the future, some of these trends will likely continue. Refinery runs in developed countries are set to remain in decline, in line with peaking and decreasing demand in the long term. This may lead to further closures or a repurposing of refineries in these countries throughout the outlook period.

Refinery throughputs in the Middle East, China and especially India are projected to continue increasing, mirroring demand trends. Contrary to historical trends, refinery throughputs in other developing regions are projected to increase significantly in the long term to meet the strong demand growth in these regions with local refinery production. This outlook shows a significant amount of required refining capacity in the long term. This is especially the case for Africa.

However, a number of uncertainties are expected to remain. These are related to oil demand growth, as well as the timely expansion of new refining capacity and the modernization of existing refineries, especially in developing regions. This chapter will discuss the major driving forces in the downstream sector and highlight potential challenges in the years to come.

5.1.2 Base refinery capacity

This section provides a detailed update on base capacity assessments – distillation and secondary capacity, including condensate splitters – of refineries worldwide. It includes additions to existing refineries, new refineries that have come on stream, as well as closures that occurred in 2023.

The OPEC Secretariat's approach is that refineries, unless officially closed, are included in the database of 'nameplate' capacity, although effective capacity may be identified as being well below the nameplate level. Overall, it should be noted that no single data source for global and regional refinery capacities can be relied upon entirely. The quality and availability of capacity reporting varies by refinery, so there is always an element of determining a 'best estimate' for base capacity. This applies to primary capacity, secondary capacity, as well as new projects and closures.



Table 5.1 provides details on base capacity by region and process totalling 101.9 mb/d of assessed base refinery capacity (distillation) as of January 2024. This includes capacity additions and closures that occurred during 2023, as well as any necessary adjustments to the database. Around 1.4 mb/d of new refining capacity was brought online in 2023. This relates to the commercial start of operation of new capacities. The Middle East accounts for nearly 60% of this capacity, notably with the commissioning of the second and third phases of the Kuwait refinery at Al-Zour, as well as new refineries in Oman and Iraq. Furthermore, some additions were recorded in other regions, including the US and the Asia-Pacific, including China. No new capacity was recorded in Europe or Latin America.

At the same time, estimated capacity closures totalled almost 0.5 mb/d. This was well below the average annual closures of around 1 mb/d that occurred in the preceding five years. This was mainly due to strong oil demand growth and healthy refining margins since 2022. At the regional level, around 250 tb/d of capacity was closed in the Asia-Pacific, while the

Table 5.1
Assessed available base capacity as of January 2024

mb/d

	US & Canada	Latin America	Africa	Europe	Russia & Caspian	Middle East	China	Other Asia- Pacific	World
Distillation									
Crude oil (atmospheric)	19.6	7.8	3.5	15.0	7.9	11.4	17.8	18.9	101.9
Vacuum	9.3	3.4	0.8	6.4	3.2	3.3	7.5	5.8	39.6
Upgrading									
Coking	3.0	0.9	0.1	0.8	0.6	0.5	2.4	1.1	9.3
Catalytic cracking	6.0	1.6	0.2	2.2	0.9	1.1	4.4	3.5	19.9
Hydro cracking	2.6	0.2	0.2	2.4	0.9	1.2	2.5	1.7	11.6
Visbreaking	0.1	0.4	0.1	1.4	0.7	0.6	0.2	0.6	4.0
Solvent deasphalting	0.5	0.1	0.0	0.2	0.0	0.2	0.1	0.2	1.2
Octane units									
Reforming	4.0	0.6	0.5	2.4	0.8	1.4	2.4	2.9	15.1
Isomerization	0.8	0.1	0.1	0.6	0.3	0.5	0.2	0.4	3.0
Alkylation	1.4	0.2	0.0	0.2	0.1	0.1	0.2	0.4	2.7
Polymerization	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
MTBE/ETBE	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.1	0.6
Desulphurization									
Naphtha	5.1	0.8	0.5	3.0	1.0	2.1	2.5	3.1	18.0
Gasoline	3.2	0.5	0.1	0.7	0.3	0.4	1.6	1.4	8.1
Middle distillates	7.4	2.5	0.7	5.7	2.5	3.7	4.8	6.9	34.3
Heavy oil/Residual fuel	3.5	0.4	0.0	1.8	0.4	0.9	1.1	3.1	11.2
Sulphur (short tons/day)	44,276	7,282	3,469	20,091	8,701	16,787	23,936	39,267	163,810
Hydrogen (million scf/d)	6,263	1,251	354	5,047	2,182	3,670	6,913	6,386	32,066

Source: OPEC.

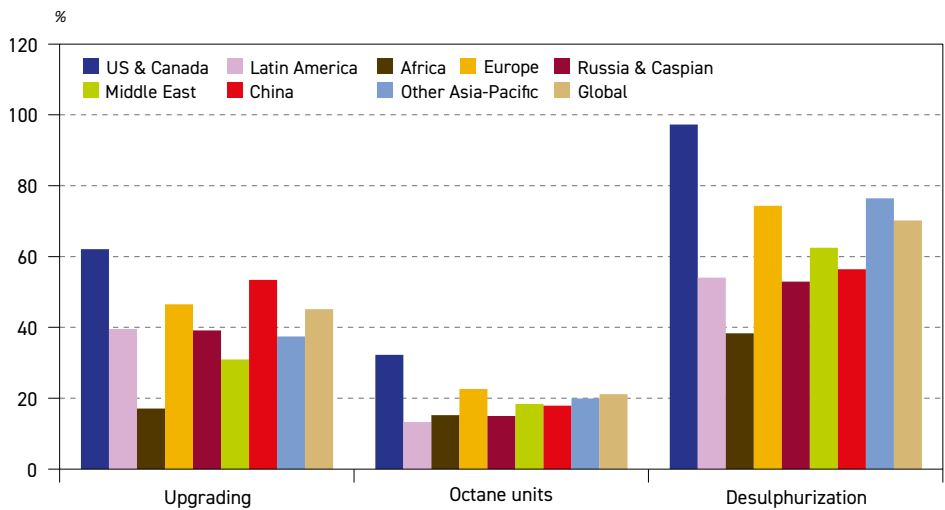
US & Canada, along with Africa, each lost around 100 tb/d of capacity. Other regions saw only limited capacity closures during 2023, if any.

Secondary capacity

Recent refinery capacity additions and new refinery projects in the medium term are increasingly complex, with expanding secondary processing capacity per barrel of primary distillation capacity. Refiners, responding to increased demand for light and clean products, and to increasingly stringent fuel quality regulations, have been investing in the rising complexity of the global refining system. Furthermore, an increasing number of existing refiners have geared production towards petrochemical feedstock production, and new refineries are increasingly designed to yield the maximum level of this. This is in line with demand development, given the rising demand for high-quality products, as well as tightening regulations related to product specifications, especially sulphur levels. This has led to increased market competition and the closure of older, simpler units, especially in developed regions, but also in some developing ones too.

Figure 5.2 shows secondary capacity in relation to distillation capacity as of January 2024. Global vacuum distillation capacity averaged 38.8% of crude (atmospheric) distillation capacity, with upgrading at around 45%, gasoline octane units at 21% and desulphurization at 70%. A review of data from previous years confirms that these ratios reflect a steady increase over time.

Figure 5.2
Secondary capacity relative to distillation capacity, January 2024



Source: OPEC.

There are significant refinery complexity variations between major downstream regions. The US & Canada continue to have the highest levels of upgrading, gasoline production and desulphurization relative to distillation. This reflects a traditionally complex refining system that has been enhanced over the past few last decades. However, large, state-of-the-art refinery capacity additions, particularly in the Middle East, China and Other Asia-Pacific, are raising overall secondary capacity relative to distillation in these regions too, with some countries coming closer to the levels seen in the US & Canada.



For upgrading capacity, the US & Canada have by far the highest ratio, at roughly 62% of distillation capacity, followed by China at 53% and Europe at 47%. Most other regions fall within the 30–40% range. The only exception is Africa, where the upgrading-to-distillation capacity ratio is only around 17%.

In terms of upgrading specifics, there are significant regional differences. The US & Canada, Latin America and China have the highest levels of coking in their upgrading mix, accounting for approximately 25% of total upgrading in each region. These three regions also account for two thirds of total global coking capacity. This partly reflects the relatively high supplies of extra heavy grades from Canada and Latin America, as well as China.

The same three regions, plus Other Asia-Pacific, have the highest proportion of catalytic cracking at around 50%, which is in line with a relatively high share of gasoline demand. All regions, with the exception of Latin America, show relatively high levels of hydrocracking in total upgrading capacity. The advantage of hydrocracking is the relatively high flexibility it offers in producing light *versus* middle distillates.

For octane units, the US & Canada serve as outliers, having a ratio of around 32% compared to installed distillation capacity. This is in line with the region's exceptionally high gasoline consumption. Europe ranks second highest in this regard, with almost 23%, partly due to the presence of installed gasoline capacity that was there before the continent's dieselization shift that led to a gasoline surplus. The Middle East, China and Other Asia-Pacific are in the range of 18–20%, while Latin America, Russia and the Caspian and Africa exhibit lower octane unit proportions, in the range of 13–15%.

Desulphurization levels vary strongly across regions depending on their fuel standards and the quality (i.e. the sulphur content, of crude feedstock). The highest share of desulphurization is in the US & Canada, at over 95%, which is significantly higher than in other regions. Refineries in the US & Canada have traditionally processed a large proportion of heavy and medium-sour crudes, mostly from Latin America and the Middle East. Domestically produced heavy barrels in Canada are also almost exclusively processed in the region.

Europe and Other Asia-Pacific, which includes developed countries such as Japan and South Korea that possess substantial residual desulphurization capacity, also have relatively high proportions of desulphurization capacity, at around 74% and 76%, respectively. The Middle East is lower at 63%, while in the remaining regions – Latin America, Russia & Caspian and China – the level is around 55%. Africa has the lowest level of desulphurization capacity, at 38%, due to less stringent fuel specifications. However, this is likely to change in the future. In addition, a large share of Africa's crude supply is sweet and, therefore, needs less desulphurization.

As expected, the regions with the highest levels of desulphurization relative to crude capacity also have the highest levels of sulphur recovery and hydrogen capacity.

5.2 Distillation capacity outlook

5.2.1 Medium-term distillation capacity additions

This section discusses the medium-term development of the downstream sector. It is based on a comprehensive review of refining projects, their status and progress. New projects and

the expansion of existing units for both distillation and secondary capacities are examined and profiled according to their probability. It should be noted that these projections do not include small and under-the-radar additions (so-called ‘creep’ capacity), which is the natural addition of capacity to an existing facility that has little or no capital expenditure.

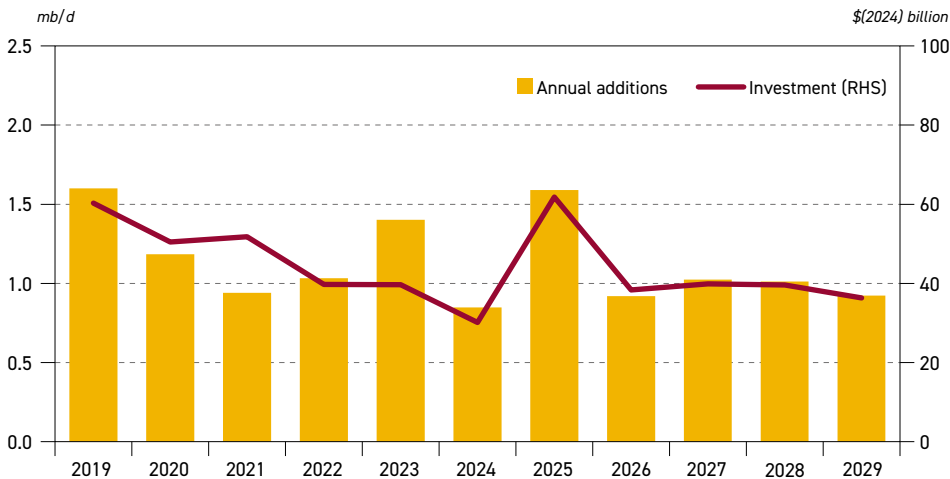
Based on the methodology described, a projected 6.3 mb/d of new refining capacity is expected to come online between 2024 and 2029. In terms of total new refining volume, this figure is slightly lower than that included in the WOO 2023.

This is partly due to the significant capacities commissioned in 2023, which total more than 1.4 mb/d in new additions. This includes the second and third phases of the Al-Zour refinery in Kuwait, the Karbala refinery in Iraq, the second phase of the Jieyang refinery in China, and the Beaumont refinery in the US.

It is worth noting that 80% of new capacities that came online during 2023 are located in non-OECD regions, mostly the Middle East and Asia. This trend is expected to continue in the medium term, with more than 90% of additional capacity located in developing regions, namely the Asia-Pacific, Africa, and the Middle East. Strong oil demand growth, as well as product export strategies in some countries, are the major drivers behind this trend.

Figure 5.3 presents annual global distillation capacity additions and the expected investment volume related to new refining projects for the period 2019–2029. The global average rate of capacity additions for the period 2024–2029 is estimated at just above 1 mb/d, which is slightly lower relative to the WOO 2023. At the global level, capacity additions will be almost evenly distributed over the medium term. It is anticipated that 0.8 mb/d of capacity will be commissioned in 2024, which is followed by 1.5 mb/d in 2025 and around 1 mb/d on average between 2026 and 2029.

Figure 5.3
Annual distillation capacity additions and total project investment



Source: OPEC.



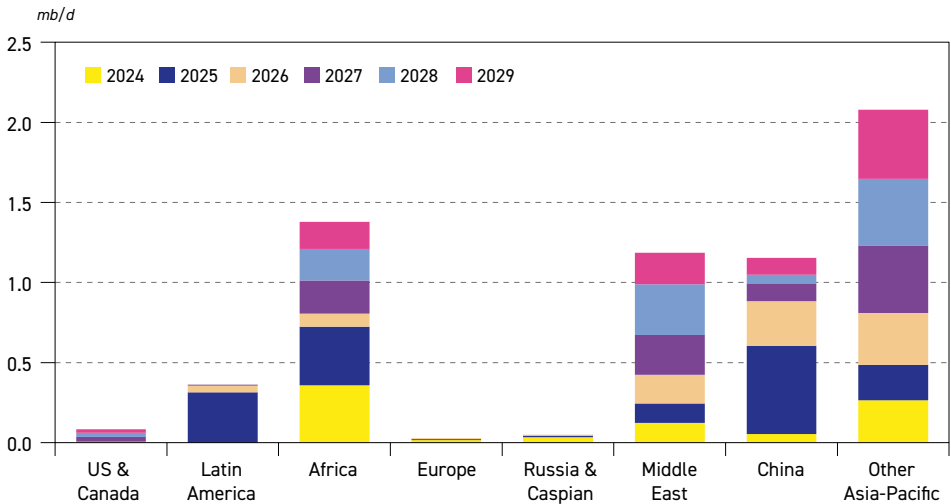
Medium-term projections for refinery additions by region are presented in Table 5.2 and Figure 5.4. Similar to recent trends, medium-term capacity additions will be concentrated in developing regions, namely the Asia-Pacific, Middle East and Africa. These regions combined represent 5.8 mb/d of capacity additions, accounting for nearly 92% of the total anticipated increase of 6.3 mb/d. It is worth noting that the medium-term additions in these regions include many large-scale projects, some of which are also integrated with petrochemical facilities.

Table 5.2
Distillation capacity additions from existing projects by region, 2024–2029 mb/d

	US & Canada	Latin America	Africa	Europe	Russia & Caspian	Middle East	China	Other Asia Pacific	World
2024	0.0	0.0	0.4	0.0	0.0	0.1	0.1	0.3	0.8
2025	0.0	0.3	0.4	0.0	0.0	0.1	0.6	0.2	1.6
2026	0.0	0.0	0.1	0.0	0.0	0.2	0.3	0.3	0.9
2027	0.0	0.0	0.2	0.0	0.0	0.2	0.1	0.4	1.0
2028	0.0	0.0	0.2	0.0	0.0	0.3	0.1	0.4	1.0
2029	0.0	0.0	0.2	0.0	0.0	0.2	0.1	0.4	0.9
2024–2029	0.1	0.4	1.4	0.0	0.0	1.2	1.2	2.1	6.3
Share	1.3%	5.7%	21.8%	0.4%	0.8%	18.8%	18.2%	32.9%	100.0%

Source: OPEC.

Figure 5.4
Distillation capacity additions from existing projects, 2024–2029



Source: OPEC.

Other Asia-Pacific is expected to see 2.1 mb/d of new refining capacity in the medium term, which is one third of global capacity additions. This increase is driven by strong oil demand growth in this region throughout the outlook period. The largest share of these additions is expected in India, with further expansions in other countries of the region like Indonesia, Pakistan, Thailand and Bangladesh.

Refinery capacity expansion in India relates to several projects, some of which are expansions of existing plants, while others are greenfield projects. All major refiners have plans to expand their capacities, including Bharat Petroleum Corporation Limited (BPCL), Indian Oil Corporation Limited (IOC), Hindustan Petroleum Corporation Limited (HPCL) and, potentially, Nayara Energy. Many of these expansions could be commissioned by 2026 or 2027, including Panipat, Baruni and Koyali (IOC), Numaligarh (BPCL) and Visakhapatnam (HPCL). However, even with all estimated capacity additions, India is not likely to reach the official total refining capacity target of 9 mb/d by 2030, which is around 3.2 mb/d above the current capacity.

Another country in the region with multiple development projects is Indonesia. These include the greenfield project in Tuban, with a processing capacity of 300 tb/d, and the expansion of the Balikpapan plant, both of which are being developed by Pertamina. Elsewhere, Saudi Aramco is developing a refinery in Pakistan with a capacity of 250 tb/d and a potential start-up date of 2027. In Bangladesh, the 150 tb/d Payra project could be commissioned in 2028.

In China, total capacity additions over the medium term are estimated at around 1.2 mb/d. The largest project is the 400 tb/d Yulong refinery, with commercial operations slated for late 2024 and 2025. The project could see further expansion in the second phase, adding another 400 tb/d towards the end of the medium-term period. Saudi Aramco and Panjin Xincheng Industrial Group are developing a 300 tb/d project in Panjin, while Sinopec has two projects under development in Ningbo City and Hainan. However, it is still uncertain whether all of the projects considered in this forecast will be delivered on time.

In the Middle East, total refinery expansion in the medium term is projected at 1.2 mb/d, with numerous medium-sized projects in the pipeline. Most of these are located in IR Iran, Iraq and Bahrain. Some minor expansions are possible in Oman, the UAE, Saudi Arabia and Jordan.

In Africa, medium-term capacity expansion is expected at 1.4 mb/d. This includes Nigeria's 650 tb/d Dangote refinery, which was officially inaugurated in 2023, but only started commercial operations in 2024. A significant number of smaller projects are projected to come online in the medium term. These include the 100 tb/d Soyo and 200 tb/d Lobito plants in Angola, and the 100 tb/d Akwa Ibom refinery in Nigeria. In addition, many smaller projects (including modular refineries) are projected to come online in Nigeria, Ghana, Angola, Uganda, Somalia and Guinea, some of which have capacity of less than 20 tb/d. In North Africa, there are new projects in Algeria (Hassi Messaoud), Libya (Ubari), as well as Egypt (Soukhna).

In Latin America, there are only two refinery projects considered in the medium term. These are the 340 tb/d Dos Bocas refinery in Mexico, which could start commercial operations in 2025 and the Bio Bio 30 tb/d refinery in Chile, which could process Argentinian tight oil.

In the US & Canada, an expansion of 0.1 mb/d in distillation capacity is expected in the medium term. This mirrors one potential project in Belfield of around 50 tb/d. In Europe, distillation expansion in the medium term is limited to one 30 tb/d potential project in Turkey (Kahramanmaraş), while no new distillation capacity additions are expected in Russia & Caspian.

The medium-term projection for new refining capacity is linked to the list of announced refinery projects totalling over 20 mb/d in capacity. However, it is expected that only a portion of these projects will materialize. The total projected capacity additions of 6.3 mb/d during the medium term relate to projects at various stages of development. Approximately 2 mb/d of capacity is either already under construction or nearing that stage. These are the projects with the highest certainty of being realized in the medium term.

Additionally, there are projects totalling over 4 mb/d, most of which are in the early stages of development. However, these projects have progressed sufficiently in terms of project development, financing and engineering to be considered 'firm' medium-term additions in the Reference Case. Nevertheless, there is a significant level of uncertainty surrounding these projects, which have the potential to only commence beyond the medium term or be cancelled for a variety of reasons.

5.2.2 Long-term distillation capacity additions

This section focuses on long-term refining capacity additions in the period 2024–2050 and is aligned with the underlying Reference Case assumptions. The long-term projections also take into account medium-term refinery capacity additions (Section 5.2.1) and announced refinery closures (Section 5.2.5).

Table 5.3 shows distillation capacity additions in the medium and long term. It includes assessed refinery projects in the period 2024–2029 and generic projects thereafter. As already noted, medium-term additions are estimated at 6.3 mb/d, while in the long term a further 12.9 mb/d of distillation capacity is required. It is important to emphasize that

Table 5.3
Refinery distillation capacity additions by period

mb/d

Distillation capacity additions starting 2024				
	Assessed projects*	New units	Total	Annualized
2024–2030	6.3	3.1	9.4	1.3
2030–2035	0.0	4.3	4.3	0.9
2035–2040	0.0	2.8	2.8	0.6
2040–2045	0.0	1.7	1.7	0.3
2045–2050	0.0	1.0	1.0	0.2
Cumulative distillation capacity additions				
	Assessed projects*	New units	Total	Annualized
2024–2030	6.3	3.1	9.4	1.3
2024–2035	6.3	7.3	13.7	1.1
2024–2040	6.3	10.2	16.5	1.0
2024–2045	6.3	11.8	18.2	0.8
2024–2050	6.3	12.9	19.2	0.7

* Firm projects exclude additions resulting from capacity creep.

Source: OPEC.

projected additions beyond 2029 are not linked to any specific refinery projects. Instead, they are projected as generic capacities required to meet long-term demand for refined products in all regions.

Long-term capacity additions also include relatively minor debottlenecking projects, totaling around 0.5 mb/d by 2050. In total, distillation capacity additions are projected at 19.2 mb/d at the global level. These additions will more than offset future refinery closures, most of which are likely to materialize in developed countries where demand is expected to peak in the coming decade and decline thereafter.

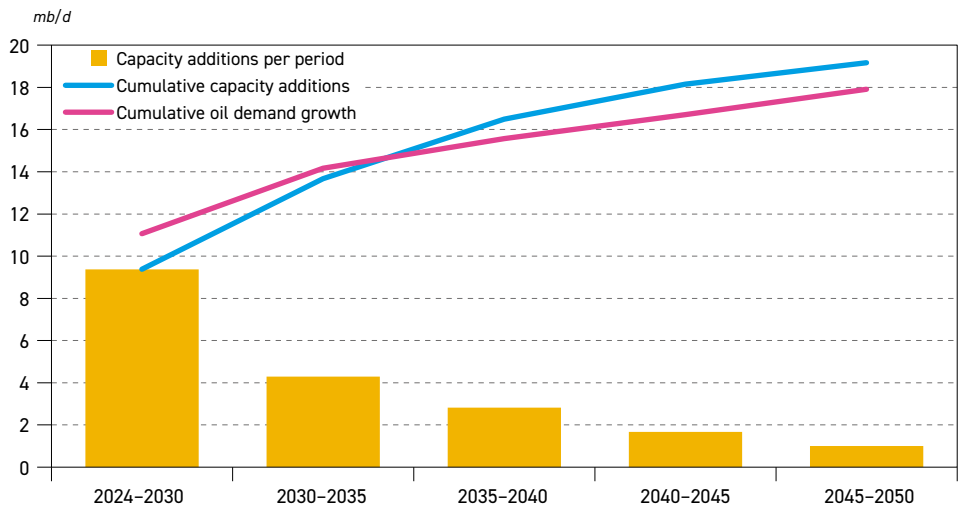
The rate of refinery capacity additions is expected to decline throughout the outlook period. In the initial period to 2030, additions are estimated at 9.4 mb/d, most of which are accounted for by medium-term projects. However, a significant share of required refining capacity is beyond assessed projects. On an annualized basis, this translates to roughly 1.3 mb/d p.a. of capacity additions.

Between 2030 and 2035, distillation capacity additions are expected at 4.3 mb/d, or 0.9 mb/d p.a., on average. The size of the additions drops to 2.8 mb/d in the period 2035–2040 (0.6 mb/d p.a. on average) and around 1.7 mb/d (0.3 mb/d p.a. on average) in the period 2040–2045. In the last five-year period, an addition of around 1 mb/d is projected or only 0.2 mb/d p.a. on average. This means that refinery additions at the end of the outlook period will likely be expansions of existing capacity, rather than new greenfield projects.

Figure 5.5 shows global refining capacity additions in relation to global oil demand, including for all non-oil liquids, in the period to 2050. Oil demand growth between 2023 and 2050 is nearly 18 mb/d, with cumulative oil demand growth to 2035 estimated at 14.2 mb/d, only slightly higher compared to the cumulative capacity additions in the same period.

Between 2035 and 2040, global oil demand growth slows down to 1.4 mb/d, while estimated capacity additions are at around 2.8 mb/d. In each of the five-year periods between 2040

Figure 5.5
Distillation capacity additions and oil demand growth, 2024–2050



Source: OPEC.



and 2050, demand is expected to increase by around 1 mb/d, with global capacity additions broadly following this trend.

The discrepancy between refining capacity additions and global oil demand trends is explained by more specific regional trends. A large majority of new refining capacity is set to come online in regions where oil demand is expected to grow in the long term.

As already noted in Chapter 3, non-OECD oil demand (mostly in the Asia-Pacific, Middle East and Africa) is set to increase by 28 mb/d between 2023 and 2050. At the same time, OECD oil demand is projected to decline by 10.1 mb/d. Consequently, only limited capacity additions are expected in this region. As OECD oil demand starts declining and non-OECD countries increase their refining capacity, the OECD downstream sector will come under pressure due to declining utilization rates. This could lead to capacity shutdowns in the long term (elaborated upon in Section 5.2.5).

However, it is possible that long-term capacity additions do not reach the required levels shown in Table 5.3. This would possibly lead to higher utilization of existing refining capacity, including capacity in developed regions, and encourage oil product flows from the OECD to non-OECD regions.

Regional additions

Global refining capacity additions for the period 2024–2050 are projected at 19.2 mb/d. As already discussed, medium-term additions are projected at 6.3 mb/d, while required additions beyond 2029 are estimated at 12.9 mb/d. Similar to medium-term trends, the majority of the incremental refining capacity is expected to be added in developing regions, predominantly in the Asia-Pacific, Middle East and Africa.

The largest refinery capacity increment by far is expected in Other Asia-Pacific (without China) at 8.3 mb/d, which is in line with strong regional demand growth. India will likely be the most significant contributor to this growth, followed by several other large countries, including Indonesia.

In China, capacity additions of 3.2 mb/d are expected in the period 2023–2050, 1.2 mb/d of which will come online in the medium term. As in Other Asia-Pacific, oil demand growth is an important driver of capacity expansions. The majority of capacity additions are already expected before 2040, with the total capacity reaching a level sufficient enough to satisfy domestic demand. New capacities will also likely replace some old and inefficient teapot plants that might close due to more stringent regulations and unfavourable economics.

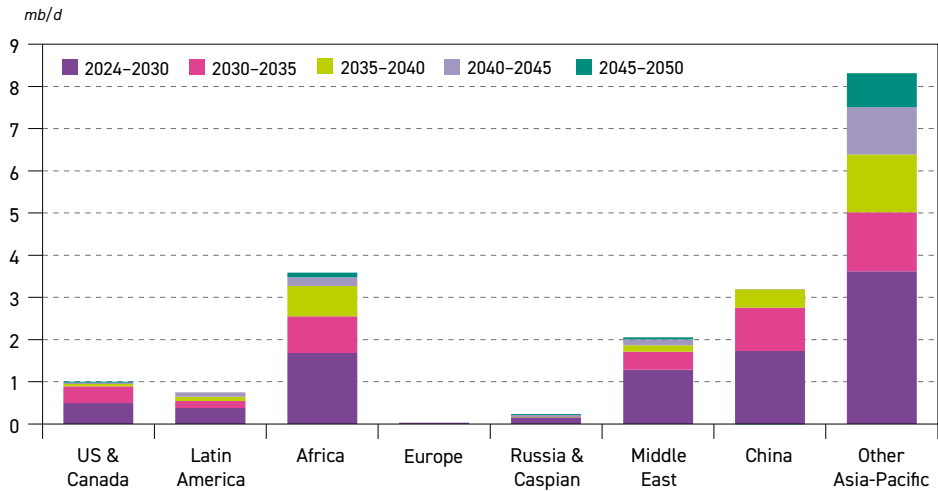
Africa's refining capacity additions in the long term are estimated at 3.6 mb/d, which mirrors domestic demand growth. This will also help reduce massive refined product imports, especially in West Africa. New refining capacities will largely use local crude oil supplies but will not be limited to them. It is worth emphasizing that the implementation of large projects such as new refineries, including the resolution of financing and technical issues, remains a challenge on the continent.

The Middle East is expected to add 2.1 mb/d of new distillation capacity throughout the outlook period. However, the vast majority of additions, around 1.3 mb/d, will already be commissioned by 2030. Additions beyond 2030 will likely be related to expansions of existing

refineries rather than the commissioning of new capacity. The region has already built several large, state-of-the-art refineries in recent years, which will help to meet expanding domestic demand and increase refined product exports to international markets.

Possible refining capacity additions in the US & Canada are estimated at around 1 mb/d, which will help decommission some older and inefficient plants. Capacity additions in this region include many continuous debottlenecking expansions at existing refineries. Ample local oil supply helps support the economics of the refining sector in the US & Canada and aid their competitiveness in the international market.

Figure 5.6
Crude distillation capacity additions, 2024–2050



Source: OPEC.

Additions in other regions are minor. Total incremental refining capacity in Latin America is estimated at around 0.75 mb/d between 2024 and 2050. These additions are significantly lower relative to oil demand growth in the same period, as Latin America has a large number of plants that are currently under-utilized. This means that some of these capacities could be modernized, thus helping increase refined product output. Secondly, due to physical proximity and relatively low transportation costs, Latin America is likely to see increasing inflows of refined products from the US, where surplus refining capacity is set to increasingly turn to international product markets.

Similarly, no major refinery additions are expected in Russia & Caspian, with only minor expansions of existing plants. Total long-term refinery additions in the period to 2050 are projected at 0.25 mb/d, consisting mostly of debottlenecking. Finally, in Europe, almost no new refining capacity is projected for the outlook period, which is in line with this region's expected demand decline.

5.2.3 Refining sector market balance

This section focuses on the downstream market outlook by taking into consideration the outlined refining capacity additions, regional oil demand and oil supply. The outlook is divided into two medium- and long-term sub-sections that follow two different approaches.



The medium-term outlook looks at refinery additions, as laid out in Section 5.2.1, and compares them with the so-called 'call-on-refining' relative to the base year of 2023. In other words, this analysis shows how the market may change compared to the base year of the Reference Case. The 'call-on-refining' is based on oil demand growth. It also considers demand for various non-refinery fuels, such as NGLs, CTLs, GTLs and biofuels.

The analysis covers the global downstream market, as well as specifics of major regions. The long-term outlook looks at modelling results over the period 2029–2050 and projects refinery throughputs and respective utilization rates at the regional level, including crude and product movements (see Chapter 6).

Medium-term global balance

As already noted, medium-term primary capacity additions are projected at 6.3 mb/d globally. On top of these additions, modelling results suggest further debottlenecking or 'creep' capacity additions of around 0.35 mb/d by 2029, mostly in the US & Canada and parts of the Asia-Pacific due to the large base of existing refineries. Consequently, total distillation capacity additions in the medium term are estimated at roughly 6.6 mb/d. As per the applied methodology, assumed medium-term refinery closures are not taken into account at this stage, but are discussed separately later.

The methodology also assumes that new refining capacities may reach the maximum assumed utilization rate of 90% throughout the year. This is considered a reasonable assumption at the global level. Consequently, this provides insight into the potential incremental crude runs or potential refining capacity between 2024 and 2029. Furthermore, as this outlook is on an annual basis, this methodology attempts to capture uncertainties related to the start-up date of refining capacity within the year. This is why the calculation takes into account only one-half of the current year (n) and one-half of the previous year (n-1). With this approach, the cumulative global potential refining capacity is set to reach levels of around 6.2 mb/d by 2029, compared to 2023.

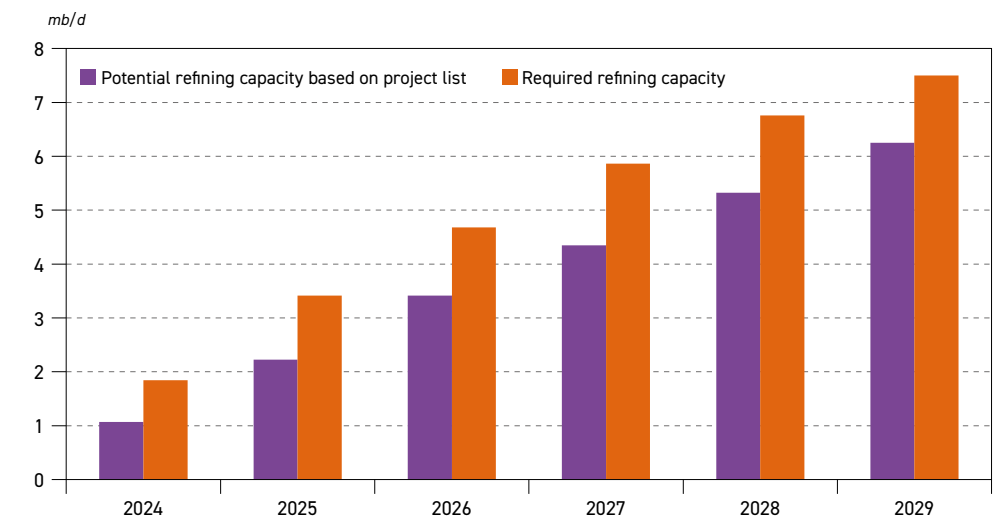
In the next step, the cumulative required incremental crude runs at the global and regional level are calculated. This is the so-called 'call-on-refining' and is based on demand patterns that take into account non-refinery fuels, such as NGLs, biofuels, CTLs and GTLs, which bypass refinery processing. This section covers balances from the perspective of distillation capacity, crude runs and total demand, without considering specific refined products that are discussed later.

While medium-term global oil demand growth is estimated at 10.1 mb/d, the total required incremental crude runs are calculated at 7.5 mb/d. In the final step, the potential incremental crude runs are compared with the cumulative incremental refined product demand at an annual level.

The analysis is done at the global level and for each of the major downstream regions. The resulting balances show the incremental refining capacity compared to incremental refined product demand relative to the base year of 2023. This is a good indicator of the state and the direction of the downstream market in the medium term, both globally and regionally.

Figure 5.7 provides a summary assessment of the global cumulative medium-term potential for incremental distillation refining capacity compared to the required incremental product supply from refineries relative to the base year.

Figure 5.7
Additional global cumulative refinery crude runs, potential* and required**



* Potential: based on expected distillation capacity expansion, assuming no closures.

** Required: based on projected demand increases, assuming no change in refined products trade pattern.

Source: OPEC.

At the global level, the trajectory of incremental refining capacity and required refining capacity shows a tighter market compared to the base year in the entire medium-term period, because of strong demand growth and rising refinery throughputs. In 2024, due to strong demand growth, the required refining capacity is around 0.8 mb/d higher compared to the potential incremental capacity. This gap is set to increase to around 1.5 mb/d by 2027, as demand is set to grow faster compared to the refining capacity additions. The gap starts narrowing afterwards, reaching 1.25 mb/d in 2029.

It is important to note that the global picture is the result of different regional trends that are explained in more detail below.

Medium-term regional balances

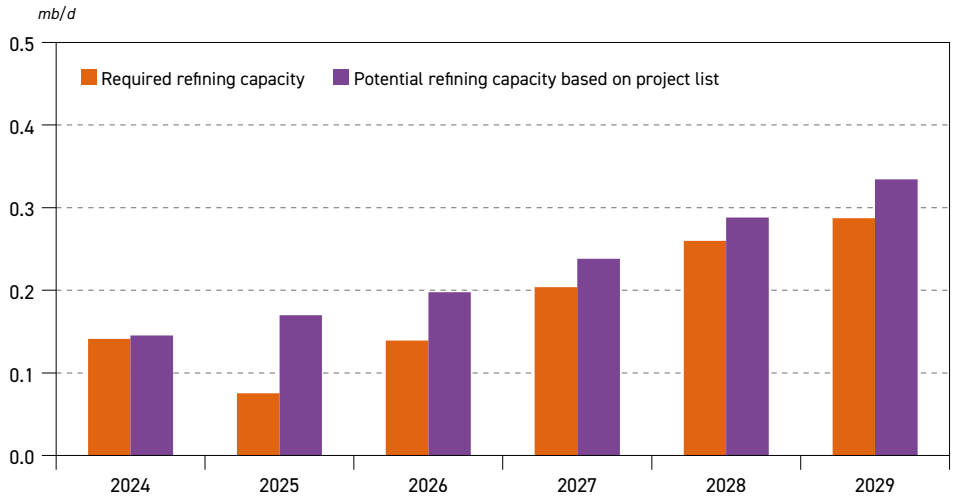
This section focuses on the regional medium-term balances as per the methodology described. Figures 5.8 to 5.15 provide a comparison of data for all major downstream regions in the medium term.

Figure 5.8 relates to the medium-term balance for the US & Canada. Relative to 2023, the potential incremental refining capacity is expected to rise gradually to levels of around 0.3 mb/d over the medium term. This is a result of minor refinery expansions in the region, combined with continuous debottlenecking expansions.

At the same time, the required refining capacity increases in parallel with the potential refining capacity, reaching around 0.3 mb/d in 2029. Consequently, the medium-term downstream market in the US & Canada is expected to be balanced relative to 2023.



Figure 5.8
Additional cumulative crude runs in US & Canada, potential and required



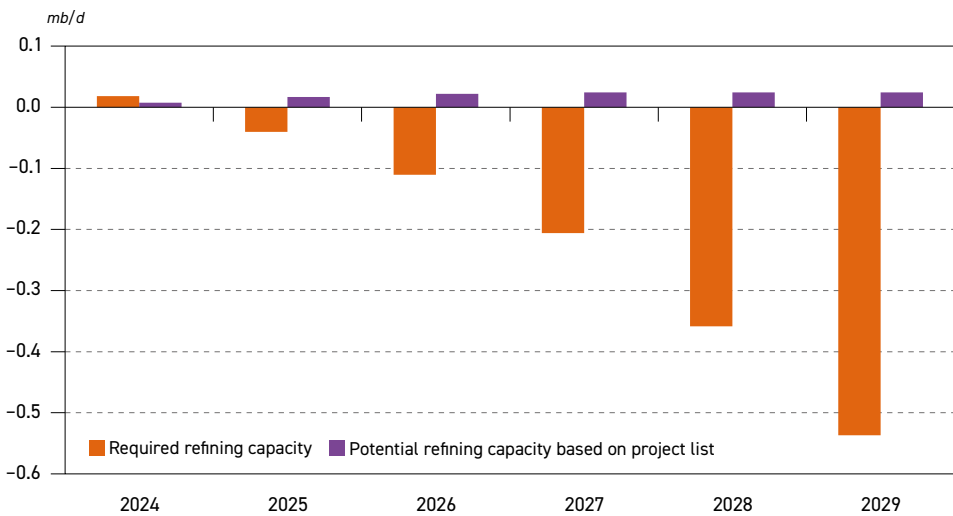
Source: OPEC.

In addition, the region is expected to remain competitive in the international downstream market. This should keep utilization rates in this region at high levels during the medium term, which is discussed in Section 5.2.4.

Europe presents a more pessimistic outlook for the medium-term downstream market compared to 2023 (Figure 5.9). Cumulative potential refining capacity in Europe is set to remain at virtually zero throughout the medium term. During the same period, the required incremental refining capacity is expected to decline to approximately -0.5 mb/d in 2029, in

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Figure 5.9
Additional cumulative crude runs in Europe, potential and required



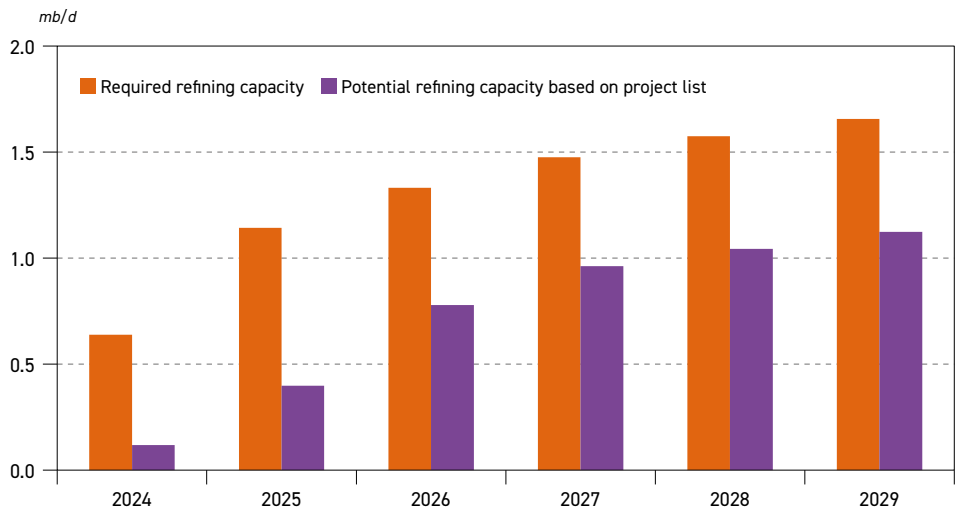
Source: OPEC.

line with declining demand for refined products and a rising volume of biofuels in the fuels mix. This will likely put some pressure on the European refining sector. Announced closures in Europe of around 0.4 mb/d in the medium term will help keep the market in balance relative to 2023.

Figure 5.10 shows the medium-term downstream market balance for China. In line with rising demand, the required cumulative refining capacity increases strongly relative to the base year. It is estimated at around 0.6 mb/d in 2024, 1.3 mb/d in 2026 and 1.7 mb/d in 2029.

At the same time, the potential incremental refining capacity is expected to increase at a significantly slower pace, which will lead to a tighter downstream market. Potential incremental refining capacity is projected to increase gradually to 1.1 mb/d by the end of the medium term. Consequently, the gap between the required and potential refining capacity remains in the 0.5 mb/d to 0.7 mb/d range throughout the medium term.

Figure 5.10
Additional cumulative crude runs in China, potential and required



Source: OPEC.

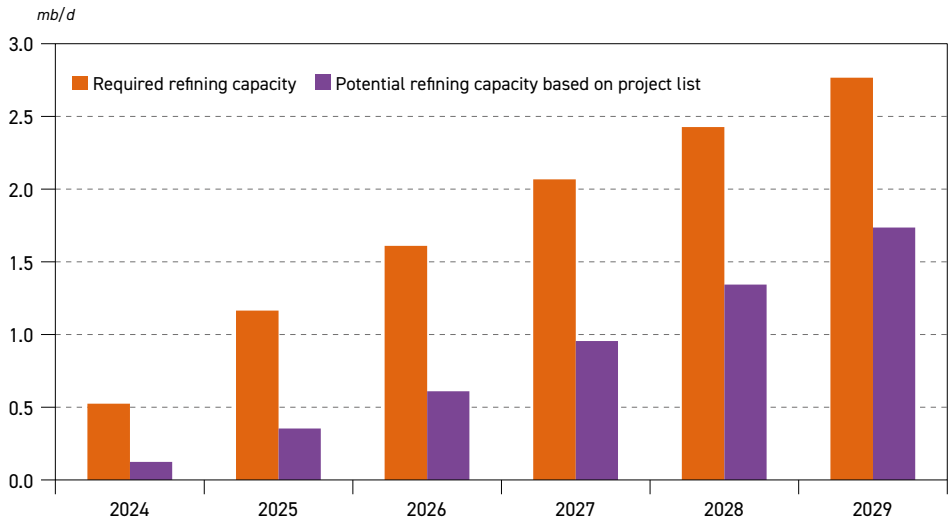
Figure 5.11 presents the medium-term market balance for the Asia-Pacific (excl. China). Required refining capacity increases strongly from 0.5 mb/d in 2024 to almost 2.8 mb/d in 2029. This is based on strong demand growth in all developing countries of the region, especially India. At the same time, the potential incremental refining capacity increases from 0.1 mb/d in 2024 to 1.75 mb/d in 2029. The gap between the required and potential refining capacity increases from 0.4 mb/d in 2024 to around 1 mb/d from 2026 to 2029. Consequently, this may lead to rising utilization rates and possibly higher product imports to the region in the medium term.

The medium-term balance for the Middle East is shown in Figure 5.12. Strong demand growth results in rising required incremental refining capacity relative to 2023. It increases from 0.2 mb/d in 2024 to 1.7 mb/d in 2029. At the same time, the potential incremental refining capacity increases from 0.4 mb/d in 2024 to almost 1.4 mb/d in 2029.



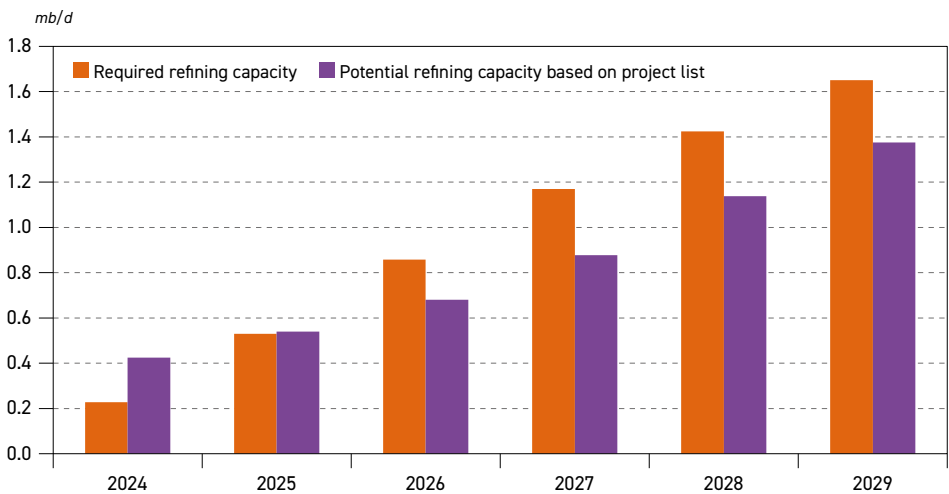
The gap between required and potential refining capacity is seen at around -0.2 mb/d in 2024. However, as required capacity rises faster, the gap reverses and hovers between 0.2 and 0.3 mb/d for most of the medium-term period.

Figure 5.11
Additional cumulative crude runs in Asia-Pacific (excl. China), potential and required



Source: OPEC.

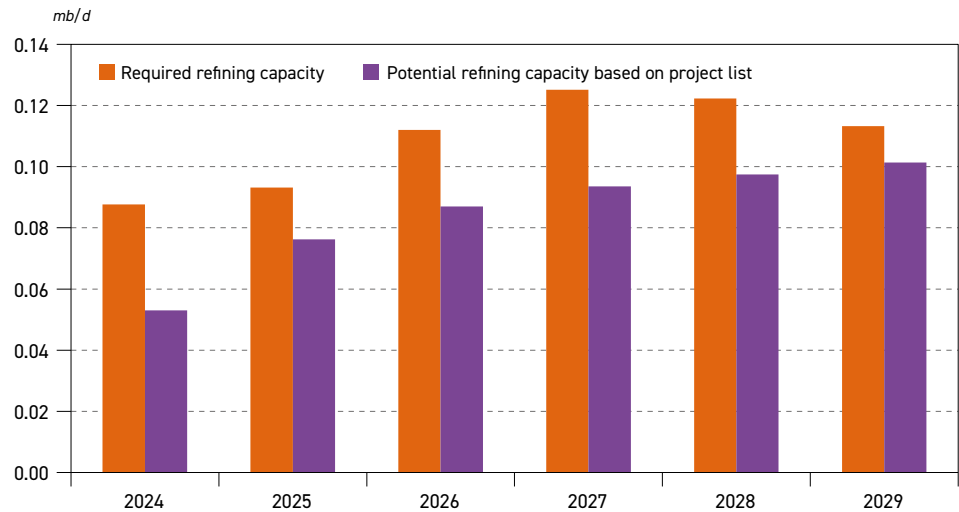
Figure 5.12
Additional cumulative crude runs in the Middle East, potential and required



Source: OPEC.

In Russia & Caspian, as shown in Figure 5.13, only minimal changes relative to the base year are projected. Required incremental refining capacity is estimated at levels around 0.1 mb/d throughout the medium term, as demand for refinery products increases only modestly.

Figure 5.13
Additional cumulative crude runs in Russia & Caspian, potential and required



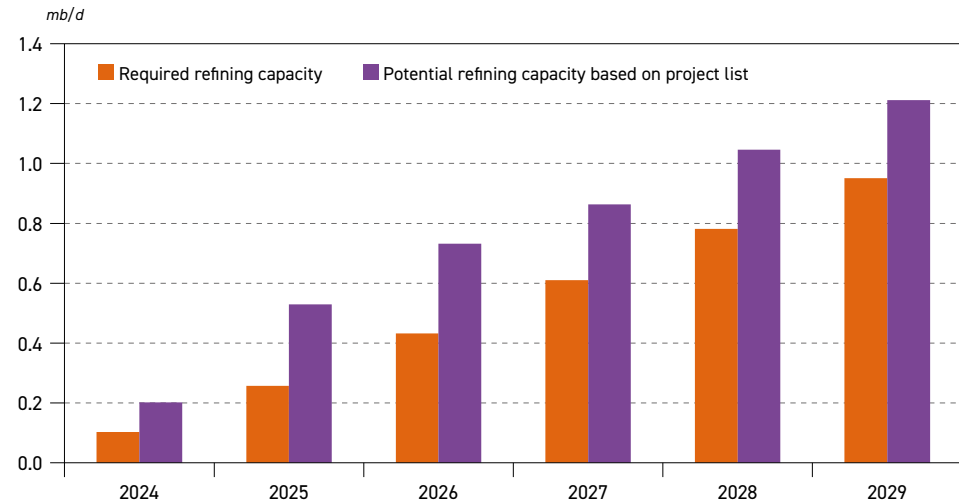
Source: OPEC.

The potential refining capacity increases to 0.1 mb/d in 2029, in line with minor capacity expansions. Consequently, the market in Russia & Caspian is set to remain largely balanced.

It is important to note that the required refining capacity relates only to domestic demand trends. However, the downstream sector in Russia & Caspian is to a large extent linked to product exports and changes in the international downstream market.

Figure 5.14 shows the medium-term downstream market balance for Africa. The potential incremental refining capacity is expected to increase throughout the medium term, from

Figure 5.14
Additional cumulative crude runs in Africa, potential and required



Source: OPEC.

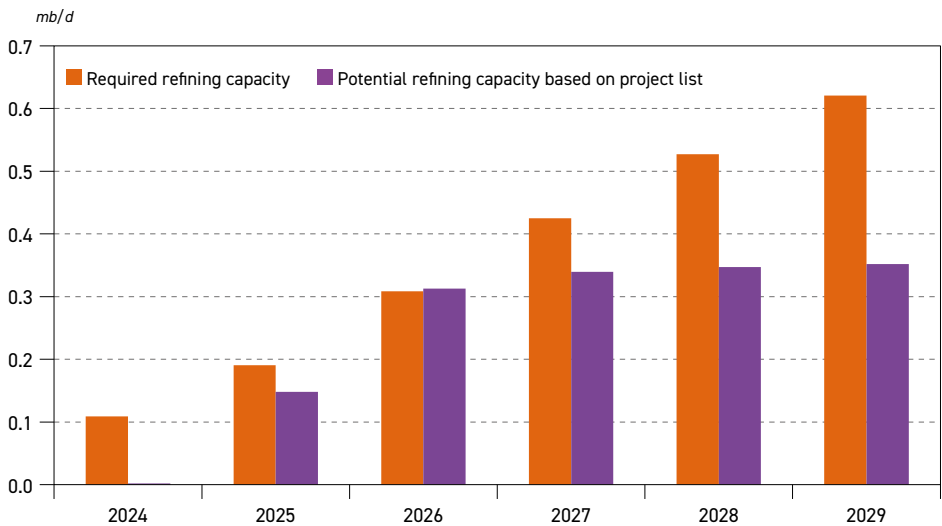


0.2 mb/d in 2024 to 1.2 mb/d in 2029, in line with significant refining capacity additions. At the same time, required cumulative refining capacity is seen increasing from 0.1 mb/d in 2024 to 1 mb/d in 2029.

The potential refining capacity relative to 2023 remains above the required capacity throughout the medium term. This means that if the new medium-term refining capacity reaches high utilization rate levels, African product imports could decline somewhat in comparison with the base year.

The downstream balance in Latin America is presented in Figure 5.15. The incremental cumulative required refining capacity is projected to increase to 0.6 mb/d in 2029, based on rising demand. The incremental potential capacity is estimated to increase too, but at a slower pace. It is seen reaching 0.35 mb/d by 2029, which largely depends on Mexico's Dos Bocas refinery. Required refining capacity remains above incremental potential capacity throughout the medium term, thus demonstrating a tighter downstream market in the medium term.

Figure 5.15
Additional cumulative crude runs in Latin America, potential and required

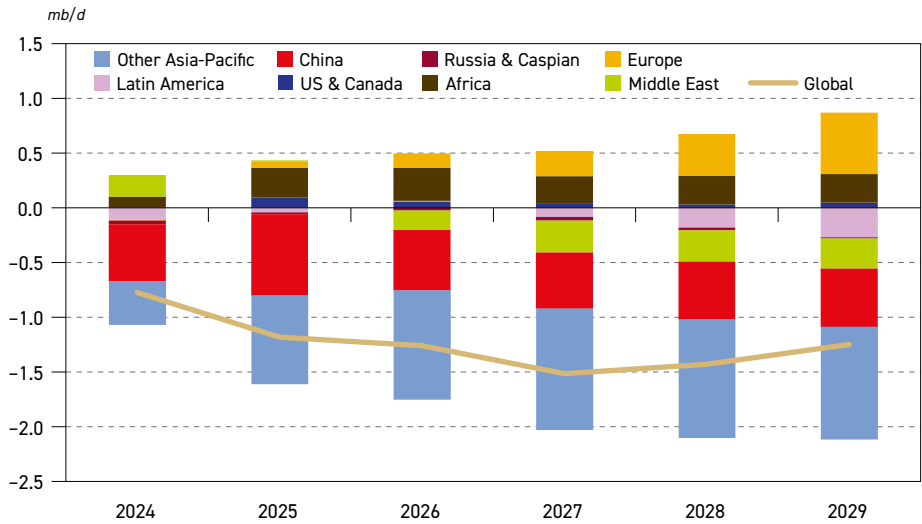


Source: OPEC.

Finally, Figure 5.16 shows a summary of the cumulative medium-term balance by downstream region and globally. It also presents the change in the gap between incremental potential and required refining capacity over the medium term. The largest deficit of refining capacity relative to requirements is expected in the Asia-Pacific (incl. China), due to strong medium-term demand growth. Limited deficits are expected in the Middle East and Latin America relative to 2023. The cumulative deficit reaches levels of just above 2 mb/d in 2026 and stays around this level until 2029.

On the other side, a surplus of refining capacity relative to requirements emerges mostly in developed regions, such as the US & Canada and Europe, but also Africa. The cumulative surplus for all three regions increases from around 0.1 mb/d in 2024 to 0.9 mb/d in 2029.

Figure 5.16
Net cumulative regional refining potential surplus/deficits versus requirements



Source: OPEC.

The resulting global balance in 2029 shows a deficit of potential refining capacity relative to required capacity of around 1.5 mb/d in 2027, which declines to around 1.25 mb/d by 2029. It is important to note, however, that this analysis does not include closures (discussed in Section 5.2.5). This means that if all closures materialize as planned, the overall deficit could be even higher. This points towards a stronger downstream market, especially in the first half of the medium term when compared to the base year.

Medium-term refinery utilization and throughputs outlooks

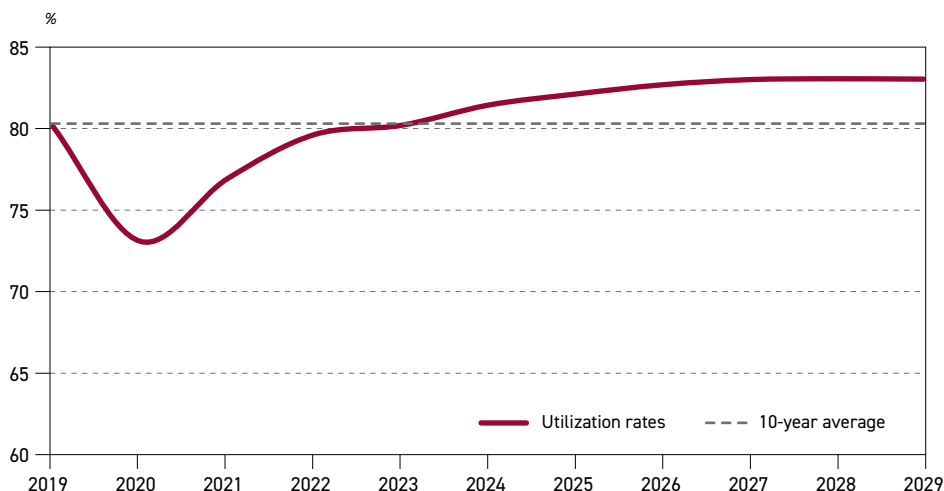
This section discusses medium-term global refinery utilization and refinery throughputs. Unlike the previous section, this analysis includes assumptions on medium-term closures, estimated at around 1 mb/d. It also shows assumed crude throughputs, the effects of historical and projected closures and assesses spare refining capacity over the medium term.

Global utilization rates in the period 2019–2029 are shown in Figure 5.17. In 2019, utilization rates were assessed at just above 80%, which was followed by a strong drop to around 73% in 2020. This was the result of the demand drop induced by COVID-19. Utilization rates recovered only gradually after 2020. They reached 79.6% in 2022 and only came close to pre-pandemic levels in 2023 at 80.2%, despite massive refinery capacity closures of roughly 4.5 mb/d between 2020 and 2023.

Driven by strong demand growth, global utilization rates are expected to continue increasing in the medium term, reaching 83% in 2027 and staying at that level until the end of the medium term. Expected closures of around 1 mb/d during the medium term are an additional supporting factor behind this trend. It is important to note that in a tightening downstream market, any potential delay in estimated capacity expansions could lead to even higher utilization rates.



Figure 5.17
Historical and projected global refinery utilization, 2019–2029



Source: OPEC.

In addition, global utilization rates are calculated based on nominal refining capacities, which are assumed to be available over the medium term. However, some countries can restrain access to international markets for their refiners due to various reasons, including security of supply for specific products.

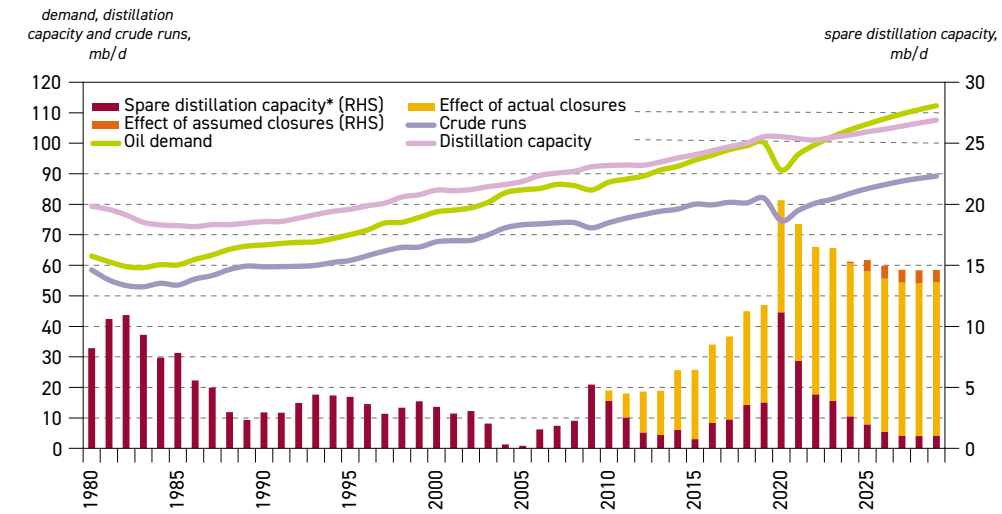
This effectively lowers the availability of refining capacity to the global market and puts more pressure on the rest of the global downstream system. Furthermore, many countries maintain relatively old and inefficient refineries, which run at relatively low levels – especially in Africa and Latin America. In 2023, average utilization rates in Africa and Latin America were estimated at close to 50% and 60%, respectively. While some improvement for these two regions can be expected in the medium term, average utilization rates will not reach levels close to 80%. This means that refinery utilization rates in other regions have to be well above 80% to maintain a global rate of around 83% by 2029.

Figure 5.18 highlights the evolution of global oil (liquids) demand, refinery throughputs, as well as the absolute nominal distillation capacity at the global level. The historical trend shows a gradual convergence of global oil demand and nominal distillation capacity. In the medium term, global oil demand is expected to overtake global distillation capacity.

This is due to the shifts in the structure of global oil demand and the increasing share of demand attributed to non-refinery fuels, such as NGLs (surpassing refinery systems), biofuels, CTLs and GTLs. The increasing share of these liquids leads to a reduced share of refinery products in total oil demand. This has kept refining capacity additions lower relative to oil demand increments.

Global oil demand is projected to increase from around 102.2 mb/d in 2023 to 112.3 mb/d by the end of the medium term, an increase of 10.1 mb/d. At the same time, refinery runs are projected to rise roughly by 7.5 mb/d to 89.3 mb/d in 2029. Figure 5.18 also shows the effects

Figure 5.18
Global oil demand, refining capacity and crude runs, 1980–2029



* Effective 'spare' capacity estimate based on assumed 84% utilization rate, accounting for already-closed capacity.
Source: OPEC.

of realized and assumed refinery closures. Since 2010, around 12.5 mb/d of refining capacity has been shut in several closure waves. The period from 2020 to 2023 resulted in closures of around 4.5 mb/d stemming from falling demand and declining margins during the pandemic. Around 1 mb/d is assumed to be decommissioned in the medium term (2024–2029), based on announcements and plans.

Global oil demand trends and projected utilization rates, as well as expected refinery closures, are the basis for the calculation of so-called spare refining capacity, where the maximum feasible global utilization rate is estimated at around 84%. This is historically the highest observed level. Consequently, the level of spare capacity was at its highest in 2020, at 11 mb/d. However, as demand recovered thereafter and significant capacity was closed, spare capacity dropped to below 4 mb/d in 2023. In line with rising refinery runs and expected closures, the spare capacity level is expected to decline to around 1 mb/d in 2027 and will remain at that level by the end of the medium term. This is under the assumption that all projected refining capacity additions are built on time, which means that any delays could lower the level of spare capacity further.

5.2.4 Long-term balance for the refining sector

This section focuses on long-term crude and condensate throughputs, as well as long-term utilization rates at the global and regional level. These are based on modelling cases and in line with oil demand (Chapter 3) and liquid supply (Chapter 4) assumptions. Assumptions on medium-term refining capacity additions and refinery closures, as discussed already, are also an integral part of the modelling cases.

Table 5.4 shows details on crude and condensate throughputs and the respective utilization rates in the outlook period for anchor years. These utilization rates take



Table 5.4
Crude unit throughputs and utilization rates, 2023–2050

mb/d

Total crude unit throughputs mb/d									
	US & Canada	Latin America	Africa	Europe	Russia & Caspian	Middle East	China	Other Asia-Pacific	Global
2023	17.7	4.6	1.8	11.8	6.6	8.0	14.8	16.7	81.8
2030	18.0	5.6	3.5	11.5	6.5	9.6	16.3	18.9	89.8
2035	18.0	6.1	4.4	11.2	6.2	10.0	16.5	20.0	92.4
2040	18.0	6.5	5.0	9.9	6.1	10.2	16.3	20.9	93.0
2045	17.6	6.7	5.2	9.7	6.1	10.4	16.3	21.4	93.4
2050	17.0	6.9	5.5	9.5	6.1	10.6	16.2	22.0	93.8

Crude unit utilizations % of calendar day capacity									
	US & Canada	Latin America	Africa	Europe	Russia & Caspian	Middle East	China	Other Asia-Pacific	Global
2023	90.2	58.4	49.6	78.6	83.8	70.0	83.2	88.1	80.3
2030	90.8	68.4	68.1	79.7	80.9	75.3	83.3	84.3	81.5
2035	88.9	72.5	73.3	77.5	77.3	76.2	80.3	84.2	80.7
2040	88.7	76.7	74.3	68.6	75.6	76.9	77.9	83.2	79.2
2045	86.5	78.5	74.9	66.9	75.4	77.8	77.6	81.6	78.5
2050	83.3	80.3	77.9	66.1	74.7	79.0	77.4	81.3	78.1

Source: OPEC.

assessed medium-term closures into account, while no further closures in the long term are assumed.

Global refinery throughputs were assessed at around 81.8 mb/d in 2023, increasing roughly by 1.5 mb/d from the year prior. In the period to 2030, global refinery runs are expected to increase strongly to almost 90 mb/d. However, global refinery runs increase only modestly after 2030, reaching levels of 93 mb/d in 2040 and almost 94 mb/d in 2050. The slowdown in global demand growth, the rising share of non-oil liquids (biofuels and synthetic fuels) and the increasing volume of NGLs that surpass refining are the major reasons for this trend. The global utilization rate was estimated at just above 80% in 2023 and is set to rise to 81.5% in 2030. Post-2030, the global utilization rate decreases stepwise to 78% by 2050. This is a result of rising refining capacity in developing countries, where demand is expected to grow. At the same time, declining utilization rates signal possible refinery closures in the long term, which will be discussed further in Section 5.2.5.

Global trends are the result of diverging regional trends. Refinery throughputs are expected to decrease in all developed regions, including the US & Canada, Europe, developed Asia, and Russia & Caspian. This will be more than offset by the increase in developing regions, especially the Asia-Pacific (including China), the Middle East, Africa and Latin America.

In the US & Canada, refinery throughputs were observed at 17.7 mb/d in 2023 and are expected to increase only marginally to 18 mb/d in 2030. Refinery throughputs are expected to stabilize at around 18 mb/d in the period to 2040. This is in line with rising product exports, which offset declines in domestic oil demand. However, in the last decade of the outlook, refinery throughputs drop and reach 17 mb/d in 2050, which is the result of declining demand in the region. Refinery utilization rates in this region are set to fall gradually from just above 90% to slightly above 83% in 2050. The utilization rate in 2050, while comparatively high, could signal the closure of some older plants in the long term.

Due to the lack of sufficient domestic oil supply and aggressive energy policies, the European refining sector is expected to experience a steeper decline in refinery runs. From almost 12 mb/d in 2023, throughputs are projected to decline gradually to 11.2 mb/d in 2035, before declining further to 9.5 mb/d by 2050. The utilization rate is set to increase from 78.6% to 79.7% in 2030, due to foreseen closures in the medium term. Beyond 2030, utilization rates are expected to reach almost 66% in 2050, leading to the need for refinery closures in the long term. Many of these capacities could be repurposed, including for the production of biofuels, synthetic fuels, hydrogen and possibly recycling.

In Russia & Caspian, refinery runs are projected to decline from 6.6 mb/d in 2023 to 6.1 mb/d in 2050. The most significant driver is the expected long-term decline in Russian product exports and the increasing competition in international downstream markets (from the US & Canada and the Middle East). Accordingly, utilization rates in Russia & Caspian are expected to decline from almost 84% in 2023 to below 75% in 2050. This could result in capacity closures, especially after 2030.

In the Middle East, refinery throughputs are set to increase strongly from 8 mb/d in 2023 to 9.6 mb/d in 2030, followed by a gradual increase to above 10.6 mb/d in 2050. Accelerated domestic demand growth, rising product exports to other regions, as well as available domestic crude oil supplies are major drivers of this increase. From around 70% in 2023, utilization rates are projected to gradually increase to 79% in 2050. Limited closures and the rationalization of older capacities in the long term cannot be excluded.

Refinery throughputs in China are expected to increase from 14.8 mb/d in 2023 to 16.3 mb/d in 2030 and further to 16.5 mb/d in 2035, supported by a strong demand increase. However, runs are seen hovering around 16.3 mb/d for the rest of the outlook period. While oil demand continues increasing after 2030, the rising share of non-refinery products in the demand mix leads to stagnating refinery runs in China. Utilization rates are expected to remain almost unchanged between 2023 and 2030 at 83.3%. Following the increase in refining capacity, utilization rates are seen declining gradually to around 77.4% by 2050. The potential implication of this development will likely be closures of older refining capacity, mostly teapot refineries.

In the Asia-Pacific (excl. China), refinery runs are expected to rise strongly. In the initial period, runs are set to increase from 16.7 mb/d in 2023 to 18.9 mb/d in 2030. The growth in throughputs is expected to decelerate afterwards, but will remain strong. Runs reach 20 mb/d in 2035 and 20.9 mb/d in 2040, finally hitting 22 mb/d in 2050. Oil demand growth in most developing countries of this region (especially India) will drive this increase in refinery throughputs. Refinery utilization rates were observed at around 88% in 2023 and are expected to see a gradual decline to about 81.3% in 2050, as new capacity comes online.

In Africa, refinery throughputs are set to soar in line with rising oil demand. In total, African refinery throughputs are seen increasing by 3.7 mb/d between 2023 and 2050. From around 1.8 mb/d in 2023, throughputs are seen reaching 3.5 mb/d in 2030 and then 5.5 mb/d in 2050. This reflects not only rising demand, but also assumes fast refinery capacity expansions and the modernization of existing refineries, as this is crucial for the African refinery sector. It is important to note that the long-term outlook makes assumptions about the required refinery capacity additions, in line with projected demand growth.

Africa's refinery utilization rates are also expected to increase accordingly, from below 50% in 2023 to nearly 78% in 2050. Further and faster modernization efforts could lead to refinery runs and utilization rates climbing even higher. At the same time, however, Africa will be exposed to rising international competition, especially from the US, where refiners will increasingly turn to international downstream markets.

In Latin America there is a similar trend. Refinery throughputs are seen increasing gradually from 4.6 mb/d in 2023 to 6.9 mb/d in 2050, reflecting strong demand growth. Refinery utilization rates are projected to increase from around 58.4% in 2023 to just above 80% in 2050. This assumes the modernization of existing refineries, many of which are old and inefficient. The region could also reduce its dependency on product imports, especially from the US & Canada, and profit from domestic crude oil supplies, which is what this outlook assumes.

5.2.5 Refinery closures

This section discusses refinery closures in the medium and long term at the global and regional level. Two different methodologies are applied in the analysis. Refinery closure projections in the medium term include firm and probable closures, largely based on announcements by companies and governments and analysis of refinery closures. In the long term (beyond 2029), the outlook is much more uncertain. Analysis is based on projections for regional utilization rates, and a conclusion is drawn on how many closures would be needed to keep regional utilization rates at technically and financially sustainable levels until the end of the outlook period.

Refinery closures in the medium term

Table 5.5 and Figure 5.19 provide an overview of recent and projected refinery closures by major region in the period to 2029.

Before 2020, the global refinery capacity was approaching the stage of potential rationalization due to additions of new state-of-the-art capacities and a rising share of non-refinery fuels in the overall mix. The trigger for a wave of closures was the COVID-19 pandemic and the corresponding demand decline in 2020, as well as related unfavourable economics. Older and less efficient plants were hit the hardest. Consequently, about 4.5 mb/d of refining capacity was closed between 2020 and 2023. The majority of closures occurred in developed countries (US & Canada, Europe and the developed Asia-Pacific), partly also due to changing narratives related to the future of the energy sector, in general, and oil demand, in particular. China also closed significant refining capacities. This was due to government policies aimed at closing old and inefficient teapot refineries and replacing them with new projects. Africa also witnessed closures during this period, primarily in South Africa.

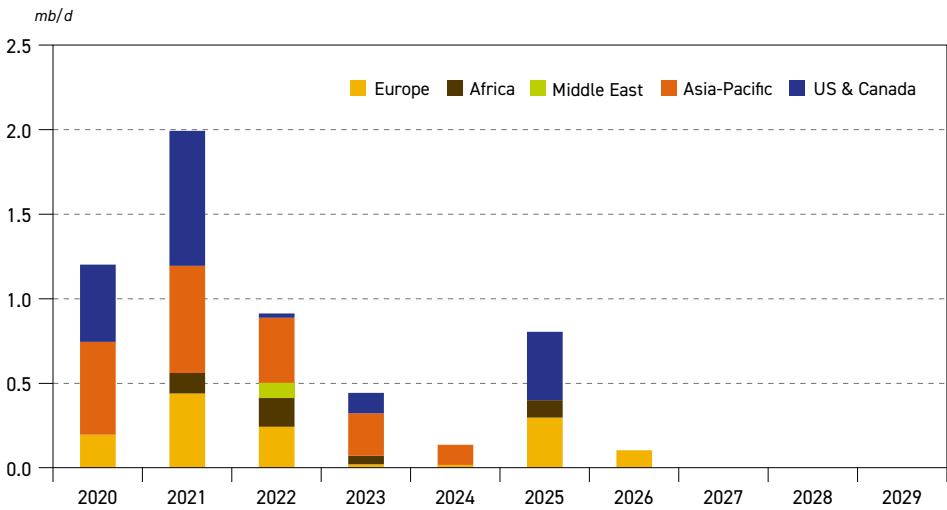
Table 5.5
Net refinery closures by region, recent and projected

mb/d

	Total 2020-2023	2024	2025	2026	2027	2028	2029	Total 2024-2029
US & Canada	1.4	0.0	0.4	0.0	0.0	0.0	0.0	0.4
Latin America	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Europe	0.9	0.0	0.3	0.1	0.0	0.0	0.0	0.4
Russia & Caspian	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Africa	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Middle East	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Asia-Pacific	1.8	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Total	4.5	0.1	0.8	0.1	0.0	0.0	0.0	1.0

Source: OPEC.

Figure 5.19
Net refinery closures by region, recent and projected



Source: OPEC.

During the medium term, it is projected that around 1 mb/d of capacity will be shut down, mostly before 2027. Closures will be located in Europe, the US & Canada and the developed Asia-Pacific. No closures have been announced or are expected in other regions.

Europe will account for almost 40% of closures between 2024 and 2029. This includes the closure of several relatively large refineries, such as Shell's Wesseling refinery in Germany and ENI's Livorno refinery in Italy. Another 40% of the total medium-term closures will occur in the US & Canada, with LyondellBasell's 270 tb/d facility in Houston being the single largest plant in this group. The remaining closures will likely materialize in the Asia-Pacific, primarily in Japan, exemplified by Seibu Oil's refinery in Yamaguchi closing in the first quarter of 2024.



Once again, it is important to highlight that the projected medium-term capacity closures are significantly lower than the closures witnessed in the past four years. The average closures observed during the previous three years exceeded 1.4 mb/d annually, while the annual average closures expected in the medium term are around 0.3 mb/d. This indicates that after the pandemic-induced closures of the most vulnerable refineries, the wave of capacity shutdowns seems to have come to an end. Moreover, improved refining margins since mid-2022 have provided relief for many plants. Nevertheless, increasingly stringent policies and related demand trends, especially in developed countries, in combination with rising competition in the downstream market, could lead to further rationalizations in the medium term.

Refinery closures in the long term

As per the applied methodology, refinery closures in the long term (2030 and beyond) are not explicitly projected. Instead, only so-called implied refinery closures are calculated and indicated, based on the long-term modelling results. In more detail, implied refinery closures are back calculated while targeting a long-term sustainable average utilization rate on a regional level. In developed regions, this rate hovers around 80%, but it is different in other regions like Africa, Latin America and – to some extent – the Asia-Pacific and Middle East.

The general assumption is that most of these implied closures will comprise simple, non-integrated and less efficient plants that will struggle to compete against complex and integrated plants once utilization rates start declining. It is important to note that long-term modelling cases already take into account projected medium-term closures of around 1 mb/d, as already discussed.

The refinery utilization rate in developed regions – the US & Canada, Europe and the developed Asia-Pacific – is expected to decline strongly in the long term, mostly due to a decline in oil demand. This development will necessarily lead to a further rationalization of refining capacity in the long term. Furthermore, other regions may also see rationalizations in their refining sectors. This includes Russia & Caspian, where utilization rates will decline mostly due to declining exports. In Africa and Latin America, it is likely that some old plants will close due to rising competition from new capacity and international competition.

On top of the assessed medium-term closures, refining capacity in the range between 4 and 5 mb/d could be closed globally if reasonable utilization rates are to be maintained. Due to the decline in demand, stringent energy policies, rising competition and falling product exports, around half of global potential long-term closures (2.5 mb/d) could be located in Europe. In this regard, it is important to note that Europe serves as an important refined product supplier to Africa. If projected additions in Africa do not materialize, this may provide some support to the European refining market and postpone closures to later dates.

In the US & Canada, the average utilization rate in 2050 is expected to remain above 80%. Despite this, some limited closures of less complex units are possible given the history of strong utilization rates in the US that have at times exceeded 90%. Some upside potential for the refining sector in this region could materialize from rising product exports to other regions.

Other regions could also see some closures. This includes China, where less efficient teapot refiners could be challenged to operate in a market dominated by large integrated plants. Some teapot plants already shut at the beginning of this decade and were replaced by large refineries with petrochemical integration. Furthermore, China's National Development

and Reform Commission (NDRC) introduced several regulations and guidelines that could negatively affect the teapot sector, including potential closures in the medium and long term. These include limiting China's overall crude processing capacity to 20 mb/d and forcing the closure of small plants of less than 40 tb/d. Furthermore, China is also seeking to increase the energy efficiency of its refining sector. The benchmark level has been established at 8.5 kilogrammes of oil equivalent/metric tonnes (kgoe/mt) multiple factor and all capacity above this level should be phased out. By 2025, 30% of refining capacity should reach an advanced level of energy efficiency, namely energy consumption of 7.5 kgoe/mt. These measures should help reduce the carbon footprint of the downstream industry in China and pose a significant risk for small teapot plants.

Finally, in Latin America and Africa, closures are possible throughout the outlook period. Both regions have a large number of older refineries, which operate at relatively low or even close-to-zero utilization rates. Some countries are trying to modernize existing refineries, for example, Nigerian National Petroleum Corporation (NNPC) refineries in Nigeria, but these efforts currently remain limited. This is why some closures in these two regions can be expected in the long term.

5.3 Secondary capacity

Refining capacity is generally denoted by primary distillation capacity. However, it is the secondary capacity that includes conversion and product quality improvement units that are crucial for processing crude fractions into finished products that provide most of a refinery's 'value-added'. Secondary capacity provides flexibility to the refining system to meet final product demand, including seasonal and structural changes. The development of secondary capacity goes hand-in-hand with evolving refined product demand and product specifications, such as sulphur content and/or octane units.

This section explores secondary capacity additions in the medium and long term by major categories of secondary units, including conversion, desulphurization and octane units. Similar to distillation capacity, the Reference Case provides projections for secondary capacity additions in the medium term (based on a review of new refinery projects) and in the long term (based on the modelling results).

5.3.1 Medium-term secondary capacity additions

This section discusses medium-term additions of secondary capacity related to distillation capacity additions that are estimated at 6.3 mb/d. Details on secondary additions in the period to 2029 are shown in Table 5.6. These include 4.3 mb/d of conversion/upgrading capacity, 4.9 mb/d of desulphurization capacity and 1.6 mb/d of octane units. The majority of these additions are projected to be commissioned in the Middle East and Asia-Pacific (including China), as well as Africa. These regions account for around 83% of conversion additions, as well as around 86% of desulphurization and octane unit additions. This is somewhat lower than the share these regions have in distillation capacity additions. This is due to additions of secondary capacity in other regions, related to upgrades and/or modernization of existing refineries.

Furthermore, the rate of secondary capacity additions in relation to new distillation capacity is relatively high, as many new refineries – especially in the Middle East and Asia-Pacific – are highly complex and integrated plants that are built to process medium- and heavy-sour crude.

Table 5.6
Secondary capacity additions from existing projects, 2024–2029

mb/d

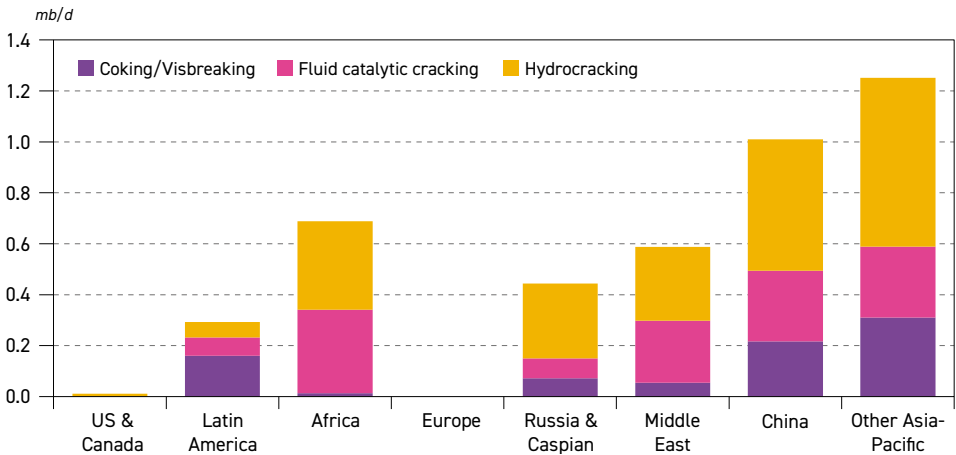
	By year		
	Conversion	Desulphurization*	Octane units
2024	0.4	0.7	0.2
2025	1.2	1.2	0.4
2026	0.7	0.9	0.2
2027	0.7	0.8	0.3
2028	0.6	0.8	0.2
2029	0.6	0.6	0.2
	By region		
	Conversion	Desulphurization*	Octane units
US & Canada	0.0	0.1	0.0
Latin America	0.3	0.3	0.1
Africa	0.7	0.9	0.4
Europe	0.0	0.0	0.0
Russia & Caspian	0.4	0.2	0.1
Middle East	0.6	1.1	0.2
China	1.0	0.8	0.3
Other Asia	1.3	1.4	0.4
World	4.3	4.9	1.6

* Desulphurization capacity in this table includes naphtha desulphurization.
Source: OPEC.

Conversion units

Conversion capacity additions in the medium term are shown in Figure 5.20. Out of 4.3 mb/d of conversion unit additions, more than 50% are for hydrocracking units. In many cases, hydrocracking is the preferred technology of many refiners due to its inherent flexibility in the production of middle and light distillates. Furthermore, refiners are set to add around 1.28 mb/d of FCC and 0.83 mb/d of coking capacity in the period to 2029.

Figure 5.20
Conversion projects by region, 2024–2029



Source: OPEC.



The vast majority of conversion capacity additions are projected to occur in the Asia-Pacific, Africa and the Middle East. China alone is set to add around 1 mb/d of conversion capacity in the medium term, while other countries of the Asia-Pacific region are likely to commission 1.25 mb/d of new conversion capacity. Africa is expected to commission almost 0.7 mb/d of additional secondary capacity, while the Middle East will add 0.6 mb/d. Russia & Caspian will see conversion capacity additions (especially hydrocracking) of around 0.4 mb/d. This reflects efforts to upgrade existing plants and reduce fuel oil output, especially in Russia. Finally, Latin America is set to expand secondary capacity by 0.3 mb/d in the period to 2029.

Desulphurization units

In the medium term, around 4.9 mb/d of new desulphurization capacity is likely to be commissioned, with more than 45% of these additions set to come in the Asia-Pacific. Including the Middle East and Africa, these three regions will represent around 86% of the total, or 4.2 mb/d of desulphurization capacity. China and the Asia-Pacific are expected to add 0.8 mb/d and 1.4 mb/d of new desulphurization capacity, respectively. In the Middle East, desulphurization capacity additions will reach 1.1 mb/d over the medium term, while in Africa they are likely to amount to 0.9 mb/d. Limited desulphurization capacity additions are anticipated in Latin America and Russia & Caspian, totalling 0.6 mb/d, with almost no additions in the US & Canada and Europe.

The majority of new desulphurization capacity is linked to middle distillates (2.4 mb/d), around 1.3 mb/d is for naphtha processing, 0.7 mb/d is for gasoline and the rest is for heavy streams (e.g. vacuum gasoil (VGO) and residue).

Octane units

Around 1.6 mb/d of octane unit capacity is likely to come online in the period to 2029. This reflects rising gasoline demand, mostly in developing regions. The Asia-Pacific (including China) is expected to add 0.8 mb/d of octane units, followed by Africa with around 0.4 mb/d. Additions in other regions are expected to be modest in the medium term due to a lack of gasoline demand growth (in the case of developed regions), or because significant octane unit capacities have already been added in recent years, such as in the Middle East, for example.

The majority of octane unit additions – around 70% of the 1.6 mb/d total – are expected to be for catalytic reforming. This will be accompanied by around 0.2 mb/d of new isomerization capacity and 0.2 mb/d of added alkylation capacity. Only minor capacity additions of methyl tertiary-butyl ether (MTBE)/ethyl tertiary-butyl ether (ETBE) are possible in developing countries, especially the Asia-Pacific.

5.3.2 Long-term secondary capacity additions

The major drivers of secondary capacity additions are the level and composition of oil demand, evolving product specifications, as well as crude oil quality. Many recent refinery additions have included relatively large and complex units with high levels of upgrading, desulphurization, and related secondary processing, generally with an increased focus on petrochemical integration. This is likely to continue in the future, in line with oil demand trends.

As already mentioned in Chapter 3, global trends demonstrate strong demand for ethane/LPG and naphtha in the long term, supported by a continued focus on petrochemicals. Global

gasoline demand is expected to increase in the first part of the outlook period, followed by slower growth thereafter. This is mostly due to the offsetting effect between OECD and non-OECD demand trends. Middle distillates will also grow strongly, especially jet/kerosene. At the same time, the outlook sees increased supplies of medium and heavy crude, especially after 2030, raising requirements for additional upgrading and desulphurization capacities.

It should be noted that condensate splitters that are primarily being built in the Middle East at present represent an exception to the overall trend towards increased complexity. Condensate splitters tend to bring only limited secondary processing, often related to light products like naphtha and gasoline, and are centred on catalytic reforming, isomerization and hydrotreating. This trend could continue, as the share of condensates and NGLs is likely to increase.

In setting out to capture the outlook for global and regional refining, particularly future processing needs by type of unit, the modelling is forced to contend with a number of challenges. One relates to the evolution of refinery process technology. This tends to be stable, with only gradual changes over time, mainly as catalysts slowly improve. That said, significant process improvements and novel technologies warrant close monitoring.

The emerging trend to increase petrochemical yields represents a second potential modelling challenge. While many existing refineries in the US and Europe have some degree of petrochemical capability, the number of large integrated refining plus petrochemical 'mega-projects' continues to rise, especially in the Middle East and Asia-Pacific. Several of these new complexes are designed to produce a significant share of petrochemical feedstocks, often 40% or more. In addition, 'crude-to-chemicals' technologies represent the next step in this direction.

Table 5.7 and Figure 5.21 show global secondary capacity requirements in addition to required primary capacity additions in the period up to 2050. On top of 19.2 mb/d for distillation

Table 5.7
Global capacity requirements by process, 2024–2050

mb/d

	Existing projects	Additional requirements		Total additions
	to 2029*	2030–2040	2040–2050	to 2050
Crude distillation	6.3	10.2	2.7	19.2
Conversion	4.3	4.2	2.3	10.8
Coking/Visbreaking	0.8	1.5	0.6	2.9
Catalytic cracking	1.3	0.9	0.6	2.8
Hydro-cracking	2.2	1.8	1.1	5.1
Desulphurization**	3.5	10.5	5.4	19.4
Gasoline	0.7	2.2	1.1	4.0
Distillate	2.4	7.1	3.7	13.3
VGO/Resid	0.4	1.2	0.6	2.2
Octane units***	1.6	3.2	1.4	6.1
Catalytic reforming	1.1	1.8	1.1	4.0
Alkylation	0.2	1.3	0.2	1.7
Isomerization	0.2	0.0	0.0	0.2
MTBE	0.1	0.1	0.1	0.3

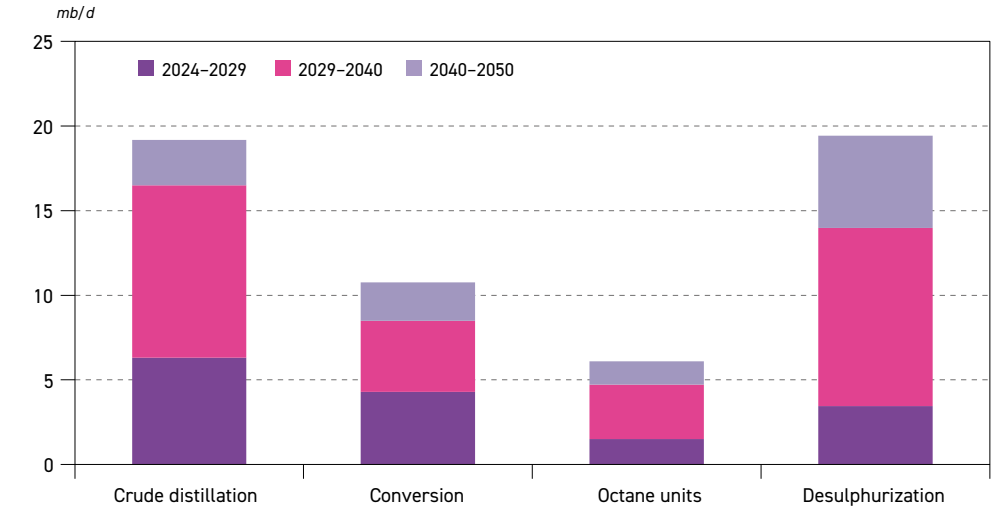
* Existing projects exclude additions resulting from 'capacity creep'.

** Naphtha desulphurization not included.

*** New units only (excludes any revamping).

Source: OPEC.

Figure 5.21
Global capacity requirements by process type, 2024–2050



Source: OPEC.

capacity, there are requirements for around 10.8 mb/d of conversion capacity, 19.4 mb/d for desulphurization and 6.1 mb/d for octane units.

Similar to distillation capacity expansions, the majority of secondary capacity additions are expected to materialize before 2040. Expansions thereafter will mostly cover the modernization of existing plants.

Conversion units

Figure 5.22 presents long-term conversion capacity requirements by region. The majority of additions are in the Asia-Pacific, Middle East and Africa, accounting for almost three quarters of the total. However, it is also important to note significant conversion capacity additions in other regions such as the US & Canada, Latin America and Russia & Caspian, despite minimal distillation capacity additions.

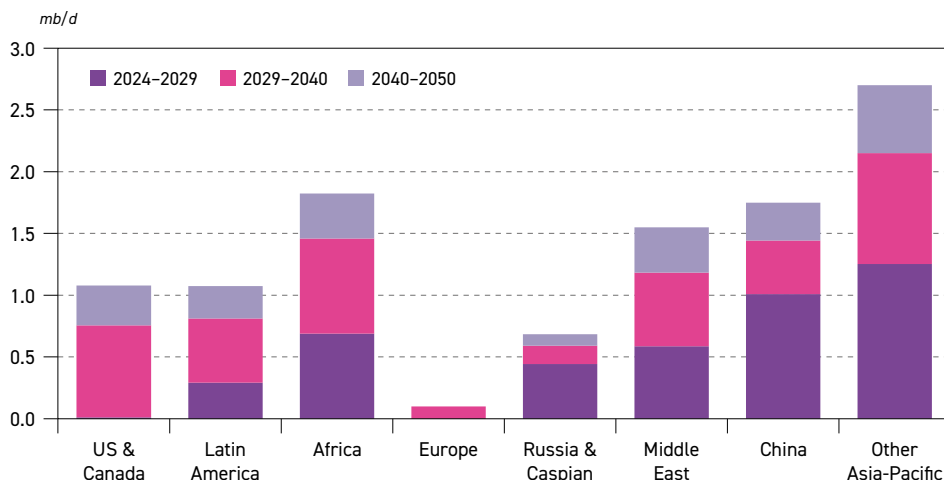
At the global level, the required level of conversion capacity is 10.8 mb/d, as shown in Table 5.7. Hydrocracking accounts for the largest share, at 5.1 mb/d. This is partly due to its inherent flexibility, which allows for adjustments in yields to focus either on naphtha/gasoline or on middle distillates. Today, their use is mainly associated with production growth of the latter, namely jet/kerosene and gasoil/diesel. Moreover, it is also projected that around 2.9 mb/d of new coking/visbreaking capacity will come online by 2050, accompanied by 2.8 mb/d of FCC capacity.

At the regional level, the majority of hydrocracking capacity additions are expected in the Asia-Pacific, Middle East and Africa, totalling just below 4 mb/d. Latin America is projected to see 0.4 mb/d of hydrocracking capacity additions. Due to upgrades of existing refineries, Russia & Caspian and the US & Canada are likely to add around 0.4 mb/d and 0.2 mb/d of new hydrocracking capacity, respectively.

FCC additions are driven predominantly by gasoline demand. This is why the majority of new FCC units are expected in developing regions, where gasoline demand is still likely to



Figure 5.22
Conversion capacity requirements by region, 2024–2050



Source: OPEC.

increase in the medium and long term. At the same time, gasoline demand in developed countries is expected to peak in the coming years and then start declining in the long term, which is why almost no FCC additions in these regions are expected.

In the long term, around 2.8 mb/d of new FCC capacity will be added at the global level. The Asia-Pacific (incl. China) will add around 1.2 mb/d of FCC capacity, followed by Africa with around 0.6 mb/d. Significant additions are expected in the Middle East, with almost 0.5 mb/d in the period to 2050. Other regions, such as Russia & Caspian and the US & Canada, are expected to register only minor FCC additions, while no FCC capacity expansions are expected in Europe.

In the period to 2050, around 2.9 mb/d of coking/visbreaking (predominantly coking) capacity is required. It should be noted that the modelling projections exclude oil sands and heavy Venezuelan or other upgraders as they employ projected volumes for crude streams delivered to the market (i.e. downstream of upgraders and blending). At the regional level, around one third of global additions is set to materialize in the Asia-Pacific (including China) with around 1 mb/d. In the US & Canada, coking additions are likely to reach around 0.65 mb/d over the long term, while in Latin America some 0.45 mb/d of new capacity is expected. Africa's coking additions over the outlook period are estimated at around 0.4 mb/d. In Russia & Caspian, and the Middle East, coking additions are projected at around 0.2 mb/d each.

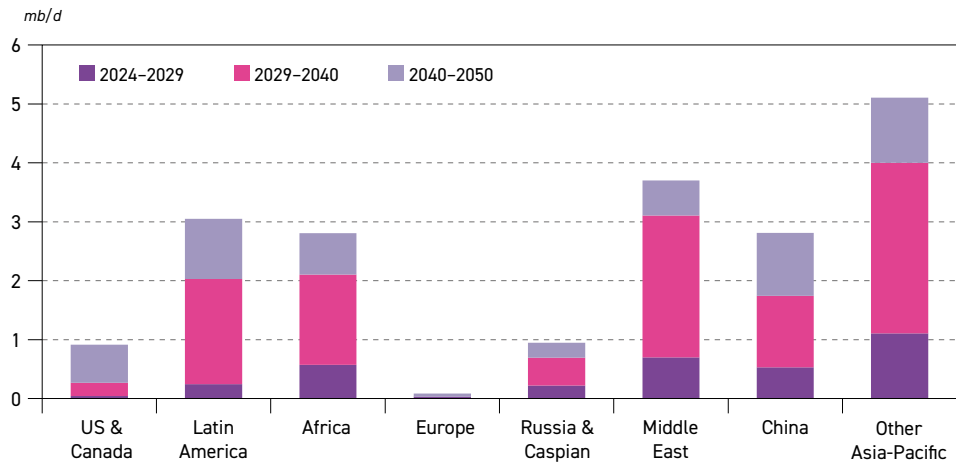
Desulphurization units

Total desulphurization capacity requirements over the outlook period to 2050 are estimated at around 19.4 mb/d. This is in line with required distillation capacity additions over the same period. This reflects the shift to higher-quality fuels, as well as increasingly stringent environmental regulations related mostly to sulphur content in transportation fuels, especially in developing countries. In the long term, the rising sulphur content of the average barrel is another driver of these additions.

Around 3.5 mb/d of desulphurization capacity is set to be added over the medium term. From 2029 to 2040, additions are projected to increase to 10.5 mb/d, followed by slower growth in the last decade of the outlook – with projected additions of 5.4 mb/d.

Figure 5.23 shows desulphurization capacity requirements by region and period. Other Asia-Pacific is set to add just above 5 mb/d of desulphurization capacity in the long term, while China sees an expansion of 2.8 mb/d. High desulphurization additions are in line with rising crude imports from the Middle East in the long term (see Chapter 6). In the Middle East, desulphurization capacity additions are estimated at 3.7 mb/d, in line with the high sulphur content of local crude supplies. Around 2.8 mb/d of new desulphurization capacity is projected for Africa. A large share of Africa's crude supply has relatively low sulphur content, thus requiring lower desulphurization additions relative to other regions.

Figure 5.23
Desulphurization capacity requirements by region*, 2024–2050



* Projects and additions exclude naphtha desulphurization.
Source: OPEC.

Finally, desulphurization additions in Latin America are also significant and estimated at 3.1 mb/d. They are mostly related to exiting refineries and driven by ultra low sulphur (ULS) standards, as well as the relatively high sulphur content of a large share of domestic supplies. Russia & Caspian, along with the US & Canada, are expected to see desulphurization additions of 1 mb/d and 0.9 mb/d, respectively.

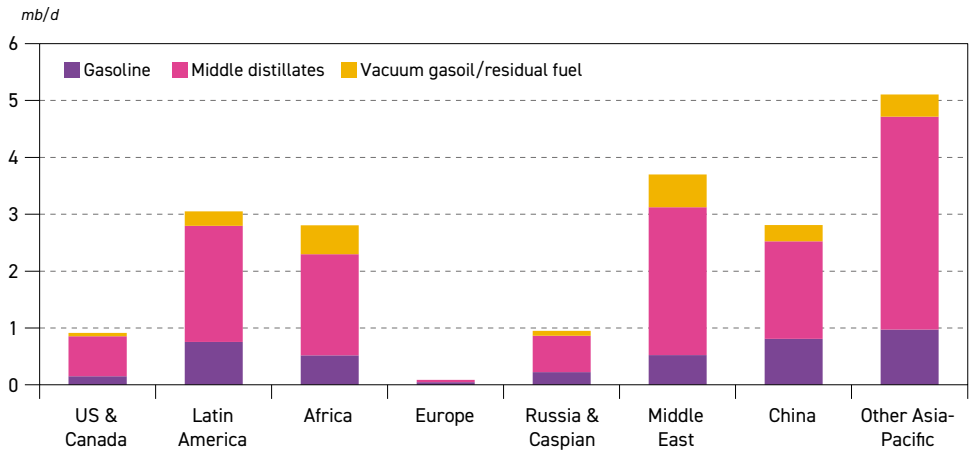
In terms of the product mix, desulphurization capacities related to middle distillates account for the majority of required additions in the period to 2050. At the global level, more than 13 mb/d of middle distillate (diesel and jet/kero) hydrotreating capacity is expected. Rising middle distillate demand throughout the outlook period and increasingly stringent regulations on sulphur levels in diesel (towards ULS standards) are the major drivers for this expansion. The majority of middle distillate desulphurization capacity additions are expected in the Asia-Pacific, the Middle East, Africa and Latin America.

Gasoline desulphurization additions (excluding naphtha) are estimated at 4 mb/d and are projected to materialize mostly in developing regions, where gasoline demand is still expected to grow.



Around 2.2 mb/d of desulphurization capacity for VGO/residual fuel is expected in the long term. One of the drivers behind this trend is the rising very low sulphur fuel oil (VLSFO) demand due to the IMO Sulphur Rule. The majority of additions are expected in the Middle East and the Asia-Pacific. Both regions predominantly process crude with a high sulphur content. Most of the rest of the VGO/residual fuel desulphurization capacity will be required in Africa and Latin America, with some minor amounts in other regions.

Figure 5.24
Desulphurization capacity requirements by product and region*, 2024–2050

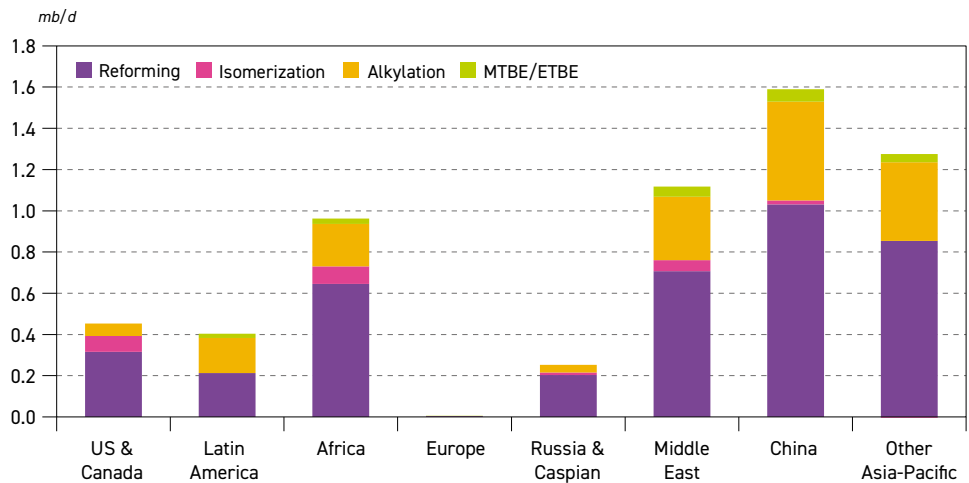


* Projects and additions exclude naphtha desulphurization.
Source: OPEC.

Octane units

As shown in Figure 5.25, around 6.1 mb/d of octane units will be required at the global level in the outlook period to 2050.

Figure 5.25
Octane capacity requirements by process and region, 2024–2050



Source: OPEC.

Around 45% of these additions are projected for the Asia-Pacific, supported by rising gasoline demand. Octane unit growth is also significant in the Middle East and Africa, around 1.1 mb/d and 1 mb/d over the long term, respectively. Traditional gasoline markets – the US & Canada and Russia & Caspian – are projected to add 0.45 mb/d and 0.25 mb/d of new octane units in the long term, respectively.

Octane unit additions are dominated by catalytic reforming, with almost 4 mb/d in the period to 2050. Isomerization and alkylation account for 0.25 mb/d and 1.6 mb/d, respectively. Reforming raises naphtha's octane content and thus enables additional naphtha – including that from condensates – to be blended into gasoline. MTBE/ETBE additions will likely be minor, around 0.2 mb/d at the global level during the entire outlook period. Some markets in Asia still use MTBE as a gasoline enhancer and are the major drivers for these additions.

5.3.3 Implications for refined products supply and demand balances

In assessing the effects of capacity additions on regional product balances, it is important to note that refiners always have some limited flexibility to optimize their product slates, depending on changing market circumstances, demand patterns, as well as economics and the availability of feedstock. This also includes adjusting the yields based on seasonal changes. This can be done by changing feedstock composition (crude slate) and by adjusting process unit operating modes. Table 5.8 presents an estimation of the cumulative potential incremental output of refined products resulting from existing projects by major product category in the period 2024–2029. It also corresponds with the potential incremental output shown in Section 5.2.3.

Table 5.8
Global cumulative potential for incremental product output*, 2024–2029 mb/d

	Gasoline/ Naphtha	Middle distillates	Fuel oil	Other products	Total
2024	0.23	0.36	–0.01	0.27	0.9
2025	0.75	0.98	–0.08	0.75	2.4
2026	1.05	1.38	–0.17	1.06	3.3
2027	1.35	1.85	–0.21	1.35	4.3
2028	1.64	2.30	–0.18	1.60	5.4
2029	1.88	2.68	–0.12	1.81	6.3
Share	30%	43%	–2%	29%	100%

* Based on assumed 90% utilization rates for the new units.
Source: OPEC.

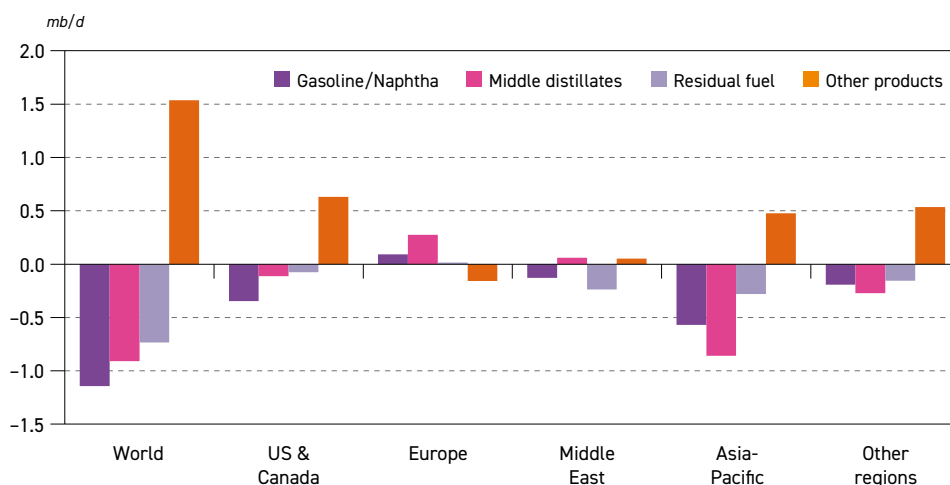
The cumulative potential refining capacity in the period to 2029 is estimated at around 6.2 mb/d, assuming a maximum utilization rate of 90%. The balance is relative to the base year of 2023, and does not include assumed medium-term closures.

More than 40% of new incremental production is related to middle distillates (2.7 mb/d). This is in line with the expected growth of diesel and jet/kerosene demand. Gasoline/naphtha

incremental output potential is assessed at 1.9 mb/d in 2029, while the potential output of other products is at 1.8 mb/d. The potential output for fuel oil is at -0.1 mb/d and reflects strong capacity additions related to the conversion of fuel oil into high-quality products.

Figure 5.26 presents the resulting balance by major product group and region. It is calculated based on the difference between incremental potential output and projected demand. Demand for refinery products is calculated considering any non-refinery streams, including biofuels, CTLs, GTLs and NGLs. It is important to mention that surpluses can be the result of declining demand.

Figure 5.26
Expected surplus/deficit* of incremental product output from existing refining projects, 2024–2029



* Declining product demand in some regions contributes to the surplus.

Source: OPEC.

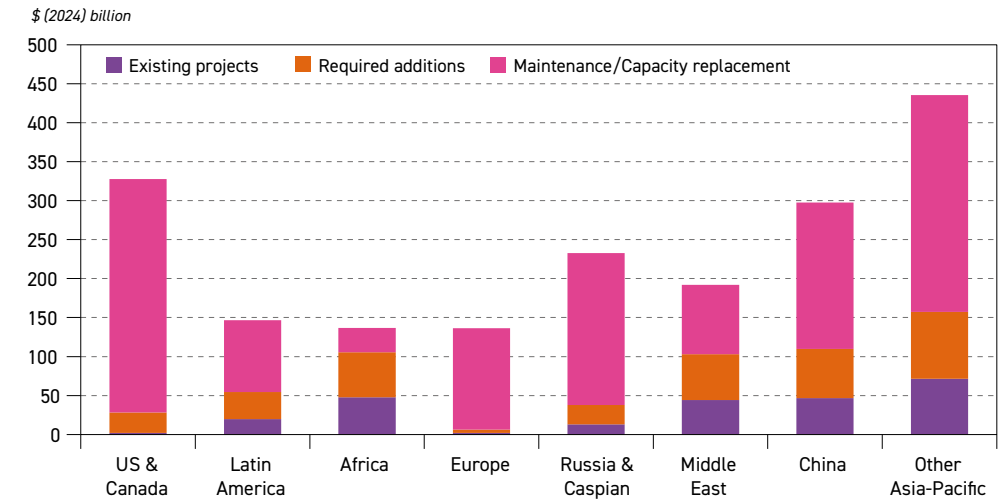
The cumulative deficit is estimated at around 1.25 mb/d in 2029, with all major products showing deficits. Gasoline/naphtha lead the way in a range of 1.1 mb/d, while middle distillates are in a range of 0.9 mb/d. Regionally, surpluses are visible in the US & Canada and Europe.

For the Asia-Pacific (incl. China), a deficit is projected. In this region, all major fuels show a deficit, especially for gasoline/naphtha and middle distillates. This may lead to higher throughputs in these regions relative to 2023, and/or increased product imports if projected demand is to be met.

5.4 Investment requirements

This section provides details related to downstream investment requirements in three different categories, as shown in Figure 5.27. The first category includes investment costs related to identified refining projects in the medium term (Section 5.2.1). Investment costs in this category are based on available and reported information to the extent possible.

Figure 5.27
Refinery investments by region, 2024–2050



Source: OPEC.

The second category covers investment requirements for refinery projects in the period 2030–2050. As these projects are generic, estimates are based on unit refining capacity costs at the regional level. The third and final category is related to necessary continuous replacement and maintenance CAPEX throughout the period to 2050.

For the first category, a total investment cost of \$246 billion is estimated. The largest share of medium-term CAPEX is located east of Suez and Africa. The Middle East, China and Other Asia-Pacific are expected to invest more than \$160 billion in the medium term. In Africa, medium-term investment volumes are projected at levels close to \$50 billion, while investments in Latin America are at almost \$20 billion. Elsewhere, modest investments are estimated for Russia & Caspian at close to \$13 billion in the medium term, while other regions are expected to see only minor investments.

In the period beyond 2029, total refining investment requirements are projected at \$357 billion. Similar to the medium term, the largest share is expected in the Asia-Pacific (including China), the Middle East and Africa. Investment requirements in China and Other Asia-Pacific are above \$150 billion in the long term. In the Middle East and Africa, refining investments beyond 2029 are estimated at close to \$60 billion each. In Latin America, required downstream investments are projected at around \$35 billion. In the US & Canada, investment volumes in the post-2029 period are estimated at a level close to \$26 billion. In this region, secondary capacity expansion is the most important driver of downstream investments. This partly relates to a gradual change in refinery feedstock, with the average crude barrel becoming heavier due to additional volumes from Canada, Latin America and the Middle East. In Russia & Caspian, investment volumes in the long term are estimated at \$25 billion, most of which will be dedicated to the expansion of secondary capacity. In Europe, downstream-related investments are estimated below \$5 billion in the same period.

Finally, maintenance requirements and the necessary continuous ‘capital replacement’ of installed refining capacity are calculated at above \$1.3 trillion for the period 2024–2050. The



assessment of this category assumes that the annual capital needed for capacity maintenance and replacement is around 2% of the cost of the installed base capacity. The leading region in terms of maintenance investments is the US & Canada at \$300 billion, followed by Other Asia-Pacific at almost \$280 billion. China, and Russia & Caspian, also have relatively large replacement costs of around \$188 billion and \$195 billion, respectively.

In summary, this brings the total downstream investment requirements to roughly \$1.9 trillion over the entire outlook period.

Oil movements



Key takeaways

- Global oil (crude oil, condensate and products) trade in 2023 is estimated at around 55 mb/d, a slight increase over 2022. By 2030, global interregional oil trade is projected to increase significantly to above 60 mb/d, with a gradual increase thereafter to almost 67 mb/d in 2050.
- Crude and condensate trade in 2023 is assessed at 36.5 mb/d and by 2030 it is expected to increase to 41.2 mb/d on the back of strong oil demand growth. After 2030, trade is expected to continue to increase further, albeit at a slower pace, reaching levels around 46.2 mb/d by 2050.
- The Middle East and Latin America, as well as the US, Canada and Africa, will be the main contributors to global crude and condensate exports in the period to 2030.
- Total oil product trade is set to increase from 18.5 mb/d in 2023 to above 20.5 mb/d in 2050. Rising exports from the US & Canada and the Middle East will mirror the rising import needs of Asia-Pacific in the long term.
- Crude and condensate exports from the Middle East are projected to increase from 17.8 mb/d in 2023, to reach levels above 20 mb/d in 2030 and almost 24.5 mb/d in 2040. Export growth from this region is set to slow in the last decade of the outlook, reaching 26.8 mb/d in 2050. The overall increase in Middle East crude and condensate exports is estimated at almost 9 mb/d between 2023 and 2050.
- Exports to the Asia-Pacific account for the highest share of Middle East exports, above 80% throughout the outlook period. Flows from the Middle East to Europe are likely to be elevated, partly due to the EU ban on Russian crude.
- Crude and condensate exports from Latin America are expected to increase from 4.2 mb/d in 2023 to 6.7 mb/d in 2045, before dropping marginally to 6.5 mb/d in 2050. The strong increase in export volumes is in line with a significant increase in Latin America oil supply.
- After an initial increase from 4.6 mb/d in 2023 to 5.2 mb/d in 2030 due to higher supply, overall crude and condensate exports from Africa are expected to decline gradually towards 4 mb/d in 2050. This is due to the higher domestic use of crude in Africa.
- Total crude and condensate exports from the US & Canada are expected to reach 5.3 mb/d by 2030, from around 3.9 mb/d in 2023. This is in line with rising supply in this region. Following a peak and gradual decline in US tight oil output, however, crude and condensate exports from the region are set to decrease gradually to around 3.2 mb/d by 2050.
- Due to declining oil demand and lower refinery runs in Europe, total crude and condensate imports are set to decline from 8.7 mb/d in 2023 to 7.3 mb/d in 2050.

Oil trade flows are a crucial part of the global oil and product markets and enable the integration of different regions into the overall global system. They help balance the market and alleviate supply shortages and surpluses at the regional level. This integration increases producer and consumer flexibility and reduces possible demand and supply shocks.

This chapter examines the main trends related to the trade movements of crude oil and condensates, as well as intermediate and refined products, between major downstream regions as defined in Annex B. Projections are based on the assumptions and modelling results discussed throughout this Outlook, including oil demand (Chapter 3), supply (Chapter 4) and refining (Chapter 5). Projections on trade movements also include assumptions regarding logistics developments.

6.1 Logistics developments

The development of logistics infrastructure is crucial for maintaining oil trade and exporting capacity, as well as for the availability of crude oil and products for markets. For this reason, significant interregional logistical developments have a major impact on oil flows and are considered among the key inputs in the modelling of global trade movements.

Both crude oil and product movements are impacted and influenced by trade infrastructure. Developments in land-based infrastructure – mainly pipelines and, to a lesser extent, rail systems – affect both short- and long-distance inland and marine movements. International market access and export flexibility are especially impacted by infrastructure development, including long-distance pipelines, coastal terminals and berthing capacity for shipments of crude oil, refined products and other liquid hydrocarbons.

Certain regions require continuous attention because of their potential to alter interregional crude trade. This applies especially to China, the Middle East, Russia & Caspian, along with the US & Canada. Over the past year or so there have also been new developments in Europe, stemming from recent geopolitical uncertainties.

6.1.1 US & Canada

The US & Canada has entered a period of modest crude oil production growth. This, coupled with the completion of several major infrastructure projects over the past few years, has seen the region enter a period of sufficient takeaway and export capacity that can accommodate future growth.

The biggest threat to takeaway capacity still stems from public resistance and political opposition, which occasionally leads to legal challenges to already operating capacity and new projects. Energy security concerns mean that the chances of existing infrastructure being shut down are lower than in previous years, but the threat nevertheless remains that an unexpected court ruling could change the infrastructure situation overnight.

US

Despite the cancellation of several oil infrastructure projects, and due to setbacks to US production in recent years, the rapid build-out of pipeline capacity over the past few years has left the US with ample takeaway capacity. This is especially the case regarding the Permian/

Eagle Ford Basins and from Cushing to the Gulf Coast. Even allowing for a relatively robust recovery in US tight oil production (see Chapter 4), the Permian/Eagle Ford takeaway capacity – now close to 8 mb/d – should be sufficient, with arguably no new pipeline projects required to handle Permian production.

The Biden Administration has approved plans to build the largest oil export terminal on the US Texas Gulf Coast. The Sea Port Oil Terminal in Texas will add capacity of more than 2 mb/d. According to the operator, Enterprise Product Partners, the terminal could be operational in late 2026 or early 2027, which represents a delay from the initial plan of 2025.

Elsewhere, several regulatory developments and uncertainties are pending related to various pipelines that could affect operations. For example, a federal court decision ordering the 750 tb/d Dakota Access pipeline out of the Bakken region to shut down marked the first time ever that an existing pipeline had been ordered to do so. However, subsequent court rulings from 2022 allowed for the continued operation of the pipeline until reviews are completed. The environmental review will now be completed in late 2024 or 2025. Of note, the Bakken region has enough rail capacity – estimated at 1 mb/d – to transport Bakken production and mitigate any potential pipeline problems, particularly if Dakota Access is shut down.

Given that adequate takeaway capacity exists for the major US producing basins, and that new projects are subject to costly litigation, it is likely that the era of new large-scale pipeline projects in the US is over. Instead, most future capacity expansion is likely to be made up of smaller-scale enhancements and the de-bottlenecking of existing infrastructure. Ultimately, given the high costs and uncertain timing of new pipeline projects, producers are likely to be more willing to rely on rail to clear the marginal production from any given region.

Canada

Canada's main pipeline project, the Trans Mountain Pipeline Expansion, was officially commissioned in early May 2024. The project has added 590 tb/d of capacity to the existing pipeline, increasing its total capacity to 890 tb/d. The project faced numerous delays and significant cost overruns, but first shipments have already commenced. This project will enable Canada to export crude to the US West Coast, as well as open-up international export markets, especially the Asia-Pacific (including China). In March 2024, for example, China's Sinochem purchased a cargo of Canadian Access Western Blend for August 2024 loading.

The pipeline will also help to reduce the price differentials of Canadian crude in the future, which was observed at substantial discounts of up to \$30/b in November 2022. The commissioning of the pipeline has already contributed to the narrowing of the differential, which was observed at around \$12/b in early May 2024. Nevertheless, some infrastructural obstacles remain to be overcome. For example, due to loading limitations at the port of Burnaby, transpacific flows could be less profitable than otherwise. This has prompted the exploration of options such as ship-to-ship and co-loading with Latin American grades.

It is also important to note that in late 2023, the Michigan Public Service Commission approved the Line 5 replacement project. Line 5 has a capacity of 540 tb/d and carries crude oil and NGLs from Western Canada to the US Midwest and Ontario. The approval related to federal permits for a new 8 km tunnel to replace an existing exposed section of the ageing underwater line. However, this approval represents only one of several steps necessary to construct the replacement project and a number of permitting approvals must

still be obtained. One crucial step is the Environmental Impact Statement process for the replacement of the pipeline tunnel, which is slated to be completed by 2026, a year later than previously estimated.

6.1.2 Other regions

In Kazakhstan, the Caspian Pipeline Consortium has completed its maintenance and de-bottlenecking programme that began in 2019. This will help to increase the transport capacity of the CPC pipeline. The capacity of the Russian section of the pipeline has been increased to roughly 1.8 mb/d, up by almost 25%, while the Kazakh section of the pipeline is now at 1.5 mb/d, up by around 11%.

In Argentina, the expectation of rising crude and condensate output in the medium and long term has consequently led to a rising need for export infrastructure. Currently, there are plans to construct pipeline infrastructure that would help to bring crude supplies from the Vaca Muerta Sur to an export terminal in the Atlantic in Rio Negro province. Preliminary plans see additional pipeline capacity of around 250 tb/d in 2026, with a potential later expansion taking it to 800 tb/d by 2030. In addition, there are plans to double the takeaway capacity of the existing Oldelval pipeline to around 600 tb/d in 2025. Thus, taking current plans and discussions into account, the potential takeaway capacity from Vaca Muerta could reach 1.4 mb/d by the end of this decade. Furthermore, Argentina plans to construct a deepwater port in Sierra Grande, on the Atlantic Coast, which could accommodate VLCCs.

In Uganda, a FID on the East African Crude Oil Pipeline from Uganda to the Tanzanian coast has still to be made. Related costs stand at an estimated \$5 billion, with the first phase of the project potentially due to start in 2024. The support of China and Chinese companies is crucial for this project, and Chinese President Xi Jinping has also expressed his support. The FID on the pipeline will determine the startup of Ugandan crude oil production, in which TotalEnergies, CNOOC and Ugandan and Tanzanian oil companies are the main shareholders.

6.1.3 Shipping

The international tanker market is influenced by the interplay of several important drivers. These include global oil (crude oil and products) supply and demand, as well as regional refining trends (e.g. refining capacity expansions and closures). At the same time, the tanker market is driven by available transportation capacity. This is primarily linked to the supply of new vessels, which is to some extent offset by the scrappage of old ships from the fleet. Global oil trade flows and the tanker market are also heavily influenced by geopolitics. Finally, environmental issues and environmental, social and governance (ESG) standards can influence the international tanker market, with market participants increasingly looking to reduce their carbon footprint and book more energy efficient ships for their cargoes.

In recent years, most of these drivers have been bullish, ultimately leading to a tighter tanker market. The increase in oil supply and demand since 2020 has boosted the demand for shipping capacity. Rising demand in the Asia-Pacific has attracted more imports from all exporting regions. This also led to rising average sailing distances, partly due to rising exports to the Asia-Pacific from North and Latin America.

The global tanker market gained additional strength in 2022 due to geopolitics, specifically following the start of the conflict in Eastern Europe. The EU's embargo on imports of Russian

crude oil and products led to a realignment of global crude oil and product flows, with new and significantly longer trade routes emerging. This has led to growth in the average sailing distance and higher tonne-mile demand. Furthermore, recent disruptions and attacks on ships in the Red Sea have led to a significant decline in Suez Canal transits. Consequently, this has resulted in the increased rerouting of ships around the Cape of Good Hope, thus further increasing average sailing distances.

Looking at tanker availability, the crude tanker fleet's total capacity is expected to increase only marginally (around 0.5%) in 2024, following several previous years of low-capacity growth. This is the result of a relatively small number of additions to the fleet, in combination with the scrappage of old vessels. In 2025, the global crude tanker fleet is only set to grow by around 1% for similar reasons.

Some positive news is that rising tanker industry revenues will likely be used for reinvestment into new builds and more capacity is expected from 2026 onwards. However, anticipated tanker capacity additions are still not in line with the possible scrappage of old vessels. In the case of very large crude carriers (VLCCs), almost 30% of the fleet is more than 15 years old, while new VLCCs on the order book account for only 2% of the total fleet. This could limit net capacity additions in the coming years and provide support to freight rates.

The product tanker fleet outlook looks somewhat more optimistic. Relative to the years prior, it is expected to exhibit stable growth in 2024, at around 2%. Based on orderbooks, this could rise to up to 5% in 2025. Similarly to dirty tankers, however, there is a significant share of older tankers in the product fleet, which could be scrapped from 2025 onwards.

In the years ahead, limited shipping capacity expansion and rising oil trade are likely to provide strong support for the freight market. This is especially the case for crude and condensate trade, which is likely to increase strongly in the medium term. The average sailing distance is also likely to increase given rising crude and condensate volumes from Latin America and the US & Canada destined for the Asia-Pacific. Moreover, in line with stricter environmental requirements, demand for younger and more energy efficient ships is rising, which may produce more upside pressure on freight rates.

The shipping sector is crucially important for the functioning of the global oil market. Any disruptions related to shipping can cause imbalances and have severe consequences on crude oil and product prices. This is why timely investments in the shipping sector are vital, if capacity shortages are to be avoided and stability preserved.

6

6.2 Crude oil, condensate and refined product movements

The integrated global downstream sector relies on the ability to move crude oil, condensates, refined products and various intermediate streams within, and between, countries and regions. This is generally driven by economics, long-term interests, and in some cases geopolitics. Downstream infrastructure (pipelines and shipping capacity) enables downstream market participants to move large amounts of oil liquids between almost any two regions of the world, over short and long distances, via a variety of transport modes.

These interregional movements enable adequate physical supply, as well as trade and competition between different suppliers, as they respond to price signals between regions.

The ability to move crude oil and products also helps to avoid short-term shortages of fuel in specific regions at any given time. For example, the market's ability to respond to price signals and swiftly deploy tankers or other logistics can help offset shortages caused by weather-related issues, as has been shown in the past.

Various factors affect the direction and volume of crude and condensate, as well as product trade movements. These involve: oil demand trends, including seasonal changes; the production and quality of crude and non-crude streams; product quality specifications and related changes; refining sector availability and configurations; potential trade barriers or policy-driven incentives; the capacity and economics of existing transport infrastructure, such as ports, tankers, pipelines and railways; ownership interests; term contracts; crude and product price levels and differentials; freight rates; and, at times, geopolitics. In fact, there is never only one factor influencing petroleum flows, rather a combination of several at the same time.

The downstream sector and its development are key elements in this regard. Based on the economics of oil movements and refining, there is a general preference to locate refining capacity in consuming regions due to lower transport costs for crude oil compared with oil products.

Strategic reasons, including those related to security of supply, also play a role. Recent trends in the downstream sector confirm this, as the majority of refining capacity additions in recent years have materialized in developing regions with strong oil demand growth, led by the Asia-Pacific. The refining outlook (Chapter 5) shows a continuation of this trend in the long term. As a result, crude and condensates account for most of the trade, especially over long distances. However, refining hubs in developed countries with highly complex plants, such as in the US, are competing increasingly in the international product market, in line with slower domestic demand growth and available feedstock at competitive prices.

Furthermore, for producing and consuming countries alike, there is an emphasis on securing refined product supply through domestic refining rather than imports, regardless of economic factors. For producing countries, there is the additional consideration of seeking to increase domestic refining capacity in order to cover domestic demand and also benefit from the export of value-added products beyond crude oil. Benefits for the local economy, including labour markets, also serve as a motivation for building refining capacity.

Given the considerations highlighted, oil movements are not always the most economical or efficient in terms of minimizing overall global costs. In contrast, movements generated in the models used for this Outlook are based on an optimization procedure that seeks to minimize global costs across the entire refining/transport supply system, in accordance with existing and additional refining capacity, logistical options and costs.

Generally, few constraints are applied to crude oil and product movements in the modelling approach, especially in the longer term, for which it is impossible to anticipate what the ownership interests and policies of individual companies and countries might be. The differences between short-term market circumstances, such as constraints resulting from ownership interests and term contracts, and a longer-term modelling approach, with few restrictions on movement and that operate to minimize global costs, mean it is necessary to recognize that model-projected oil movements cannot fully reflect short-term factors. Therefore, they may project oil trade patterns that are not direct extensions of those that occur today.



Nevertheless, the model-based results presented in this section provide a useful indication of future crude oil movement trends, which necessarily function to resolve regional supply and demand imbalances for both crude and products. Of course, these projections are dependent on several assumptions used in this Outlook, which, if altered, could materially affect projected movements.

Key elements in the model-based projections are the volumes and qualities of both crudes produced and products consumed by region, and how these change over time. Another element is the location and capability of refining capacity. Over the longer term, the relative economics of building new refinery capacity in different regions, and the ability of existing refineries to export and compete against imports, all affect the trade patterns of crude and refined products. There is also an interplay between freight and refining costs (capital and operating costs). Broadly speaking, higher freight rates tend to curb interregional trade and encourage more refining investment, while lower freight rates tend to enable greater trade and competition between regions and provide more opportunity to export products for regions with spare refining capacity.

This approach alone, however, is not well suited for modelling and estimating the impact of geopolitics on oil trade. The conflict in Eastern Europe has readjusted global oil trade flows since early 2022. New trade links have been established, while some old ones have discontinued. The EU, UK and US have introduced an oil embargo on Russian oil imports. Nevertheless, due to traded volumes, the EU's embargo has by far the largest impact. It became effective from late 2022, albeit with some exemptions in the EU, which are still valid and relate to pipeline supplies of Russian crude to landlocked refineries in Central Europe.

In 2023, Russian oil exports to the EU plunged. From around 2.3 mb/d in 2021, the EU imported only 0.2 mb/d of Russian crude in 2023. On the refined product side, the EU's imports from Russia were estimated at around 1 mb/d in 2021, but fell to around 0.1 mb/d in 2023. The EU turned to imports of additional barrels from other regions, including the US & Canada, Africa, the Middle East and the North Sea (e.g. Norway).

At the same time, Russian oil producers managed to reroute a large part of their exports to other destinations, especially to India and China. Similarly, Russian refiners successfully rerouted their exports of refined products, including to destinations in Europe outside of the EU, Africa, the Middle East and Latin America. This has been possible due to hefty discounts on Russian crude and product barrels.

It is important to note that this reshuffling was the result of geopolitical developments rather than economics. In this context, the Reference Case cannot fully mirror the downstream modelling results because they are based on an optimization procedure, but it is important nevertheless to reflect geopolitical realities.

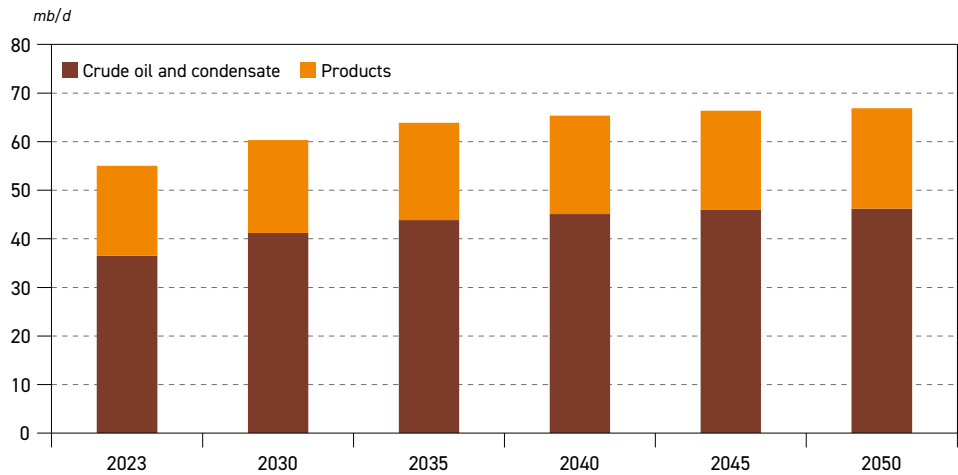
This Outlook maintains the view that the EU's oil embargo will have lasting consequences. This means that Europe will likely see higher crude oil inflows from other regions compared to recent years. Nevertheless, it also assumes that parts of Europe that are not in the EU will continue to import some Russian crude in the medium to long term, although a high degree of uncertainty remains.

It is important to note that the regional definition underlying this Outlook sees Europe as one region (including the EU, as well as other European countries). Russia, on the other hand, is

part of a larger Russia & Caspian region, which includes large oil producers like Kazakhstan and Azerbaijan. This should be considered when referencing this Outlook.

Figure 6.1 illustrates global interregional trade for crude oil, condensates, and products in the period from 2023–2050. Only trade between major regions is shown, which means that any intra-trade movements are not included.

Figure 6.1
Interregional crude oil, condensate and products exports, 2023–2050



Source: OPEC.

Global trade in 2023 was estimated at around 55 mb/d, representing a slight increase relative to 2022. By 2030, global interregional oil trade is projected to see a significant increase to above 60 mb/d. This is the result of increasing oil demand, especially in developing regions, led by the Asia-Pacific. The trend is expected to continue after 2030, with total oil trade reaching almost 64 mb/d in 2035 and 65.5 mb/d in 2040.

In the last decade of the outlook period, total oil trade growth is set to witness a slowdown and reach levels just below 67 mb/d in 2050. This is due to a drop off in global oil demand growth, as well as the increased domestic use of crude in some developing countries (e.g. Africa), which reduces export volumes.

Crude and condensate trade was assessed at 36.5 mb/d in 2023 and due to strong oil demand growth and rising refining capacity in some importing regions (mostly developing countries), it is expected to reach 41.2 mb/d in 2030. The growth is anticipated to increase further in the long term, although at a slower pace. This is in line with growing demand in the Asia-Pacific, which more than offsets lower importing needs in Europe. Global interregional crude and condensate trade is projected to rise to around 45 mb/d in 2040 and increase further to 46.2 mb/d in 2050.

Interregional crude oil and condensate trade accounted for around 66% of the total oil trade in 2023. This share is expected to increase gradually in the long term and reach levels of almost 70% in 2050.

Interregional oil product trade is set to increase marginally from 18.5 mb/d in 2023 to around 19.2 mb/d in 2030. Refining capacity expansion and rising throughputs in these regions will limit the



need for importing volumes of products. In the longer term, the global product trade is expected to increase gradually, reaching levels just above 20.5 mb/d in 2050. This will be driven by rising exports from the Middle East, the US & Canada and higher imports to the Asia-Pacific. This is in line with assumptions related to long-term refining capacity expansions that are presented in Chapter 5, which occur mostly in developing countries. Of note, slower-than-expected refining capacity expansion would necessarily result in higher product trade volumes in the long term.

6.3 Crude oil and condensate movements

This section discusses global crude and condensate supply developments by downstream regions, as defined in Annex B. This is fully in line with projections provided in Chapter 4. Crude and condensate supply developments explain changes in long-term trade movements. The trade movements are discussed later in this section, with a focus on the main exporting and main importing regions.

Crude oil and condensate supply

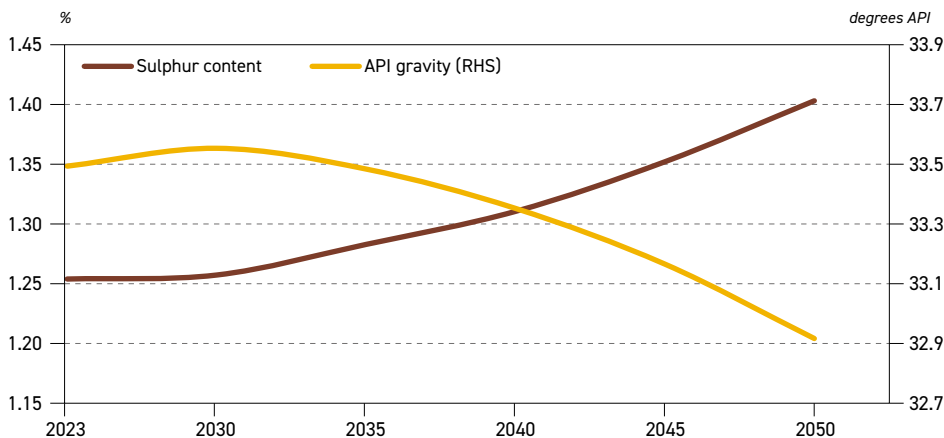
The analysis below relates only to crude and condensates, which includes oil sands and synthetic crudes, but excludes any other liquids, such as biofuels, synthetic fuels, CTLs, GTLs and NGLs.

In the period to 2030, crude and condensate supply is projected to increase strongly, rising by nearly 7.5 mb/d. This is driven by growth in four regions – the Middle East, Latin America, the US & Canada and Africa.

In the period 2030–2050, global crude and condensate supply is expected to increase by a further 2.5 mb/d. This growth is the result of strong supply expansion in the Middle East and Latin America, which more than offsets declines in several other regions, including the US & Canada, Asia-Pacific and Europe.

In line with changes in the global crude and condensate supply, the quality of the average barrel will gradually change (Figure 6.2). With an expected higher supply of light-sweet barrels from

Figure 6.2
Global average API gravity and sulphur content



Source: OPEC.

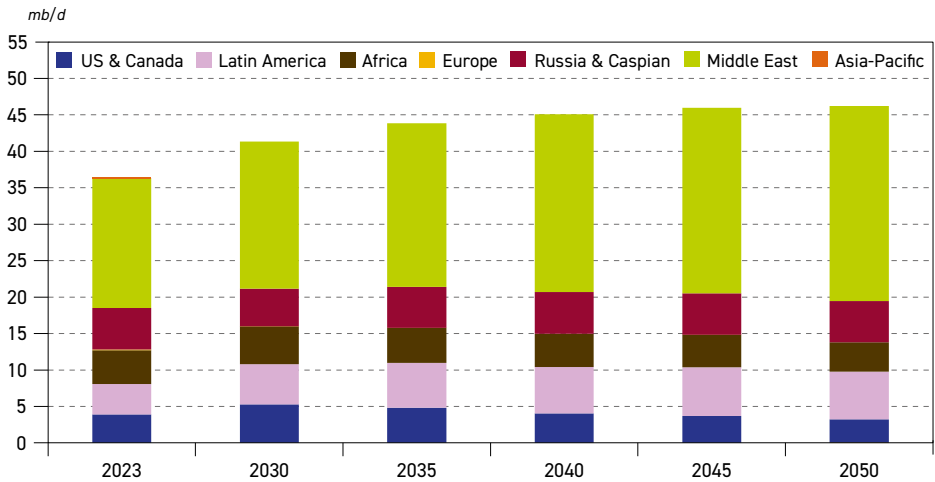
the US, Latin America and the Caspian, the average API gravity is set to increase from around 33.5° API in 2023 to 33.6° API in 2030. However, a US tight oil supply peak, a declining supply of light-sweet grades in the Asia-Pacific and a rising share of medium and heavy crude in the global crude supply (from the Middle East, Canada and Latin America) is anticipated to change the average API gravity, causing it to sink gradually towards 32.9° API by 2050.

At the same time, the average sulphur content is expected to remain stable at around 1.25% between 2023 and 2030. It is then expected to increase gradually to 1.4% in 2050, underlining the rising share of high sulphur supplies from the Middle East, Latin America and Canada.

Crude oil and condensate movements

In Figure 6.3, global crude oil and condensate exports by major exporting region are shown. As per the definition, only movements between these major regions are considered, while intra-trade movements are not included. Total crude oil and condensate trade volume in 2023 was estimated at around 36.5 mb/d in 2023, only slightly above 2022 levels. Interregional trade is expected to increase to 41.2 mb/d by 2030 on the back of strong oil demand growth. After 2030, crude and condensate trade is expected to continue increasing further, though at a slower pace, reaching levels of around 46.3 mb/d by 2050. The growth in the long term is driven mostly by rising oil demand in developing regions (mostly the Asia-Pacific) and declining local supply in oil-importing regions such as the Asia-Pacific and Europe.

Figure 6.3
Global crude and condensate exports by origin*, 2023–2050



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

Crude and condensate exports from the Middle East are expected to increase throughout the outlook horizon. Starting at around 17.8 mb/d in 2023, exports from the Middle East are projected to reach 20.2 mb/d in 2030 and rise further to almost 24.5 mb/d in 2040. Export growth from this region is then expected to slow a little in the last decade, reaching levels of nearly 27 mb/d in 2050. An overall increase in Middle East crude and condensate exports is estimated at just over 9 mb/d between 2023 and 2050.



Latin America's crude and condensate exports are projected to increase strongly, supported by rising supply in the region over the entire outlook period. Total crude and condensate exports were estimated at around 4.2 mb/d in 2023 and are projected to reach 6.7 mb/d by 2045, an increase of 2.5 mb/d. Due to expected higher local crude use and peaking supply in this region, crude and condensate exports are set to decline slightly towards the end of the outlook period, reaching 6.5 mb/d in 2050. By 2030 already, Latin America is expected to become the second largest crude and condensate exporting region with total outflows of around 5.5 mb/d, overtaking other regions such as Russia & Caspian and Africa.

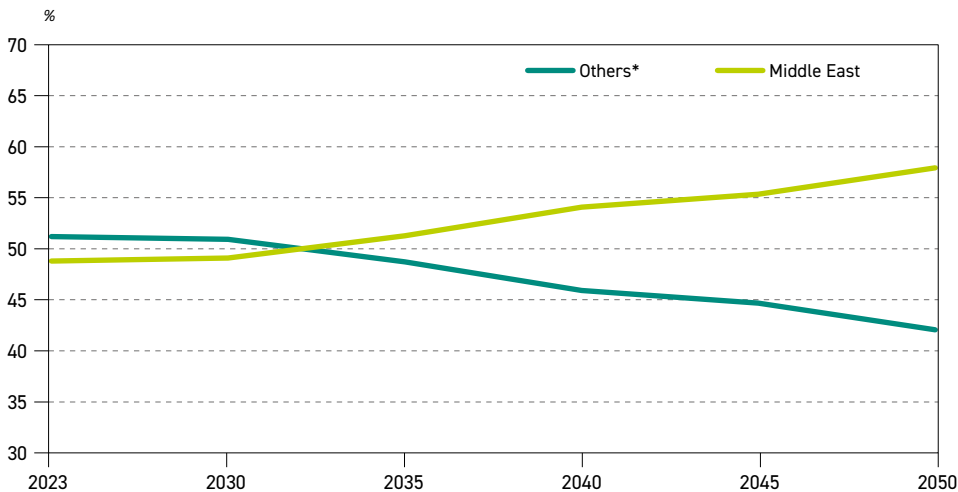
Crude and condensate flows from Africa are conditioned not only by supply trends, but also by the expected increase in the domestic use of crude. Under the assumption that domestic crude use in Africa rises strongly in line with increasing refining capacity, crude and condensate exports are expected to peak around 2030 at around 5.2 mb/d, followed by a gradual decline to 4 mb/d in 2050. Overall, crude and condensate exports from Africa are expected to decline by around 0.6 mb/d over the outlook period.

Exports from Russia & Caspian are projected to decline from around 5.7 mb/d in 2023 to 5.2 mb/d in 2030. Exports are expected to recover gradually, thereafter, mostly due to rising supply and declining domestic crude use in this region. In 2050, total crude and condensate exports from Russia & Caspian are estimated at 5.6 mb/d, only slightly under 2023 levels.

Crude and condensate exports from the US & Canada are projected to increase from 3.9 mb/d in 2023 to 5.3 mb/d in 2030 on the back of rising supply. However, following a peak in US tight oil supply around 2030, total crude and condensate exports are expected to decline gradually in the long term, reaching just over 3.2 mb/d by 2050.

Global crude and condensate exports are heavily dominated by the Middle East, with its share standing at almost 49% in 2023 (Figure 6.4). Due to a strong increase in crude and condensate exports from Latin America and the US & Canada, the Middle East's share is expected to

Figure 6.4
Middle East share in global crude and condensate trade, 2023–2050



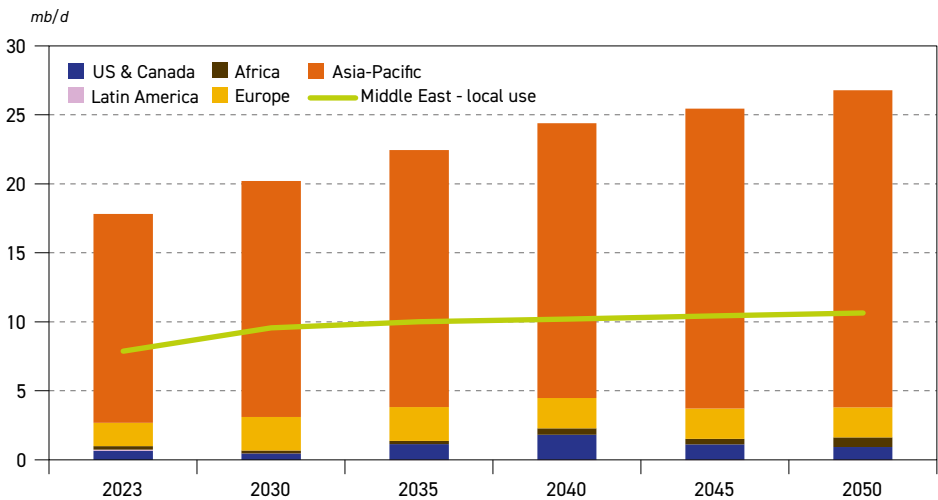
* Including Latin America, Russia & Caspian, Africa and the US & Canada.

Source: OPEC.

increase only marginally by 2030. However, in the post-2030 period, the Middle East's share in the total export mix is projected to rise by almost 10 pp to 58% by 2050. This is in line with the aforementioned strong increase in exports from the Middle East, combined with declines in other regions such as Africa and the US & Canada.

Middle East crude and condensate exports by destination are shown in Figure 6.5. Total export volumes are expected to increase throughout the outlook period, from 17.8 mb/d in 2023 to 26.8 mb/d in 2050. Flows to the Asia-Pacific account for the highest share of exports from the Middle East, above 80% throughout the outlook period. Driven by rising demand, crude and condensate exports to the Asia-Pacific from the Middle East are expected to increase from around 15.1 mb/d in 2023 to 23 mb/d in 2050.

Figure 6.5
Crude and condensate exports from the Middle East by major destination, 2023–2050



Source: OPEC.

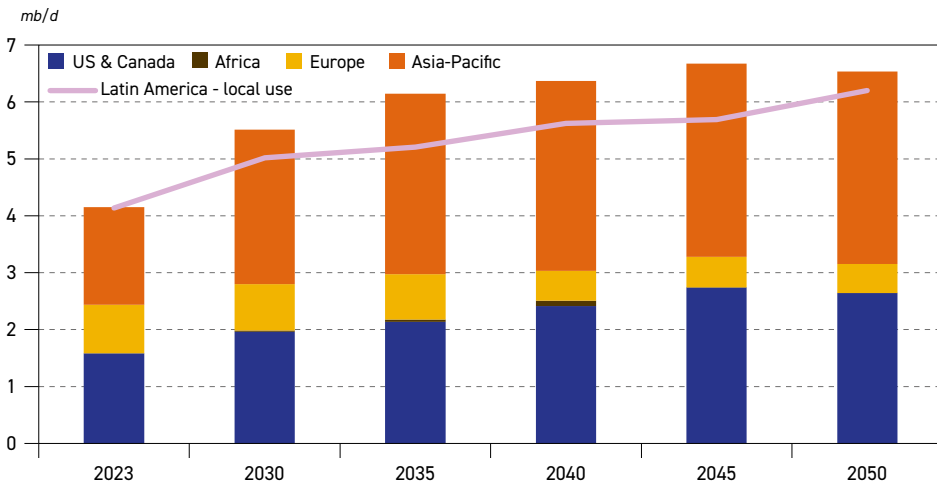
Middle East crude and condensate flows to Europe are set to increase from 1.7 mb/d to 2.4 mb/d in the period 2030–2035, partly replacing Russian exports to the EU. In the period after 2035, however, exports are expected to drop and remain stable at around 2.2 mb/d due to declining demand in Europe. Exports to the US & Canada are anticipated to increase from around 0.6 mb/d in 2023 to 1.8 mb/d in 2040, as medium-sour barrels from the Middle East fit well into the US refining configuration. Nonetheless, flows are projected to decline gradually to 0.9 mb/d in 2050 due to falling demand in the US & Canada and a higher supply of Canadian heavy crude.

Minor exports from the Middle East to Africa are expected, increasing from around 0.3 mb/d in 2023 to almost 0.6 mb/d in 2050, reflecting strong oil demand growth in Africa over the outlook period. Finally, local crude use in the Middle East is projected to increase from around 7.9 mb/d in 2023 to 10 mb/d in 2035. This is in line with rising refining capacity in the Middle East, increasing local demand and rising product exports. In the longer term, local crude use in the Middle East is projected to increase marginally, reaching 10.6 mb/d by 2050.

Figure 6.6 highlights crude and condensate exports from Latin America, with total volumes increasing strongly due to robust supply growth (see Chapter 4). Exports from Latin America



Figure 6.6

Crude and condensate exports from Latin America by major destination, 2023–2050

Source: OPEC.

are set to increase from 4.2 mb/d in 2023 to 6.7 mb/d in 2045, before dropping marginally to 6.5 mb/d in 2050.

The majority of crude and condensate exports from Latin America are expected to go to the US & Canada and the Asia-Pacific. Exports to the US & Canada were assessed at 1.6 mb/d in 2023, with a gradual increase towards 2.1 mb/d in 2035 and further to around 2.7 mb/d from 2045 onwards. Given its heavy and medium grades, which fit the US refining system, as well as its proximity, the region favours crude and condensate flows to the US & Canada.

Crude and condensate exports from Latin America to the Asia-Pacific are set to see a significant increase from 1.7 mb/d to 2.7 mb/d in 2030 and further to 3.3 mb/d in 2040. Exports to the Asia-Pacific are expected to remain around this level in the last decade of the outlook. Exports from Latin America to Europe are anticipated to remain stable at levels of around 0.8 mb/d between 2023 and 2035. Following the oil demand decline in Europe in the long term, flows of crude and condensate from Latin America are set to sink to around 0.5 mb/d between 2040 and 2050.

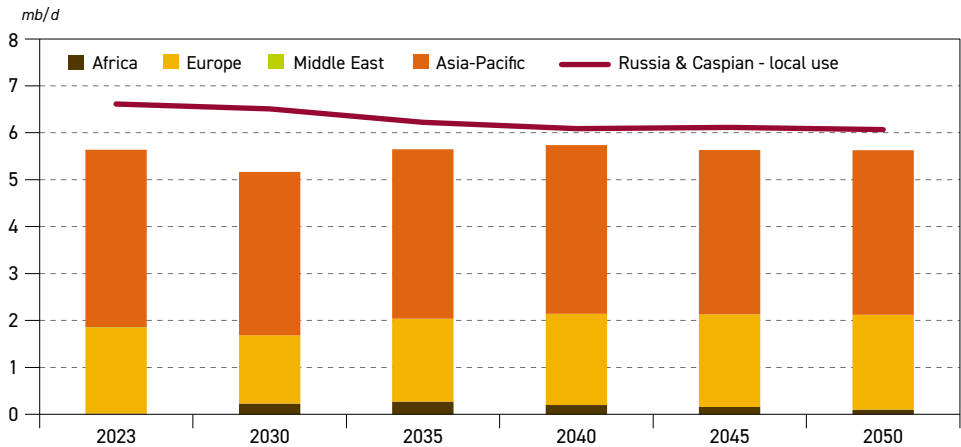
Local crude use in Latin America is set to increase from 4.1 mb/d in 2023 to around 5.2 mb/d in 2035 and further to 6.2 mb/d in 2050. This reflects higher refinery throughputs in this region, which helps to meet the region's rising oil demand.

Crude and condensate exports from Russia & Caspian are shown in Figure 6.7. Total exports are expected to decrease somewhat initially. In the long term, exports are set to recover in line with rising supply, as well as declining local crude use. They reach levels of around 5.6 mb/d from 2045 onwards.

Exports of crude and condensates to Europe are initially seen to decline from around 1.8 mb/d in 2023 to 1.5 mb/d in 2030. This will be followed by a gradual increase in the long term to reach levels around 2 mb/d from 2045 onwards. Nevertheless, this is still significantly lower than the levels seen before the start of the conflict in Eastern Europe and subsequent EU embargo on Russian crude oil imports.

Figure 6.7

Crude and condensate exports from Russia & Caspian by major destination, 2023–2050



Source: OPEC.

Exports of crude from Russia & Caspian to the Asia-Pacific increased significantly in 2023 based on a rerouting of Russian export barrels from Europe. Around 3.8 mb/d of crude and condensates from Russia & Caspian were exported to the Asia-Pacific in 2023, which was almost 1 mb/d higher compared to 2022. Throughout the outlook period, flows of crude and condensate from Russia & Caspian to the Asia-Pacific are seen at levels around 3.5 mb/d. Limited flows of crude and condensate from Russia & Caspian to Africa are projected, but these flows are not expected to reach levels above 0.3 mb/d.

Local crude use in Russia & Caspian is seen declining gradually from 6.6 mb/d in 2023 to 6.1 mb/d in 2040, before remaining stable out to 2050. Lower local crude use is in line with higher competition in the global downstream market and lower product exports from this region.

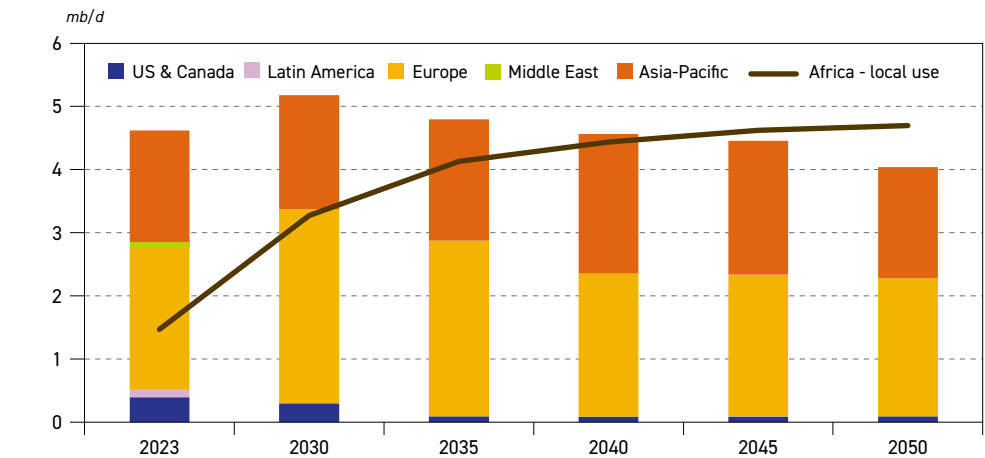
Figure 6.8 illustrates crude and condensate exports from Africa. After an initial increase from 4.6 mb/d in 2023 to 5.2 mb/d in 2030 due to higher supply, overall export volumes are expected to decline gradually towards 4 mb/d in 2050. This is mostly due to higher local use of crude and condensate and is in line with projected rising refining capacity and refinery throughputs in this region. Overall, local crude use in Africa is expected to rise from around 1.5 mb/d in 2023 to 3.3 mb/d in 2030. In the longer term, local crude use is expected to increase further given higher refinery throughputs, reaching levels of around 4.7 mb/d by the end of the outlook period.

The main destination for crude and condensate exports from Africa is Europe. Flows are projected to increase from 2.3 mb/d in 2023 to 3.1 mb/d in 2030, in line with rising supply from Africa. Furthermore, Europe's shift away from Russian crude contributes to rising flows of African crude in this period too. However, African exports of crude to Europe are expected to decline gradually after 2030, reaching around 2.2 mb/d by 2050, which is mostly due to declining European demand.

Africa's crude and condensate exports to the Asia-Pacific are expected to remain stable between 2023 and 2030 at around 1.8 mb/d. Following declining exports to Europe, Africa is expected to increase outflows to the Asia-Pacific, reaching around 2.2 mb/d in 2040. However, as domestic crude use in Africa keeps increasing in the long term, exports to the Asia-Pacific are projected to decline to 1.8 mb/d in 2050.



Figure 6.8
Crude and condensate exports from Africa by major destination, 2023–2050

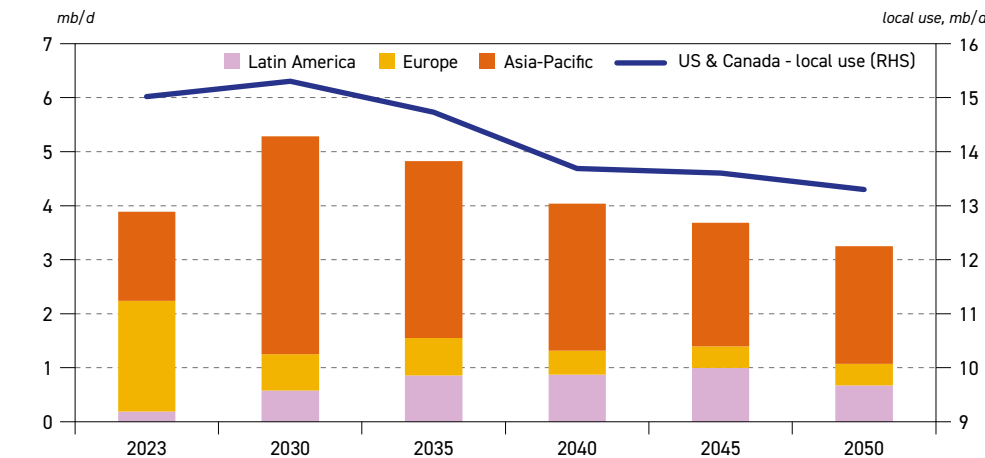


Source: OPEC.

Minor flows of African crude and condensate to the US & Canada are expected. From around 0.4 mb/d in 2023, these flows are set to drop to 0.3 mb/d by 2030 before declining further to negligible volumes thereafter.

The US & Canada exported nearly 4 mb/d of crude and condensate during 2023, an increase of around 0.6 mb/d relative to 2022. Exports increased further in early 2024, reaching levels above 4 mb/d. Exports consist predominantly of light-sweet US barrels, which are a good fit for markets driven by gasoline and petrochemicals, especially the Asia-Pacific. Total crude and condensate exports from the US & Canada are expected to reach 5.3 mb/d by 2030 (Figure 6.9), in line with the region's rising supply. However, following a peak and gradual

Figure 6.9
Crude and condensate exports from US & Canada by major destination, 2023–2050



Source: OPEC.

decline in US tight oil output, crude and condensate exports from the US & Canada are set to drop gradually and reach levels of around 3.2 mb/d by 2050.

In 2023, the main destination for barrels from the US & Canada was Europe, with exports of around 2 mb/d. This represented an increase of around 0.4 mb/d compared to 2022. However, the increase in exports from the US & Canada can be partially explained by the EU's efforts to replace missing barrels, following its embargo on Russian crude imports. In the long term, these exports are expected to decline to levels around 0.7 mb/d in 2030 and 2035, before dropping further to between 0.4 mb/d and 0.5 mb/d for the remainder of the outlook period. This is due to the European refining sector generally being geared towards diesel production, which is not the best match for US light-sweet feedstock.

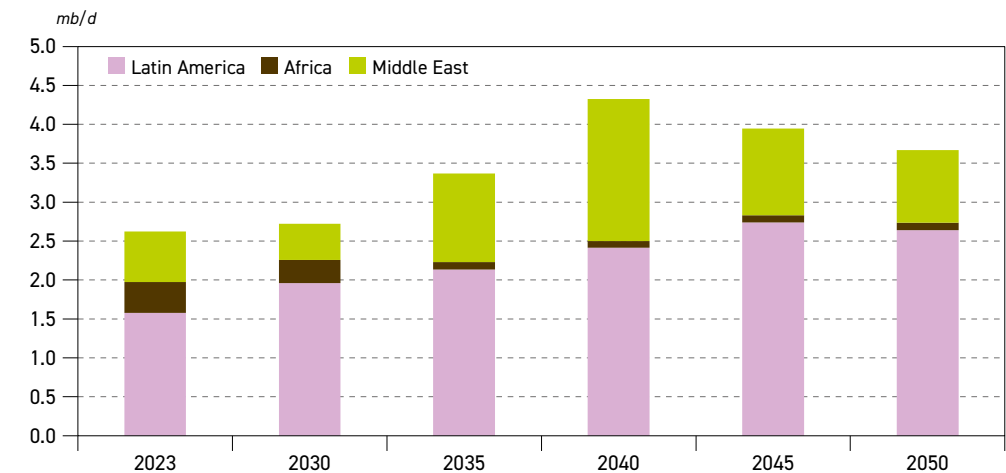
Exports from the US & Canada to the Asia-Pacific are projected to rise from 1.7 mb/d in 2023 to 4 mb/d in 2030. This is in line with demand patterns in the Asia-Pacific and given the large number of refineries with petrochemical integration. In addition, the startup of the Trans Mountain pipeline will allow for exports of Canadian heavy crude to international markets, including the Asia-Pacific, which is its main target. Flows to Asia are set to decline gradually after 2030 and reach 2.2 mb/d in 2050, in line with declining supply.

Limited exports from the US & Canada to Latin America are also projected. These volumes are expected to increase from 0.2 mb/d in 2023 to almost 1 mb/d in 2045. Towards the end of the outlook period, shipments to Latin America are anticipated to drop to around 0.7 mb/d, in line with declining US supplies.

Local crude oil use in the US & Canada is projected to inch up from roughly 15 mb/d in 2023 to 15.3 mb/d in 2030. In the long term, however, local crude use is expected to drop to 13.3 mb/d by 2050, due to declining demand and lower refinery runs in the region.

In Figures 6.10, 6.11 and 6.12, crude and condensate imports for the three largest importing regions are shown, namely the US & Canada, Europe and the Asia-Pacific.

Figure 6.10
Crude and condensate imports to the US & Canada by origin, 2023–2050



Source: OPEC.



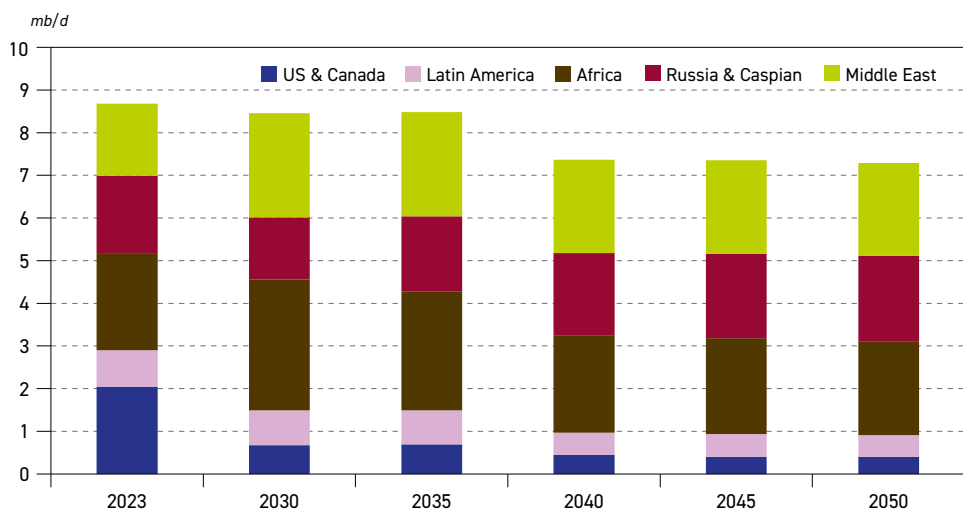
As shown in Figure 6.10, the US & Canada remains an important crude oil importer throughout the outlook period, due to the complexity of the region's refining system and composition of demand. In 2023, the US & Canada imported around 2.6 mb/d of crude oil and condensate, mostly from Latin America, but also from the Middle East and Africa. Imports are expected to grow gradually in the first part of the outlook period, reaching 4.3 mb/d in 2040. Due to an expected decline in demand, as well as a drop in refinery throughputs, imports are set to fall to around 3.7 mb/d in 2050.

Latin America is set to remain the main crude and condensate supplier to the US & Canada, with volumes continuously increasing throughout the outlook period. From around 1.6 mb/d in 2023, volumes are expected to rise to 2.1 mb/d in 2035 and further to around 2.7 mb/d from 2040 onwards. This is in line with rising supply expectations from Latin America, as well as the proximity of the regions, which serves to minimize transportation costs.

Exports from the Middle East to the US & Canada are set to increase from around 0.7 mb/d in 2023 to 1.8 mb/d in 2040. However, due to expected declining demand in the US & Canada, these flows are set to drop to around 0.9 mb/d in 2050. Finally, imports from Africa are projected to fall from 0.4 mb/d in 2023 to 0.3 mb/d in 2030 and then further to around 0.1 mb/d for the remainder of the outlook period.

European crude and condensate imports are shown in Figure 6.11. Due to falling oil demand and lower refinery runs in the region, total import volumes are set to decline from 8.7 mb/d in 2023 to 7.3 mb/d in 2050. Declining European domestic supply prevents imports from falling even lower in the long term.

Figure 6.11
Crude and condensate imports to Europe by origin, 2023–2050



Source: OPEC.

Europe sources its crude and condensate supplies from all major exporting regions. Following the EU's embargo on Russian crude imports, Europe's import mix has become much more diversified and less dominated by barrels from Russia & Caspian. Europe has managed to

replace Russian barrels by securing additional imports from the US & Canada, Africa and the Middle East. This Outlook maintains the view that Europe's import mix will remain diversified in the future too.

European crude and condensate imports from Africa are expected to increase from around 2.3 mb/d in 2023 to 3.1 mb/d in 2030, supported by rising African supply and the proximity of the two regions, which limits freight costs. After 2030, however, imports from Africa are expected to decline gradually to around 2.2 mb/d in 2050 due to lower European demand and the lower availability of African crude for exports.

Imports from the Middle East were assessed at around 1.7 mb/d in 2023. Flows from the Middle East to Europe are expected to rise to around 2.4 mb/d in 2030 and 2035, but drop in the longer term due to declining European demand. From 2040 onwards, imports from the Middle East are projected at levels around 2.2 mb/d.

European crude and condensate imports from Russia & Caspian are expected to decline from around 1.8 mb/d in 2023 to almost 1.5 mb/d in 2030. This mirrors a full discontinuation of Russian crude and condensate supply to the EU, although estimated levels in 2023 were still around 0.3 mb/d. In the long term, imports from Russia & Caspian are projected to increase somewhat (mostly additional volumes from non-Russian regions) and settle at around 2 mb/d from 2040 onwards.

Imports from the US & Canada increased to 2 mb/d in 2023, in line with EU efforts to replace Russian barrels. However, these flows are expected to decline significantly to around 0.7 mb/d by 2030, as US light-sweet supplies are not the desired crude for European diesel-gear refineries. In the long term, crude and condensate flows to Europe are expected to hover between 0.4 mb/d and 0.5 mb/d from 2040 onwards.

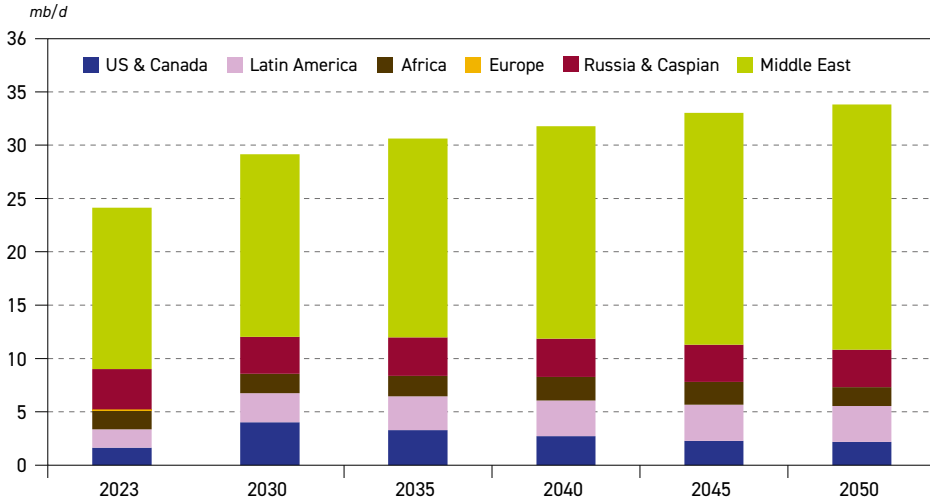
Finally, crude and condensate imports from Latin America are projected to remain at levels around 0.8 mb/d between 2023 and 2035, followed by a decline to around 0.5 mb/d for the remainder of the outlook period.

Figure 6.12 shows crude and condensate imports to the Asia-Pacific, which is by far the most significant importing region. Total import volumes reached levels around 24 mb/d in 2023 and are expected to increase significantly in the medium and long term. In 2030, imports are projected at 29.1 mb/d and are set to continue to rise to around 33.8 mb/d in 2050. This is predominantly due to increasing oil demand in the Asia-Pacific, as well as declining domestic supply from local ageing oilfields.

Flows from the Middle East to the Asia-Pacific are set to increase from 15.1 mb/d in 2023 to 17.1 mb/d in 2030. Imports are then expected to rise further in the longer term, reaching almost 20 mb/d in 2040 and 23 mb/d in 2050. Imports from the Middle East have by far the highest share in the import mix of the Asia-Pacific, standing at around 63% in 2023. This share is expected to decline somewhat in 2030, due to rising inflows of crude and condensate from other regions. However, the Middle East's share of total Asia-Pacific imports is expected to increase again and reach 68% by 2050.

Imports from Russia & Caspian to the Asia-Pacific reached record levels of around 3.8 mb/d in 2023. In the future, these flows are projected to stay at a level between 3.5 mb/d and 3.6 mb/d between 2030 and the end of the outlook period.

Figure 6.12
Crude and condensate imports to Asia-Pacific by origin, 2023–2050



Source: OPEC.

The US & Canada as a region is expected to become an increasingly important supplier of crude and condensate to the Asia-Pacific. From levels of around 1.7 mb/d in 2023, the Asia-Pacific is set to increase imports from the US & Canada to around 4 mb/d in 2030. This is predominantly expected to be US light-sweet tight oil crude, a good fit for Asian refiners that are geared towards maximizing gasoline and petrochemical feedstock production.

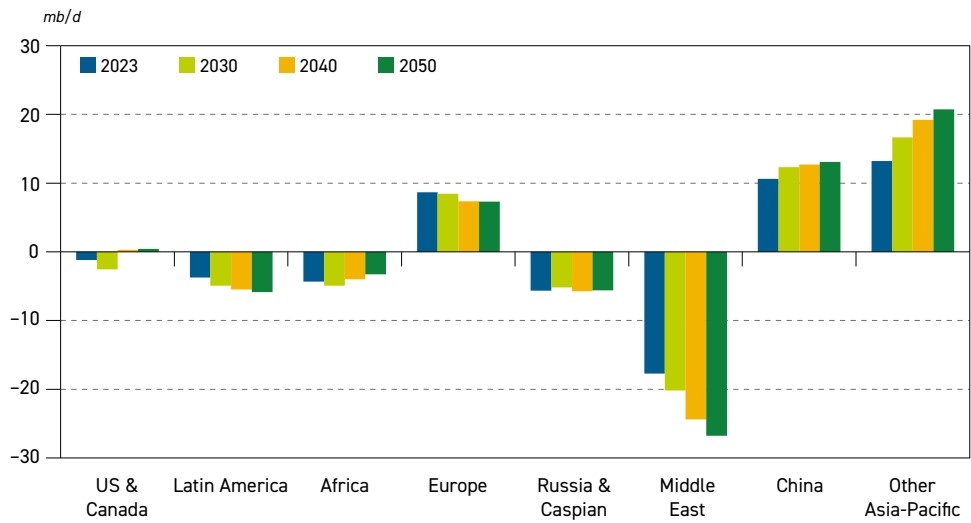
At the same time, some of these flows could be reserved for Canadian heavy barrels, following the commissioning of the Trans Mountain pipeline in mid-2024. In the longer term, total supplies from the US & Canada to the Asia-Pacific are expected to decline gradually towards 2.2 mb/d in 2050 due to declining US supply.

The Asia-Pacific is projected to significantly increase its imports of crude and condensate from Latin America, expanding from around 1.7 mb/d in 2023 to 2.7 mb/d in 2030, which reflects rising crude supply in Latin America. This will be followed by a more gradual increase to 3.4 mb/d in 2045 and 2050.

Crude and condensate shipments from Africa to the Asia-Pacific are expected to remain at levels around 1.8 mb/d between 2023 and 2030, followed by an increase to 2.2 mb/d by 2040. In the last ten years of the outlook period, imports from Africa are expected to decline to 1.8 mb/d due to the lower availability of African crude exports.

Regional net crude and condensate imports are shown in Figure 6.13. The largest increase in net imports is expected for Other Asia-Pacific (excl. China), with volumes rising from 13.2 mb/d in 2023 to 19.2 mb/d in 2040 and 20.7 mb/d in 2050. Net imports to China are also set to increase, predominantly in the medium term, and in line with demand trends. China's net imports are expected to increase from 10.6 mb/d in 2023 to 12.3 mb/d in 2030. This is expected to be followed by marginal increases, thereafter, to reach around 13.1 mb/d in 2050. Finally, European net imports are projected to decline gradually throughout the outlook period. From 8.7 mb/d in 2023, net import volumes are projected to drop to 7.3 mb/d by 2050.

Figure 6.13
Regional net crude and condensate imports



Source: OPEC.

On the net export side, the largest increment is observed in the Middle East, where net exports are projected to increase from 17.7 mb/d in 2023 to 26.8 mb/d in 2050. Net exports in Latin America are expected to rise from 3.7 mb/d in 2023 to 5.9 mb/d in 2050. Net exports from Russia & Caspian are set to drop from 5.7 mb/d in 2023 to 5.2 mb/d in 2030, followed by a gradual increase to 5.6 mb/d in 2050.

The US & Canada were net crude and condensate exporters in 2023, at around 1.2 mb/d. With rising domestic crude and condensate supplies, net exports are set to increase to 2.6 mb/d in 2030. Thereafter, however, these volumes are expected to drop gradually as the region becomes a net importer due to declining supply. At the end of the outlook period, the US & Canada is set to be a net importer of around 0.4 mb/d in 2050. Finally, in Africa, net exports are projected to see a temporary, medium-term increase from 4.3 mb/d in 2023 to 5 mb/d in 2030. However, this figure is set to decline to 3.3 mb/d in 2050, due to lower exports and higher domestic crude use.

6.4 Refined product movements

As already discussed, refined product movements between the seven major regions are significantly lower compared to interregional crude and condensate flows. This is due to the preference of consuming countries to increase domestic refining and import crude and condensates, and to benefit from lower transportation costs for crude and/or condensates relative to refined products. This is why the majority of refined products are produced and consumed within the respective regions.

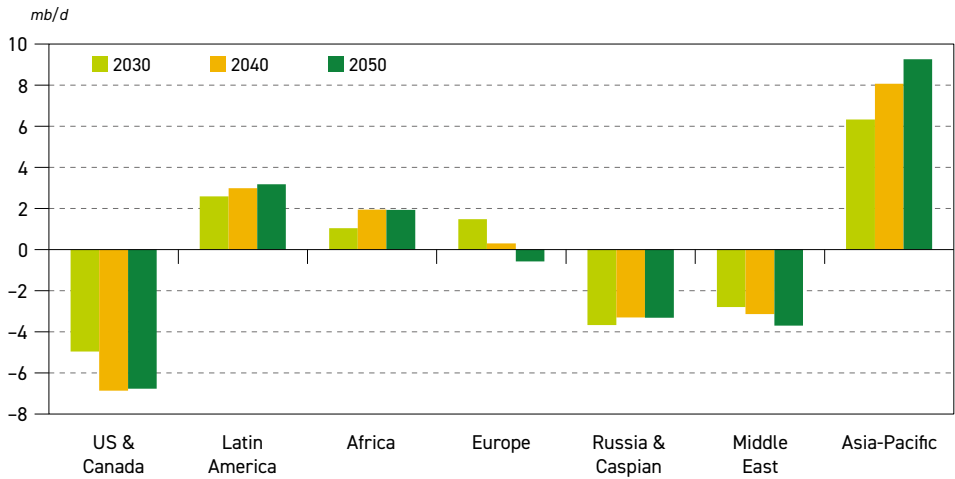
Furthermore, some regions with significant crude and condensate exports (especially Africa) are likely to see a significant increase in long-term oil demand. This is why these regions are expected to process more crude domestically, which will serve their local product demand and limit crude exports.



In other words, a large part of refined product trade remains an intra-trade issue (trade within the region itself). However, there are still significant refined product flows from regions with sufficient refining capacities to others where local product demand is higher compared with local refinery output. In some cases, large crude oil producers (e.g. several countries in the Middle East) have chosen to expand their refining capacity and replace a portion of their crude exports with product exports. Consequently, future trends depend on local demand growth, as well as available and new refining capacity (see Chapter 5).

Figure 6.14 shows projected product net imports by major region. Net imports to the Asia-Pacific are set to increase from roughly 6.3 mb/d in 2030 to above 9 mb/d in 2050. On the net import side, increases are expected in Africa, from around 1 mb/d in 2030 to almost 2 mb/d in 2050, and in Latin America, from 2.6 mb/d in 2030 to 3.2 mb/d in 2050. In Europe, net imports of round 1.5 mb/d in 2030 are expected to flip to net exports of around 0.6 mb/d in 2050.

Figure 6.14
Regional net product imports



Source: OPEC.

This will be covered by rising net exports in the US & Canada, from 5 mb/d in 2030 to around 6.8 mb/d in 2050. In the Middle East, net exports are seen increasing from around 2.8 mb/d in 2030 to 3.7 mb/d in 2050. Net exports in Russia & Caspian are expected to decline somewhat, but remain strong at around 3.3 mb/d in 2050.

Energy Scenarios



Key takeaways

- The narrative, pushed by some, that there is only one pathway towards achieving significant emissions reduction is today being rebuffed by swathes of consumers, government and industry. Moreover, given the evident need for more oil and gas, demand for which keeps rising, it is increasingly apparent that efforts to simply halt investments into these valuable sources of energy are strongly misguided.
- Besides the harmful side-effects in terms of energy price volatility, inflation, and loss of energy security, it is clear that any efforts to transform our energy system cannot afford to stymie poorer countries and societies' efforts to develop and prosper through providing access to modern energy services. In OPEC's view, there is an urgent need to widen the debate to be more inclusive, open-minded, technology-agnostic, and realistic.
- To this end, the WOO once again highlights two alternative scenarios to stimulate debate and demonstrate that focusing on a one-sided narrative, which effectively picks winners and punishes losers, is unhealthy.
- The 'Technology-Driven' Scenario illustrates a different pathway to the dominant narrative; one that achieves the goal of limiting the global temperature increase to well below 2°C while avoiding substantial negative economic impacts on developing economies, especially those that export energy, and ensuring a high degree of energy security. This scenario outlines a feasible roadmap in which technology solutions allow for both a higher share of renewable energy and the continued use of oil and gas. They complement each other in a manner that avoids potential negative impacts on the economies of energy-exporting developing countries.
- Primary energy demand in the Technology-Driven Scenario by 2050 will be around 52 mboe/d lower compared to the Reference Case. The share of non-fossil fuels in this scenario is projected to gradually expand to more than 48% by 2050. Global oil demand in this scenario stabilizes at a level above 100 mb/d in the period to around 2040, before moderately slowing to 96 mb/d over the last ten years of the outlook period. This represents a demand decline of around 24 mb/d compared to the Reference Case in 2050.
- By contrast, the 'Equitable Growth' Scenario illustrates a pathway that sees a more equitable and prosperous economic future for developing countries, coupled with a differentiated approach to how and when to achieve emission reduction targets. This scenario results in higher long-term demand for energy, in general, and oil, in particular.
- Oil demand in this scenario tops 115 mb/d by 2030 and continues growing to 127 mb/d in 2050. Compared to the Reference Case, this is higher by almost 2 mb/d in 2030, which then expands to 7.1 mb/d in 2050.
- In all energy futures, the critical role of oil and gas in meeting future energy demand, developing new technologies and helping eradicate energy poverty should be taken into consideration when developing investment plans and energy portfolios that enable a low-emissions future.

Only a few years ago, the prevailing narrative in efforts to reduce emissions and transform the global energy system in a sustainable manner was to substitute fossil fuels with renewable energy as much as possible, and as fast as possible. The 2022 energy crisis, however, with energy prices sharply increasing, especially for gas and electricity in Europe, was a wake-up call for policymakers that highlighted several shortcomings to this approach.

The crisis led to a realization that redirecting investments towards renewables would overly narrow development options and potentially steer transitions into a dead end. It also saw populations push back against many initial net-zero policies, as they saw a glimpse of what these could mean for them. What has become clear is that there is not a uniform solution for everybody – there is no such thing as a one-size-fits-all solution for global challenges. Thus, it is important to recognize the need to diversify transition options to create a plethora of pathways, on which people, countries and regions can transition at different speeds and in varying directions.

There was also a realization that pushing for reduced or no new investments in oil and gas and an over-reliance on renewables has the potential to initiate frequent energy crises and spikes in energy prices. This resulted in energy security and affordability becoming key priorities for policymakers again.

What all this has emphasized is the quest for alternative future energy pathways, with questions posed such as: What should be the emphasis? What should be the direction of travel for different peoples, countries and regions? What are the realities on the ground? And what can energy sources offer in terms of delivering energy security, energy availability and reducing emissions?

What is central in this debate is not only how to tackle the emissions issue, but also how to address the rising energy needs of developing countries – making sure that energy is available to the millions of people in these countries in an affordable manner, and achieving this in a way that avoids adverse impacts.

This chapter attempts to provide a contribution to this debate by developing alternative scenarios. To this end, it describes two alternative scenarios relative to the Reference Case. Firstly, a 'Technology-Driven' Scenario illustrates a technology-driven means of limiting the global temperature increase to well below 2°C, while curbing the negative economic impact on developing economies, especially energy-exporting ones, and ensuring energy security. Secondly, the 'Equitable Growth' Scenario highlights how a more optimistic and equitable outlook for developing economies could result in higher long-term energy and oil demand.

The analysis in this chapter serves to illustrate that alternative pathways exist and are feasible. In particular, the findings provide insights into how future energy demand and the energy mix are likely to be affected, but also estimates the adverse distributional impacts of response measures and the corresponding level of global emission reductions.

7.1 Alternative energy scenarios

To address the objectives of this chapter, two alternative scenarios to the Reference Case were developed. Each scenario is based on a distinct set of assumptions in respect to adopted energy policies, economic growth trajectories, the use of available technology options and investment priorities.



The first scenario shows an alternative possible pathway to achieve emission reductions consistent with the main long-term goals of the Paris Agreement, with a view to offering a different narrative, and in OPEC's view, a more realistic means of achieving these long-term goals. In the Technology-Driven Scenario, a greater deployment of technological solutions to abate CO₂ emissions enables a greater share of oil and gas to be maintained in the long term. This reduces economic harm to the economies of energy-exporting developing countries and also sees an increased share for renewable energy.

The second, the Equitable Growth Scenario, sees stronger economic growth in developing countries and is combined with a policy framework that fosters development needs, including enhanced energy access and energy poverty eradication. In turn, this accelerated and more equitable economic growth in the 'Global South' results in a stronger rise in overall energy demand and, in part, requires higher demand for oil and gas.

This chapter compares the results of these two alternative scenarios relative to the Reference Case, presenting implications for future energy demand, the energy mix, oil demand and energy-related emissions. It highlights the key differences and also assesses the differing potential socio-economic impacts. The background, key elements and analysis of each scenario are presented below.

Technology-Driven Scenario

The Technology-Driven Scenario assumes the same basic socio-economic Reference Case assumptions on global population and economic development to 2050. It differs from the Reference Case, however, in two important areas.

Firstly, it assumes accelerated investments in measures and technologies leading to faster energy efficiency improvements across all consuming sectors. This includes the faster deployment of renewable energy, which primarily replaces older and inefficient coal power plants. It also substitutes ageing gas turbines with new ones with higher efficiency, provides for a faster penetration of ICE-based cars with better fuel economy and EVs in the road transportation sector, and provides measures that support more efficient appliances and heating and cooling systems in the residential sector, as well as similar improvements in industry and other transport sectors.

The second area relates to the greater deployment of carbon removal technologies, such as stationary CCUS, mobile CCUS, CCS and direct air capture (DAC) technologies in industrial sectors and others, an expansion in hydrogen use, and a more rapid shift towards adopting a CCE framework across the global economy. In sum, this different framework in the energy sector results in a global emissions reduction pathway that is consistent with the long-term goals of the Paris Agreement to limit the temperature rise to well below 2°C.

Crucially, this different pathway towards achieving net-zero (though not necessarily by 2050) allows for the continued and elevated use of hydrocarbons through a more extensive application of carbon removal technologies, including the large-scale deployment of bioenergy with CCUS in the second half of the century. Moreover, nuclear power plays a more significant role compared to the Reference Case. It should be noted that demand for coal falls further in this scenario, being largely substituted by other energy sources throughout the outlook period, while any remaining use of coal will mostly be associated with CCUS.

Equitable Growth Scenario

The Equitable Growth Scenario is based on the assumption of stronger long-term economic growth, especially for developing countries. It avoids an unnecessarily ‘one-size-fits-all’ ideology, one imposed top-down, that prevents equitable and long-overdue economic development and growth in the Global South. Thus, as a result, Africa, India, and developing countries in Asia and Latin America see their economies expand faster compared to the Reference Case.

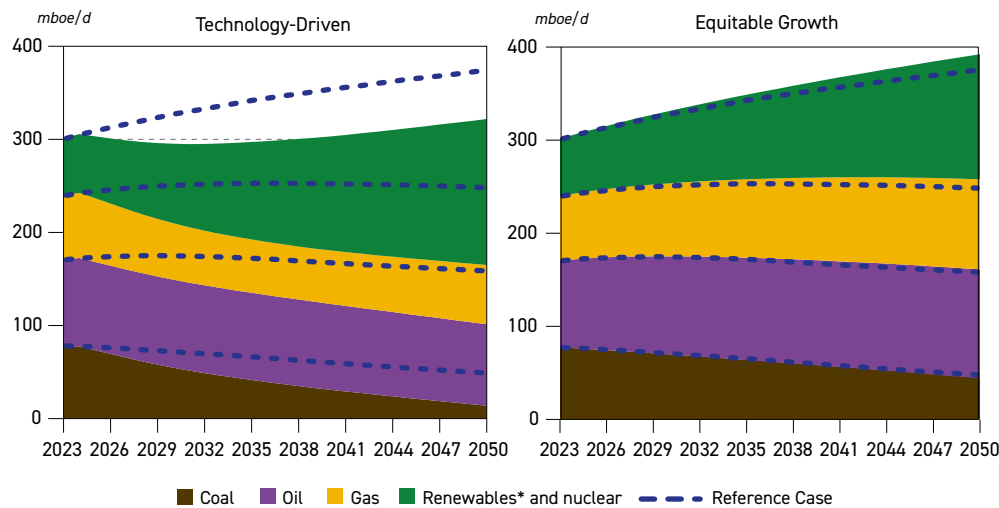
As a consequence, these countries experience higher levels of industrialization and urbanization, which then leads to a larger middle class and improved living conditions for billions of people. This helps to improve energy access in the least developed regions and aids in the further eradication of energy poverty. It also results in a quicker transition to modern sources of energy in these countries, including renewable energy, oil, gas and nuclear power, especially in the latter half of the outlook period.

In this scenario, improved efficiencies are achieved as a result of tighter policies, which also serve to support a further expansion of renewables. However, this is not implemented consistently across the board, in the absence of a coordinated move to reduce future emissions. In addition, local development needs are prioritized over global issues due to wider protectionism and unilateralism holding sway.

7.2 Energy demand and the energy mix

Major trends in future primary energy demand for alternative scenarios are presented in Figure 7.1. Clearly, driven by varying narratives, future energy demand in these scenarios differs significantly in terms of both overall levels and the composition of the energy mix. A

Figure 7.1
Global primary energy demand in the Reference Case and in alternative scenarios, 2023–2050



* Renewables include hydro, biomass, wind, solar and geothermal energy.

Source: OPEC.



measurable difference can already be observed during the current decade as energy demand in the Technology-Driven Scenario is projected to decline in the period to 2030, while it continues growing in the Equitable Growth Scenario.

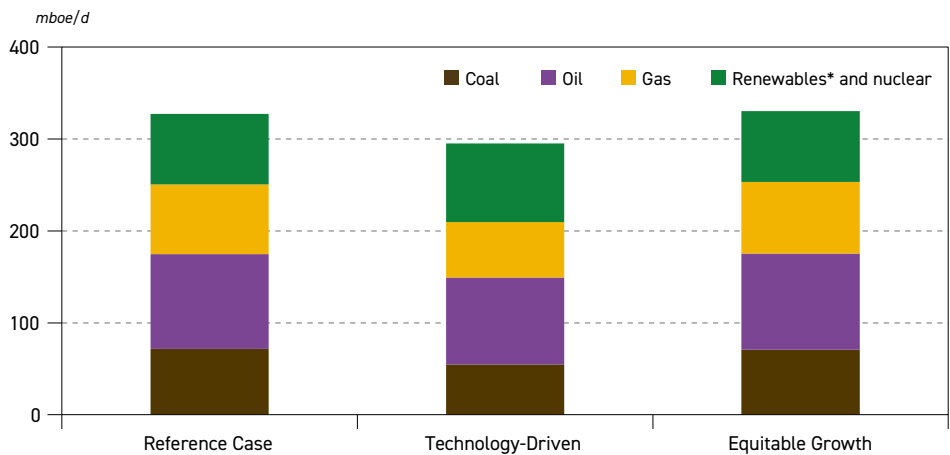
The initial energy demand decline in the former scenario is primarily linked to assumed efficiency improvements that could be introduced with a relatively short lead time – hence, the effect starts to be visible within a few years. The impacts are two-fold. Firstly, the faster deployment of more efficient technologies limits the growth of final energy consumption, meaning it increases more slowly compared to the Reference Case during the first half of the outlook period. Moreover, new technologies will intensify the electrification of industry, transportation and the residential sector.

The second effect is linked to how expanding electricity demand is met. In the power sector, coal will be particularly impacted because reducing its use offers the fastest and most cost-effective way to curb emissions. This is on top of the industrial use of coal being affected by more efficient processes.

The decline in electricity produced from coal will be more than offset by the projected rapid growth in renewables and, to some extent, by nuclear energy. The latter is anticipated to come mainly from small modular reactors that substantially shorten the long-lead times of large nuclear power plants. Increased electricity production from these sources will also partly substitute natural gas – on top of lower gas demand due to more efficient gas turbines.

The combined effect of these two factors on primary energy demand in the Technology-Driven Scenario by 2030 is presented in Figure 7.2. The overall decline in energy demand in this scenario between 2023 and 2030 is not large, estimated at less than 6 mboe/d. However, due to growing energy demand in the Reference Case during the same period, the gap between the two is projected to increase to around 32 mboe/d by 2030.

Figure 7.2
Global primary energy demand in the Reference Case and in alternative scenarios, 2030



* Renewables include hydro, biomass, wind, solar and geothermal energy.

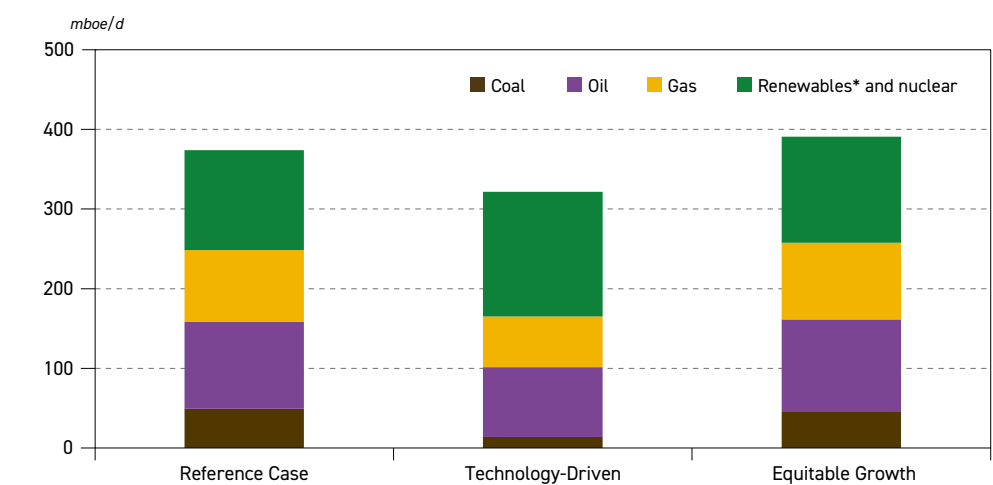
Source: OPEC.

Lower coal demand is projected to account for more than half of this. Significantly lower demand is also projected for natural gas and oil. Part of this decline will be offset by higher primary demand for renewables and nuclear. Combined demand for these two energy sources in the Technology-Driven Scenario is projected at 85.4 mboe/d, which is almost 9 mboe/d higher than the corresponding Reference Case demand by 2030.

Figure 7.2 also shows that neither global energy demand nor the energy mix in the Equitable Growth Scenario is significantly different from the Reference Case in the period to 2030. The main reason for this pattern is that this period is relatively short for any significant departure of regional GDP levels compared to the Reference Case. Therefore, total energy demand in the Equitable Growth Scenario is only 3.1 mboe/d higher by 2030, mainly due to faster oil and gas demand growth in developing countries, each being around 1.8 mboe/d higher compared to the Reference Case. Somewhat faster growth is also projected for renewables, while coal demand is slightly lower compared to the Reference Case.

Nevertheless, these changes indicate the momentum building towards a larger change when moving to the second part of the outlook period, as presented in Figure 7.3. It shows that the demand gap between the Technology-Driven Scenario and the Reference Case widens to 52 mboe/d by 2050, despite the fact that demand in the former is back on a growth trajectory as incremental demand in developing countries outweighs the potential for further efficiency improvements. These were mostly explored in the first part of the outlook period.

Figure 7.3
Global primary energy demand in the Reference Case and in alternative scenarios, 2050



* Renewables include hydro, biomass, wind, solar and geothermal energy.

Source: OPEC.

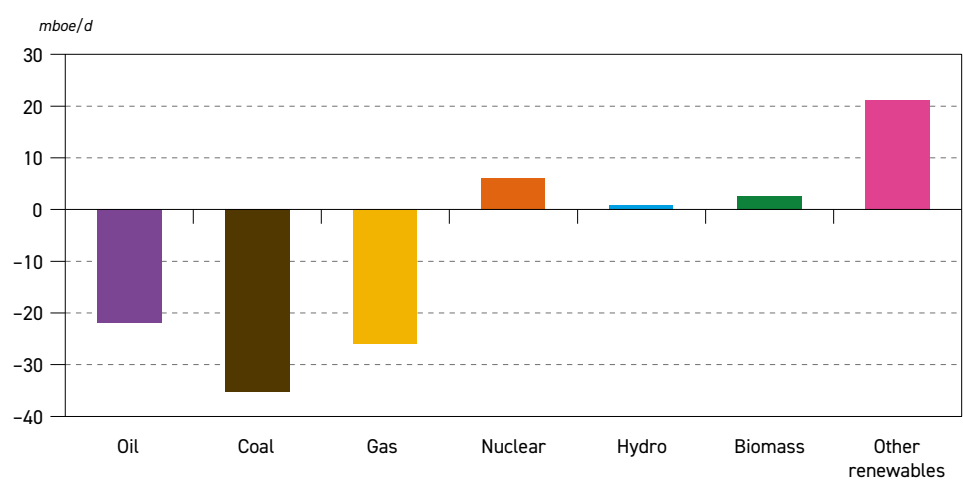
A larger gap of almost 17 mboe/d by 2050 is clearly visible in the case of the Equitable Growth Scenario, when compared to the Reference Case. Global energy demand in this scenario continues expanding by higher rates driven by faster economic development, especially in developing countries, and improved living standards and energy access for billions of people. It is worth noting that assumed global GDP growth rates in this



scenario are not significantly higher compared to the Reference Case. Nevertheless, the cumulative effect of long-term annual growth rates that are on average higher by around 0.3% is sufficient to push global GDP levels in this scenario almost \$20 trillion higher compared to the Reference Case by 2050, with a large part of it taking place in developing countries.

In the case of the Technology-Driven Scenario, details on the changing energy mix are presented in Figure 7.4. Given the ambition to reduce emissions to levels consistent with the Paris Agreement, coal demand in this scenario continues to decline, falling to a level below 14 mboe/d in 2050. This is 35 mboe/d lower compared to the corresponding demand level in the Reference Case and around 64 mboe/d lower than observed demand in 2023. In fact, this means the almost complete elimination of coal, especially in OECD countries, from the future global energy mix.

Figure 7.4
Change in primary energy demand between the Technology-Driven Scenario and the Reference Case in 2050



Source: OPEC.

Demand for natural gas will also be significantly affected in the Technology-Driven Scenario. Demand for this energy source is projected to decline by around 8 mboe/d in the period to 2030. It will then stabilize at this lower level and even marginally increase over the last ten years of the outlook period, however, supported by available CCS capacity. Its initial decline will be mostly affected by substitution with renewable sources, the electrification of the residential and industry sectors and energy efficiency improvements in major developed and developing countries, chiefly the US and China. The overall impact is that, by 2050, gas demand is projected to revert to a level comparable to the beginning of the outlook period. This is, however, around 26 mboe/d lower compared to the Reference Case in 2050.

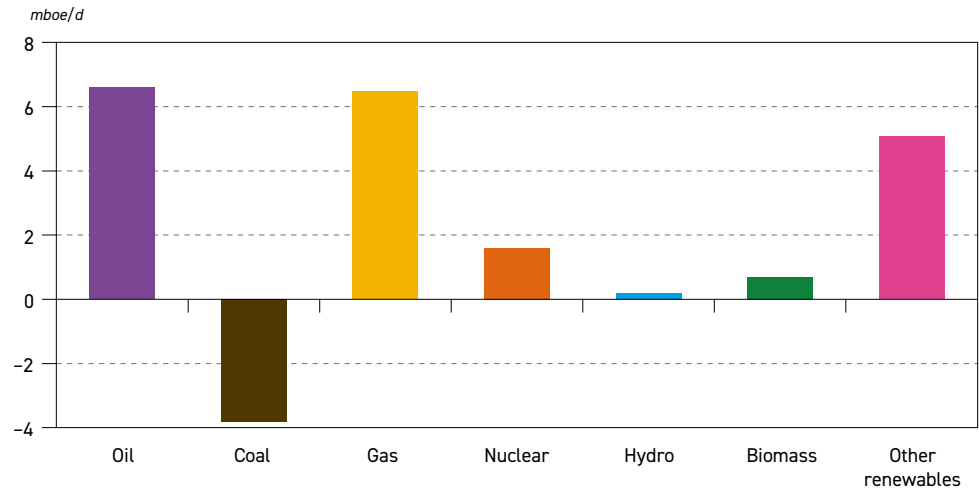
Oil demand in this scenario will be less affected. Emission reductions primarily achieved by coal substitution in the power and industry sectors, lower demand for coal and gas due to efficiency improvement measures, as well as the extended use of carbon removal technology at a later stage, will lessen the need for oil substitution in hard-to-abate sectors, especially the transportation and petrochemical sectors.

As a result, global oil demand in this scenario is projected to broadly remain at current levels during the present decade, before it starts a slow decline to 88 mboe/d by 2050. It is worth noting, however, that this relatively stable demand pattern is the result of the offsetting effects of growing demand in developing countries and declines in developed ones, as further elaborated on in Section 7.3.

The demand outlook for renewable energy sources and nuclear energy shows a different picture. Combined demand for these sources is projected to increase by around 96 mboe/d over the outlook period, growing from 61 mboe/d in 2023 to almost 157 mboe/d in 2050. Technology-Driven demand for solar and wind is projected to be 21 mboe/d higher compared to the Reference Case in 2050, while nuclear energy provides an additional 6 mboe/d.

In the long term, the prospects for the energy mix in the Equitable Growth Scenario, compared to the Reference Case, is provided in Figure 7.5. As already mentioned, global primary energy demand in this scenario is expected to be 16.9 mboe/d higher than in the Reference Case by 2050. The largest part of this additional energy demand will be met by oil and gas, each growing by an additional 6.6 mboe/d and 6.5 mboe/d, respectively. This means that gas demand in the Equitable Growth Scenario is projected to increase by 27 mboe/d between 2023 and 2050. The corresponding oil demand increase is 23.3 mboe/d.

Figure 7.5
Change in primary energy demand between the Equitable Growth Scenario and the Reference Case in 2050



Source: OPEC.

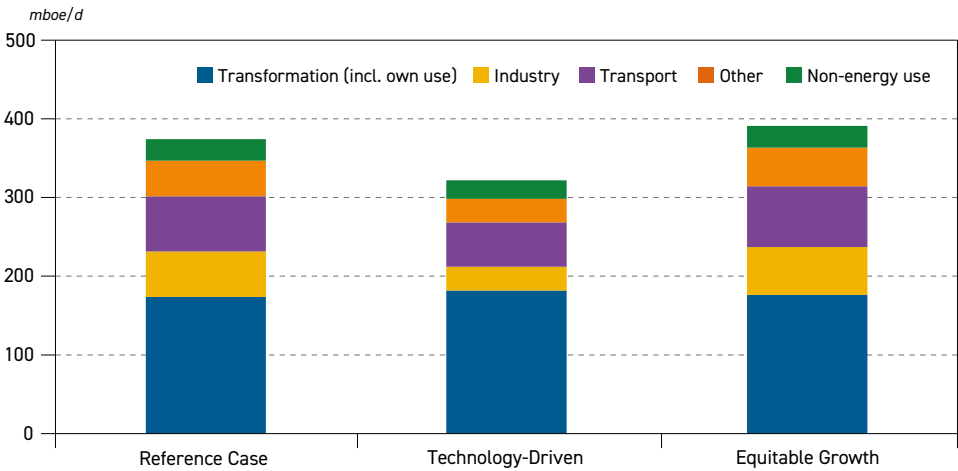
Moreover, continued demand growth is also projected for solar and wind. In fact, solar and wind combined will be the fastest growing energy source in the Equitable Growth Scenario, increasing by almost 7% p.a. on average over the entire outlook period, or cumulatively by almost 48 mboe/d between 2023 and 2050. This is around 5 mboe/d higher than Reference Case projections. Adding in incremental demand for nuclear, hydro and bioenergy pushes up overall demand growth for these forms of energy by around 72 mboe/d in the period to 2050.



Coal demand is projected to decline in all scenarios considered in this Outlook, the Equitable Growth Scenario being no exception. Moreover, the drop in coal demand in this scenario is even steeper than the Reference Case. It is projected in the range of 33 mboe/d between 2023 and 2050, which is 3.8 mboe/d more than the corresponding number in the Reference Case. This additional decline is projected mainly in the OECD and China, where a part of the higher GDP is used to implement additional measures to reduce emissions.

Figure 7.6 complements the previous discussion on the changing energy mix in alternative scenarios by providing an overview of global energy demand in 2050 from a sectoral perspective. In the Technology-Driven Scenario, global energy demand is projected to be lower in all sectors of final energy consumption compared to the Reference Case. As mentioned in the narrative for this scenario, the main reasons for this lower demand are a higher rate of electrification, the use of more efficient technologies and progressing fuel substitution across all sectors.

Figure 7.6
Global energy demand by sector in the Reference Case and alternative scenarios, 2050



Source: OPEC.

In this respect, the industry and 'other' sectors provide the 'low hanging fruit'. The key elements contributing to lower energy demand in the industry sector include the further penetration of energy efficient technologies, the use of hydrogen, shifts from coal to electricity and increased recycling rates. The overall effect is that these measures reduce energy demand in the industry sector by more than 27 mboe/d compared to the Reference Case.

A significant reduction in energy demand is also projected in the 'other' category, which includes the residential, commercial and agriculture sectors. The Technology-Driven Scenario assumes that this will be achieved by applying stricter building codes, more efficient lighting, heating and cooling systems, better building insulation, as well as through the faster introduction of more efficient machines and vehicles in the agriculture sector. The estimated combined impact of these measures is that energy demand in this sector in 2050 will be around 15 mboe/d lower than the corresponding demand in the Reference Case.

Energy demand in the transportation sector will also be affected by the policy setup assumed in the Technology-Driven Scenario, though the level of decline is somewhat smaller compared to previous sectors, estimated at 14 mboe/d compared to the Reference Case. Demand reduction in this sector is mainly associated with the faster penetration of EVs, and more efficient vehicles and powertrains in road transportation, rail, aviation and maritime shipping.

The energy savings in the above-mentioned sectors, however, are projected to be partly offset by higher energy demand in the transformation sector driven by the increased electrification of global final consumption. Despite much higher additional demand for electricity in the Technology-Driven Scenario compared to the Reference Case, total energy demand in the transformation sector will only be around 8 mboe/d higher in 2050. This is possible due to the large substitution of inefficient coal use by renewable and nuclear electricity. This substitution allows for a comparable amount of electricity with a lower input of primary fuels. However, the potential displacement of coal from the power sector will have largely been exploited in the second part of the outlook period; hence, the effect of higher efficiency in electricity generation is diminished. During this period, the increased availability of CCUS technology enables a revival in gas demand, which helps to meet still-growing electricity demand without increasing CO₂ emissions.

For the Equitable Growth Scenario, demand changes at the sectoral level, compared to the Reference Case, are much less complicated because demand in all major sectors is projected to be higher. The largest incremental demand is seen in the transportation sector, estimated to be 7 mboe/d higher than 2050 demand in the Reference Case. This is not surprising, as mobility tends to increase with a higher level of economic activity. A significant increase in energy demand is also projected in the residential, agriculture, industry and transformation sectors. However, the level of incremental demand in these sectors is much lower, in the range of 3 to 4 mboe/d.

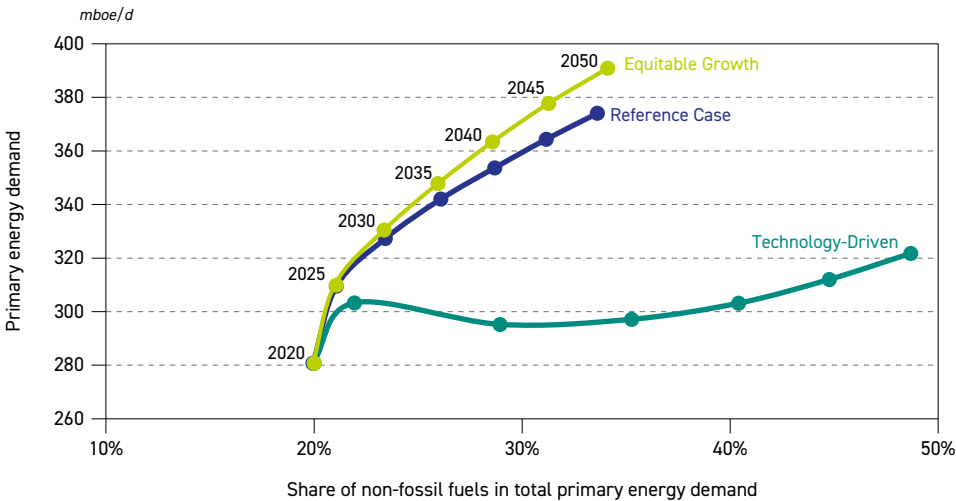
Figure 7.7 illustrates the dynamics of the link between the level of primary energy demand and the share of non-fossil fuels in the energy mix in the energy pathways considered in this Outlook. It shows that the Technology-Driven and Equitable Growth Scenarios, as well as the Reference Case, evolve in distinct ways and represent fundamentally different energy systems at the end of the outlook period.

Given the narrative and the main target of the Technology-Driven Scenario, which is to achieve significant emission reductions, the combined share of renewable energy sources and nuclear in this scenario grows faster than in the other two pathways. It already reaches almost 30% by 2030 and approaches 50% by the end of the outlook period. This share, in combination with a capacity expansion of carbon removal technologies in the range of 12 billion tonnes (bt) by 2050, is sufficient to reduce global energy-related annual emissions to less than 10 bt at the end of the outlook period. This is consistent with the long-term goals of the Paris Agreement.

Moreover, a significant component of this scenario is the continued use of natural gas in the power sector. Together with a higher share of nuclear and a smaller reduction in coal demand compared to the other pathways that focus on renewable energy sources as a primary means of reducing emissions, this approach allows for a larger electricity baseload and greater flexibility. Therefore, intermittency issues, electricity storage and investments to shift to a higher degree of electrification, for example, in the road transport, residential and industry sectors, is expected to be less of a problem in the Technology-Driven Scenario.



Figure 7.7
Global energy system in the Reference Case and alternative scenarios, 2020–2050



Source: OPEC.

It is also worth noting that the gradual increase in the share of renewables and nuclear in the future energy mix is inherently also a feature of both the Reference Case and Equitable Growth Scenario. In the Equitable Growth Scenario, the combined share of these energy sources expands from around 20% in 2020, to 29% in 2040 and then to more than 34% in 2050. In fact, besides assumed efficiency improvements, it is the rising share of renewable energy sources and nuclear, with their higher assumed efficiency in electricity generation, that leads to the declining energy intensity that is clearly present in the Reference Case, as well as both scenarios.

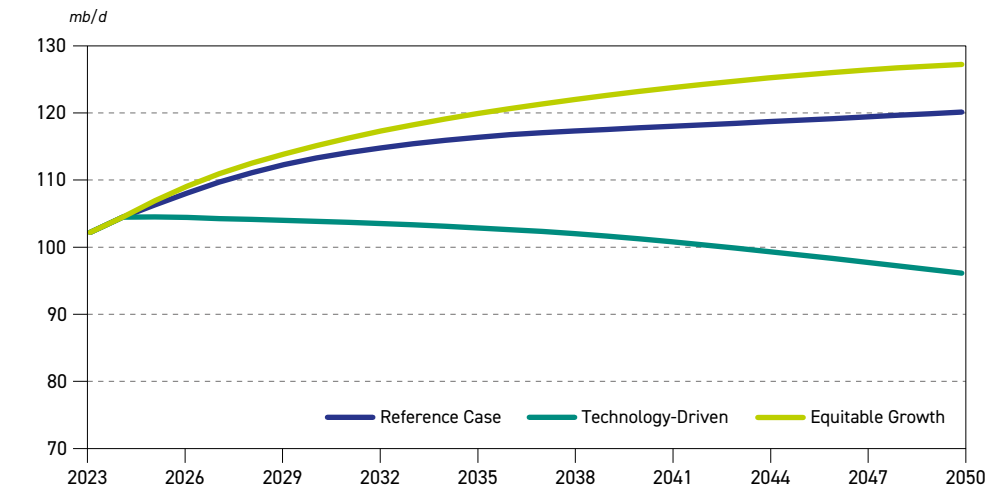
7.3 Oil demand

Given the necessity to use a common unit when dealing with various energy sources, all figures in the previous part of this chapter were expressed on an energy content basis. For the benefit of readers familiar with a volumetric measure, however, this sub-section converts oil demand to a barrel per day unit. Moreover, for better comparability – as oil demand expressed in this case typically also includes other liquids blended with refined products, such as biofuels, GTLs and CTLs – further corresponding adjustments were also made (hence, the reference to liquids demand in Figures 7.8 and 7.9).

At the same time, it is worth noting that the proportions of these additional streams do not change significantly in the considered scenarios and broadly follow the same trajectory as described in the Reference Case (more details are available in Chapter 4). Nonetheless, the implication is that oil demand figures presented in this sub-section are not directly comparable with those mentioned in the previous part of this Chapter, as both units and coverage differ.

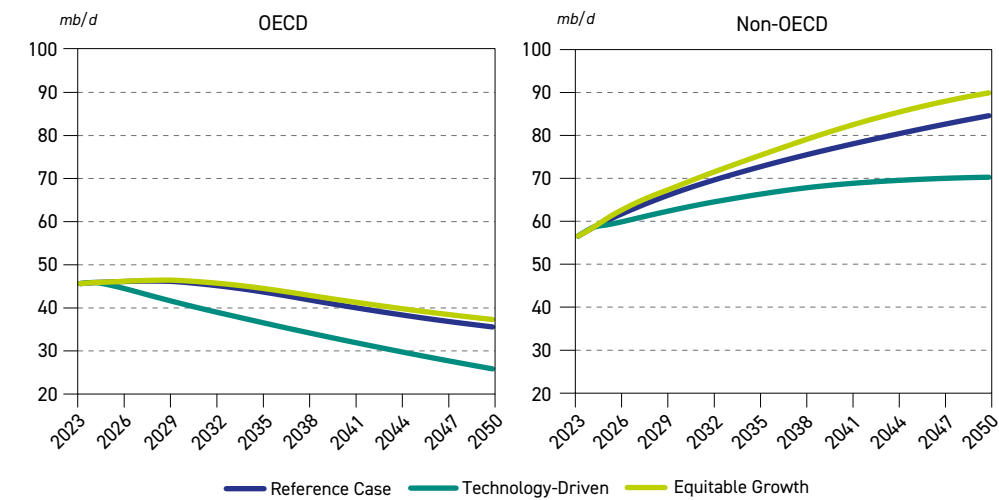
As presented in Figure 7.8, the oil demand trajectory in the Technology-Driven Scenario differs significantly from the ones shown in the Equitable Growth Scenario and the Reference

Figure 7.8
Global oil demand in the Reference Case and alternative scenarios, 2023–2050



Source: OPEC.

Figure 7.9
Oil demand in the Reference Case and alternative scenarios, 2023–2050



Source: OPEC.

Case. While oil demand in the latter two continues to expand during the entire outlook period, demand in the Technology-Driven Scenario stabilizes at levels above 100 mb/d in the period to 2040 and then starts to slowly decline towards 96 mb/d at the end of the outlook period. This pathway gradually opens up a gap *vis-à-vis* the trajectory projected in the Reference Case. This gap reaches more than 9 mb/d in 2030, before expanding to more than 16 mb/d in 2040 and 24 mb/d in 2050.

Clearly, this difference gradually evolves on the back of the underlying narratives of the energy pathways. The Technology-Driven Scenario is driven by the need to lower energy-related



emissions. This is achieved by a combination of a higher contribution from renewables to the future energy mix, the faster deployment of technologies with higher energy efficiency and the expanded use of hydrogen, CCUS and a CCE framework. The introduction of these technologies allows for a smoother transition to a lower-emissions system in which oil demand is less adversely affected compared to other scenarios focusing on renewables only.

Nevertheless, oil demand in this scenario remains consistently below the levels projected in the Reference Case. However, it does not drop precipitously to much lower levels, as the technology setup either directly supports the continued use of oil or lowers the pressure for its reduction by achieving required emission reductions in a more cost-effective way in other sectors.

Oil demand in the Equitable Growth Scenario follows a different path. Driven primarily by more robust economic growth, compared to both the Reference Case and the Technology-Driven Scenario, especially in developing countries, as well as a lack of coordinated efforts to enforce stricter emission reduction policies, oil demand in this scenario is projected to surpass Reference Case levels consistently over the entire outlook period. Moreover, because of the varying response to this higher economic growth, the impact on oil demand in the OECD and non-OECD differs significantly, as depicted in Figure 7.9.

Indeed, the rapid economic expansion in non-OECD countries fosters a larger middle class and accelerates urbanization and industrialization. This economic growth allows for governments to invest in infrastructure that improves mobility, enables faster industrialization, and advances access to electricity and modern energy sources, including LPG. Therefore, oil demand in this region is expected to rise to 90 mb/d by 2050, which is more than 5 mb/d higher than in the Reference Case.

In OECD countries, the Equitable Growth Scenario also anticipates stronger economic growth. However, increased oil demand in these countries is somewhat mitigated by additional policy measures aimed at reducing emissions, the quicker adoption of efficient technologies, and the more rapid growth of renewable energy compared to the Reference Case. Besides affecting oil demand, these measures will also limit the growth in gas demand and further accelerate the reduction in coal demand. As a result, the overall change in OECD oil demand is projected to be less than 2 mb/d by 2050, compared to the Reference Case.

The combined effect of the varying dynamics in the OECD and non-OECD leads to oil demand in the Equitable Growth Scenario exceeding 123 mb/d by 2040, before climbing further to more than 127 mb/d by 2050. This represents an increase of more than 5 mb/d in 2040, when compared to the Reference Case, expanding to a difference of 7.1 mb/d by 2050.

To some extent, the differentiated impact of the policy setup on oil demand in OECD and non-OECD countries is also present in the Technology-Driven Scenario. In the OECD, efficiency improvements in all transportation modes, supported by the faster penetration of EVs and continued oil substitution (also largely assumed in the Reference Case), as well as efficiency improvements in the industry and residential sectors, consistently drives oil demand to lower levels. The gap to oil demand levels projected in the Reference Case evolves relatively fast, already reaching 5 mb/d by 2030, before progressing to almost 10 mb/d by 2050.

However, non-OECD demand in this scenario is relatively less affected in the period to around 2035, as more time is needed to achieve comparable efficiency improvements and the higher

electrification of processes in developing countries. During this period, substantial emission reductions will primarily be achieved through the expansion of renewable energy and the substitution of coal and gas. This will gradually change in the second part of the outlook period, as EVs and more efficient technologies begin to penetrate non-OECD markets too. Consequently, oil demand in these regions stabilizes at around 70 mb/d towards the end of the outlook period, as opposed to the continued growth projected in the Reference Case. As a result, non-OECD oil demand in this scenario is projected to be more than 14 mb/d lower than the corresponding Reference Case demand in 2050.

7.4 Cooperation is critical

It is important to note that there is another facet of the discussion on future oil demand in various energy pathways that relates to the socio-economic implications of these changes, especially in oil and energy-exporting countries. It is evident that the implementation of ambitious climate mitigation actions focused on fossil fuel substitution results in adverse impacts on energy-exporting developing countries. Past estimates indicate that the GDP of OPEC Member Countries in typical mainstream mitigation scenarios (with a strong focus on renewables displacing oil and gas) could be as much as 16% lower than in the Reference Case by 2050. Significant impacts were also indicated for non-OPEC countries participating in the DoC.

However, these adverse impacts on energy-exporting developing countries could be significantly mitigated if a CCE framework, as well as CCUS and hydrogen technologies, were implemented at scale. This is highlighted in the Technology-Driven Scenario, despite an oil demand decline in this scenario that sees demand more than 24 mb/d lower in 2050, compared to the Reference Case.

To this end, any pathways toward sustainable energy transitions must balance environmental challenges with the right to development, prosperity and energy security. Policy frameworks and discussions must take into account that needs depend on national circumstances and capabilities – as reflected in the core principles of the UNFCCC. Since countries differ in starting points and history, and have different needs and capabilities in terms of facilitating the economic, social and environmental dimensions of sustainable development, different countries inevitably have different priorities.

To progress in the quest to find new directions of travel, cooperation is considered critical, as it can catalyze energy pathways. An important role is given to international cooperation that enhances collective and inclusive climate mitigation action and stimulates rapid change in energy systems, while recognizing that sustainable development and just transitions remain priorities for developing countries.





Key takeaways

- A range of uncertainties continue to cloud the long-term outlook for the energy sector. The challenge of how to balance sustainable, equitable development with energy affordability and energy security, while addressing climate concerns, has stimulated much debate, but also polarization among key stakeholders.
- COP28, held in OPEC Member Country the UAE, heralded many positive outcomes, underscoring the important role of multilateralism and international cooperation. However, persistent implementation and finance gaps, geopolitical tensions, electoral challenges and further impetus for economic growth and energy security could potentially affect policies aimed at addressing the climate challenge.
- The latest assessments tracking the Sustainable Development Goal (SDG) 7 achievements in 2023 highlight the ongoing challenges in achieving universal access to modern energy. Despite progress, around 685 million people have no access to electricity, and 2.1 billion lack access to clean cooking fuels. Significant regional disparities persist, and international cooperation and increased investment are essential for progress.
- Security of supply can be guaranteed only with sufficient and timely investments into energy supply and infrastructure. Given projected requirements of \$640 billion p.a. to ensure stable supplies of oil alone, concerns remain that insufficient capital expenditure will lead to supply shocks, volatility and energy insecurity. Calls to divest from, or transition away from, traditional fuels as soon as possible are misguided.
- The global refining and petrochemical industries are facing several major uncertainties in the medium and long term, reflecting evolving demand trends and related market challenges, technology developments, as well as sustainability issues. With established and new technologies, the downstream and petrochemical sectors are well placed to support the further development of the global oil and energy sectors.
- Carbon abatement technology is assumed to significantly contribute to CO₂ emission reductions in all scenarios in this Outlook. It is important to create an environment that is conducive to accelerating investments, including stationary applications of CCUS, supplemented by other forms of carbon capturing, such as DAC, and mobile CCUS applications in the maritime sector and for heavy trucks.
- The large-scale deployment of hydrogen has been slowed by uncertainties regarding its demand prospects. To reverse this trend, continued advancements in hydrogen technologies, investments in the deployment of this technology and related infrastructure, as well as a stable policy framework, are essential to unlock the full potential of hydrogen in the future energy mix.
- Data centres and AI are becoming more important for daily life and an increasingly important part of the global economy. These services require electricity demand and, in some regions and countries, electricity demand from data centres and AI constitutes a significant and expanding share of total electricity demand.

A range of uncertainties continue to cloud the long-term outlook for the energy sector. The challenge of how to balance sustainable, equitable development with energy affordability and energy security, while addressing climate concerns, has stimulated much debate, but also polarization among key stakeholders. As this Outlook's Chapter 7 spells out, a narrowly restrictive focus on only one possible pathway towards achieving the above-mentioned goals is not helpful, or even realistic.

Furthermore, shifting geopolitical realities and rapid technology advancements means that the energy picture remains fluid. This chapter will discuss some of the critical issues, challenges and opportunities that the global energy industry, in general, and the oil industry, in particular, could face in the coming decades, touching on energy policy and climate negotiations, investment and the role of new and existing technologies.

8.1 Pace of energy transitions

The concept of energy transitions has gained traction globally, with the primary priority of achieving a reduction in carbon emissions. So far, most of these transitions have taken place within the electricity sector, with the focus on renewable energy sources, in particular, wind and solar. There has been notable improvement in renewable energy technologies, which have advanced their efficiencies while also achieving a reduction in acquisition costs.

Wind turbine technologies have seen significant structural improvement, primarily through increasing their power generation capacities. This has been complemented by more advanced storage capabilities with lithium-ion batteries, which has helped mitigate intermittency challenges. Furthermore, the advancement of intelligent grid technologies and overall digitalization efforts, have played a significant role in the optimization of energy distribution and the consumption of alternative sources in global energy systems. Combined with supportive policies and lower acquisition costs, an estimated 42.9 mboe/d of essentially wind and solar power capacity is set to be added to the global energy mix by 2050, making it the single largest contributor to future energy supply growth.

Despite these considerable advancements, there are factors that are impeding energy transition plans being implemented across the world. These factors are related to technological, infrastructural and economic challenges, including supply chain constraints, delays in government policies, pushbacks from consumers and regulatory implementation barriers. These have been responsible for delays or even cancellations of renewable projects globally.

In order to address the technological and infrastructural challenges, it is essential to understand the management of renewable energy integrations. It is imperative to expedite the commercial use of CCUS or to implement advanced nuclear reactors, which still require more research to meet global energy market standards. Addressing these challenges comprehensively will help reduce the challenge of intermittency in renewables and catalyze the rollout of these technologies.

An additional concern in the shift to renewables is supply chain bottlenecks. This is especially relevant when it comes to procuring technology components. Disruptions in these supply chains are a significant impediment to the development and adoption of energy solutions. Further delays can also be caused by government policies, such as tax rebates/incentives and subsidies that significantly affect the pace of implementing a renewables agenda.



The EU's Green Deal and the United States' IRA are examples of supportive policy frameworks that are geared towards accelerating green energy systems. However, guaranteeing energy security is increasingly the energy policy focus in many economies, and to this end, there is a reassessment of energy policies worldwide. The urgency of this concern has intensified with the ongoing Russia-Ukraine conflict. As a result, many countries now consider energy security a major priority in the short and medium term as a means to avoid energy shortages and price spikes.

In conclusion, the pace and nature of energy transitions will be largely dependent on the intricate interaction of technological and structural advancements, resolving supply chain bottlenecks, actionable government policies, and the dynamics of global market economics. Despite all the visible progress, particularly in the efficiency of renewable energy technologies and related cost reductions, it is important to highlight that their share in the global energy mix is currently only at 3.2%. To this end, the combined efforts of international communities, energy industry players and environmental activists is required to foster an adherence to the Paris Agreement and implement an action plan that will enhance global energy sustainability and security.

8.2 UN climate processes and implementation of the Paris Agreement

At a time of heightened uncertainty and widespread disruptions, the latest UN Climate Change Conference (COP28) convened from 30 November to 13 December 2023, in Dubai, the UAE, featuring *inter alia* the conclusion of the first GST process under the Paris Agreement and the adoption of a decision on the operationalization of the Loss and Damage Fund.

A set of decisions called the 'UAE Consensus' was agreed upon by Parties at COP28, which is expected to lay the groundwork for enhanced climate ambition and support. Besides the outcome of the first GST, Parties reached an agreement on matters relating to the mitigation work programme, the work programme on just transition pathways, and the framework of the global goal on adaptation. Additional decisions covered topics ranging from the non-market approaches under Article 6.8 of the Paris Agreement to the forum on the impact of the implementation of response measures.

Despite lengthy discussions, some critical negotiation items remained unresolved in Dubai and were postponed for consideration in upcoming sessions. These were related to matters on cooperative approaches under Articles 6.2 and 6.4 of the Paris Agreement, and emissions from fuels used for international aviation and maritime transport. Thus, although COP28 may have started on a high note with the swift adoption of the provisional agendas, negotiations proved difficult on substantive issues related to the Paris Agreement implementation.

After a two-year technical phase, Parties agreed on the outcome of the first GST by culminating its political phase too. The subject decision assesses the status of global emissions and presents different strategies for adapting to and mitigating climate change, while addressing issues concerning loss and damage, and the impacts of response measures. The need for providing means of implementation and support to developing countries is also captured, focusing on climate finance, technology development and transfer and capacity building.

Recognizing that implementation of the already communicated NDCs will not put the world on a pathway consistent with the Paris Agreement's temperature target, the outcome of the

first GST is regarded as a balanced set of recommendations. It allows each Party to consider the most suitable approaches and pathways for contributing to global efforts on emission reductions, in a nationally determined manner, according to different national circumstances, and in the context of sustainable development and poverty eradication.

The outcome is consistent with the bottom-up approach of the Paris Agreement and makes clear that tackling climate change requires a transformation across all sectors of the economy rather than any single sector. As already elaborated in Chapter 1, the subject decision promotes different technologies within the energy system, which could lead to an enhancement of Parties' climate actions, while pursuing efforts to ensure energy security, energy access and affordability. Within this framework, it delivers support for accelerating abatement and removal technologies, such as CCUS, alongside renewable energy, nuclear energy, low-emission fuels and hydrogen.

The above demonstrates that emission reductions from the global energy system should be inclusive, just, and equitable, considering the different starting points of each economy and in light of their national priorities and needs. However, recent economic, trade and energy-related disruptions, as well as growing, complex geopolitical tensions, are affecting the requirements of sustainable development and international solidarity. Against this backdrop, the foundations of multilateralism and cooperation could be compromised, potentially leading to an increasingly multipolar world, which could undermine public support for climate policies and affect Parties' mitigation plans.

Consequently, the thrust of the first GST's outcome may present an opportunity to pave the way to future climate action, but it also raises the dual challenge of tackling climate change while addressing social and economic issues through effective approaches that leave no one behind.

Moreover, developing countries have voiced concerns about the adequacy of financial support provided by developed countries that put the implementation of their NDCs at risk. For example, there may be opportunities for developing economies to leapfrog the deployment of the aforementioned technologies. Yet significant funding gaps make the acceleration of climate ambitions more challenging, especially for developing countries who already have high debt burdens.

Noting that developed countries have fallen short of achieving their 2020 commitment to collectively mobilize \$100 billion each year to help developing countries implement their NDCs, potential concrete decisions on financing continue to be a priority for climate diplomacy. Indeed, this issue will be a particular focus of attention at COP29, in Baku, with Parties expected to negotiate and eventually set a new collective quantified goal on climate finance for the post-2025 period. COP28 (the UAE), COP29 (Azerbaijan) and COP30 (Brazil) Presidencies are collaborating under a new partnership – the so-called 'Troika' – aiming to ensure more ambitious NDCs and to deliver the financing needed to incentivize climate action. Parties' updated NDCs are due by early 2025, well ahead of COP30, with emission reduction targets for 2035.

Meeting this deadline will also require progress on other crucial negotiation issues and challenges around the Paris Agreement implementation. At COP28, and after a decades-long effort by developing countries vulnerable to climate change, Parties reached an agreement on the operationalization of the Loss and Damage Fund. A key outcome was adopted for the



first time at a COP opening session, and Parties collectively pledged almost \$800 million to this fund. The World Bank will initially host the fund for four years, yet its board has pushed back the timeline for working out key details on how the fund will work, owing to delays in nominations from developed countries. More importantly, it is estimated that the amount pledged currently accounts for only a fraction of the annual needs of developing countries.

It is, therefore, evident that the financing challenge is not limited to climate mitigation efforts and additional resources should be directed towards adaptation actions, including funding arrangements for loss and damage. Reliable and affordable support in the form of grants and concessional funding is essential for both climate mitigation and adaptation. Developed countries have committed to double adaptation finance; whereas in Dubai, Parties agreed on a framework for the global goal on adaptation that introduced overarching targets on how Parties could increase their resilience to climate change. The first round of planning and reporting has a deadline of 2030, and a two-year work programme was launched to create indicators for measuring and assessing progress towards this goal's targets. Yet the agreed targets do not relate to financial support for developing countries, raising concerns regarding transparency issues.

Another critical factor relates to the fact that progress towards a new international mechanism under Article 6 of the Paris Agreement was stalled in Dubai, leading to delays in finalizing its complex architecture. This development resulted in the postponement of the establishment of a market as a cooperative approach that could potentially have a significant impact on global emission reductions and mobilize meaningful financial support to developing countries.

To this end, the outcome of upcoming negotiations may provide clarity on whether the growing gap between the needs of developing countries and the support provided by developed countries will be adequately addressed, as well as how this would be reflected in any updated NDCs.

8.3 Progress and critical issues in the context of sustainable development

Every year, progress made towards achieving the SDGs are critically assessed by a range of authorities. Among these, SDG 7 – ensuring access to affordable, reliable, sustainable, and modern energy for all – remains a focal point of global efforts. In assessing the current progress towards achieving SDG 7, significant challenges remain.

As of the latest reports, global progress towards ensuring universal access to affordable, reliable, sustainable, and modern energy have seen mixed results. Although there has been commendable development in expanding electricity access globally – with millions gaining electricity for the first time – the pace is still not sufficient to meet the 2030 target. In particular, the transition to renewable energy sources, a critical component of SDG 7.2, has been slow, and investment in renewables would need to be ramped up dramatically to meet the set objectives. Energy efficiency improvements, tracked within SDG 7.3, have also lagged the desired annual improvement rates, highlighting the need for enhanced policy frameworks and technological innovations in energy systems.

According to the UN's latest assessment, approximately 685 million people worldwide still lack access to electricity, and around 2.1 billion do not have access to clean cooking fuels and

technologies, with the vast majority residing in sub-Saharan Africa and South Asia. These regions face persistent challenges due to infrastructure deficits, political instability and limited financial resources. Nearly one out of two people in sub-Saharan Africa lacked access to electricity in 2021, thus access in this region would need to more than double by 2030 to meet SDG target 7.1. Despite progress in some countries within these regions, the pace remains slow compared to East Asia and Latin America, where electrification efforts have seen more substantial success due to stronger policy support and investments in renewable energy technologies.

In terms of renewable energy, its global share in total energy consumption has only slightly increased in recent years. The transition to renewable energy is progressing at a faster rate in Europe and North America, driven by strong policy frameworks and mature markets for renewable technologies.

Energy efficiency, another critical aspect of SDG 7, has shown global advancement, but the rate is still below the target of doubling the rate of improvement by 2030. Some developed countries have made notable strides in improving energy efficiency through technological innovation and stringent policies. Many developing countries lag, however, due to a lack of technology transfer, inadequate regulatory frameworks and insufficient funding.

The latest UN statistics reveal that, as of the end of 2023, significant disparities in progress persisted across different regions. The lingering impacts of the COVID-19 pandemic exacerbated existing disparities in energy access, especially in less developed countries and rural areas where modern energy solutions are less prevalent. Around 80% of the global population that lack access to electricity live in rural areas, and this is most evident in sub-Saharan Africa where almost 60% of people live in rural communities.

This has underscored the importance of international cooperation and robust financial mechanisms to support the development of energy infrastructure in these regions. The declining trends in international public finance for clean energy development are particularly concerning, as these funds are crucial for supporting the infrastructure and technological developments needed for modern energy development in these regions.

As the world moves towards the latter half of the SDG timeline, the focus intensifies on overcoming these barriers. In 2023, international conventions, such as the 78th session of the UN General Assembly (UNGA-78) and the High-Level Political Forum on Sustainable Development (HLPF 2023) played important roles in reinvigorating global commitment towards the SDGs. The UNGA-78 centred on 'Rebuilding trust and reigniting global solidarity: Accelerating action on the 2030 Agenda and its Sustainable Development Goals towards peace, prosperity, progress, and sustainability for all.' The event featured high-level discussions aimed at reinvigorating the realization of the 2030 Agenda.

Additionally, the SDG Summit, which coincided with the high-level week of the UNGA, marked a significant review of the SDGs' implementation, culminating in a Political Declaration that emphasized the need for accelerated actions and systemic transformations to foster an inclusive, resilient and sustainable global environment. The declaration highlighted the slow pace of the renewable energy transition and called for increased investment and international cooperation to ensure broader and faster implementation. This includes significant commitments to financing for development and reforming international financial structures to better support sustainable development.



The HLPF, held under the Economic and Social Council (ECOSOC), also underscored the urgent need for sustained international cooperation and investment in sustainable and equitable energy solutions. Dialogues were called to amplify efforts on key transitions essential for SDG progression, such as scalable actions for energy access and the application of science, technology, innovation and data in transformative actions. These discussions were informed by the 2023 Global Sustainable Development Report and a special edition of the SDG Progress Report, which alarmingly noted that less than 15% of SDG targets are on track.

A notable development from these events was the launch of the UN Data Commons for the SDGs by the UN Statistics Division and Google.org in September 2023. This new platform aims to centralize and enhance the accessibility of authoritative SDG data, promoting informed decision-making through advanced analytical tools.

In 2024, the global community has continued these discussions to build upon the foundations laid in previous years. The focus remains on developing sustainable, resilient and inclusive solutions that address the ongoing and emerging challenges. Key reports and forums, such as the Arab Regional Forum on Sustainable Development and the 2024 HLPF, have critically assessed and guided these efforts, ensuring that progress towards the SDGs, is not only maintained, but accelerated.

The HLPF in 2024, was the first HLPF under the auspices of ECOSOC after the 2023 SDG Summit – with the aim to support the implementation of the Political Declaration and other outcomes of the SDG Summit for advancing the 2030 Agenda and the SDGs. The forum served as a critical platform for evaluating progress, sharing best practices, and reinforcing commitments from member states and stakeholders. The theme for HLPF 2024, 'Reinforcing the 2030 Agenda and eradicating poverty in times of multiple crises: the effective delivery of sustainable, resilient and innovative solutions,' emphasizes the need for a unified approach to address the complex challenges that threaten global progress on sustainability goals.

The ministerial segment of the 2024 forum provided an opportunity for high-level engagement and decision-making. This segment focused on reviewing progress towards five specific SDGs, including SDG 1 (End poverty in all its forms everywhere), and SDG 13 (Climate action). The discussions stressed the centrality of poverty eradication as the overarching goal of the 2030 Agenda and as an indispensable requirement for sustainable development. They also addressed special challenges and needs facing all developing countries, especially countries in special situations, including small island developing states, least developed countries, landlocked developing countries, and African countries and the challenges of middle-income countries. Additionally, the HLPF looked to strengthen the means of implementation by mobilizing necessary resources, fostering international cooperation and promoting technology transfer and capacity building. The outcomes of this forum are anticipated to influence the direction for the remaining years leading up to the 2030 deadline. The UN is also holding a major Summit of the Future in September 2024, which is expected to reaffirm existing commitments to the SDGs.

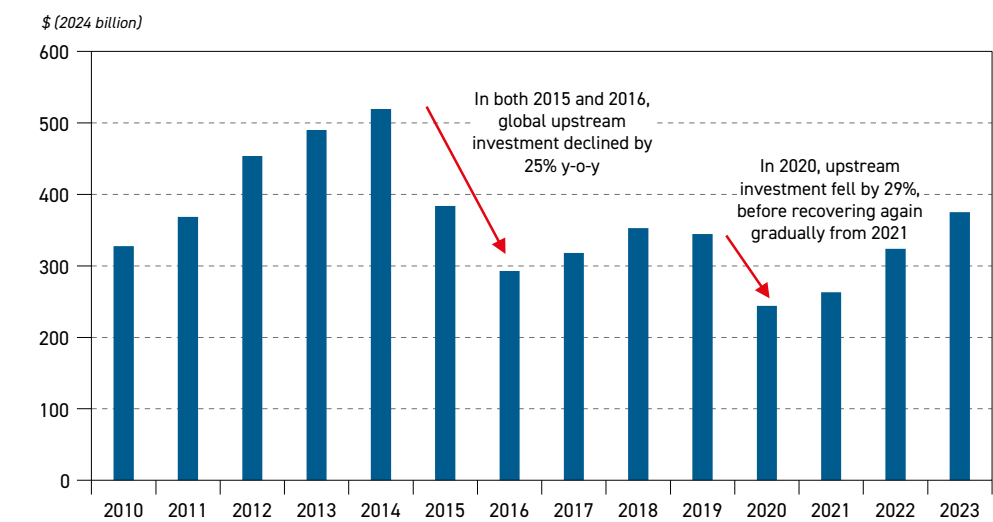
8.4 Oil upstream investments and strategies of major oil companies

Energy investments and energy security are closely interrelated. Security of supply can be guaranteed only with sufficient and timely investments into energy supply and infrastructure. This

especially applies in the case of oil and gas, where most investments relate to lengthy and capital-intensive projects with long lead times. While steered by market dynamics, oil and gas investment trends are also heavily influenced by energy policies, as well as geopolitical developments.

Figure 8.1 shows annual global oil upstream investments since 2010. After peaking in 2014 at over \$500 billion, investments dropped to below \$300 billion in 2016, a drop of 44%, mostly due to the sharp drop in oil prices during 2015 and 2016. Oil-related upstream investments recovered somewhat in the following years, but to levels far below 2014 values.

Figure 8.1
Global upstream (oil only) capital expenditure



Source: Rystad Energy.

It is important to note that part of this drop can also be explained by increasing production efficiency and declining investment costs, after several years of pronounced oil sector cost inflation. Another drop followed in 2020 to levels around \$245 billion, as a consequence of the COVID-19 crisis, and the respective demand and price drop. This investment level was the lowest since 2006, according to Rystad Energy data. Since then, investment levels have recovered, gradually rising to an estimated \$375 billion in 2023. This is, however, still almost 30% lower than the peak in 2014.

Besides the specific oil market dynamics, the sluggish recovery in oil upstream sector investments increasingly reflects wider energy market trends. The recent shift in energy policies, aimed at the long-term reduction of fossil fuel consumption and supply, is one of them.

Many of these policies are based on back-casted scenarios, targeting a specific long-term outcome, while often neglecting short-term realities and trends. Despite this fact, these scenarios have served as the basis for calls to reduce or even discontinue investments into fossil fuels, including oil and gas. Many regions have adopted energy policies and/or long-term targets, which discourage further investments into fossil fuels. In addition, corporations, investors, and business associations have increasingly shifted towards so-called ESG standards, although there has been reassessment from some in recent years.



These standards supposedly represent a means to 'objectively' measure the commitment of entities (usually requiring investment) to certain principles considered essential for a good corporate citizen, among which climate action is to the fore. The generation and endorsement of metrics to measure corporate performance based on ESG indicators has also become more pronounced. Many non-governmental organizations, minority shareholders, activist hedge funds and related actors (predominantly in Europe and North America) have played an important role in increasing pressure on investors and energy companies to readjust their investment plans and reduce their exposure to oil and gas.

Several banks and financial institutions, predominantly in Europe and North America, have joined the UN-convened Net-Zero Banking Alliance (a part of the Glasgow Financial Alliance for Net Zero, Gfanz) since 2021. The current membership includes over 500 global financial institutions, which share the target to lend and invest only into portfolios with net zero commitments by 2050. Although there are no clear guidelines, most of the members intend to limit financing for oil and gas in some way.

As a reaction to the pressure from policymakers and financial markets, some international oil companies, such as BP, TotalEnergies or Shell have committed themselves to net zero targets in the long term. In some instances, this includes reducing overall investment volumes into oil and gas in the medium and the long term, while increasing investments into renewable capacity.

Geopolitics and energy security concerns are other important factors related to energy investments. The start of the Russia-Ukraine conflict in February 2022 and developments in the Middle East since October 2023, have had significant implications for global energy markets with possible lasting consequences.

With rising commodity prices and uncertainties related to oil and gas supply and trade, many energy-importing countries have shifted their focus to energy security, as well as energy affordability. This is why numerous countries have started diversifying their oil and gas supplies. This is especially the case with European countries, which intend to expand their partnerships with oil and gas suppliers from various regions, including the US, the Middle East and Africa, while reducing their reliance on Russia.

At the same time, revived energy security concerns could have lasting medium- and long-term implications. Consuming countries could intensify efforts related to energy efficiency and raise the share of renewables in the energy mix, followed by an accelerated electrification of the energy sector. This can be seen not only as a way to reduce CO₂ emissions, but also increase energy security and energy independence.

Even before the recent energy crisis, several major consumers had announced ambitious energy policies that target reduced fossil fuel consumption, including the EU, the US and China. Achieving this transition will continue to require significant and sustained investments, as well as infrastructure upgrades, to suit the necessary new technologies. While this is possible, reconciling bold long-term plans with short-term demand and energy concerns, is easier said than done.

The EU and the US have announced concrete policy steps as a reaction to the energy crisis (e.g. RePowerEU, US IRA), which aim to reduce the share of fossil fuels in the energy mix. Other regions also have strong commitments related to increasing the share of non-fossil

fuels in the energy mix. While endorsing oil and gas investments, China, for instance, sees the increasing share of non-fossil fuels as a way to strengthen its energy security. This is why Chinese oil and gas companies actively promote energy transformation with some of them announcing carbon neutrality and/or net-zero targets.

It remains to be seen whether, and how fast, these long-term targets can be reached and what implications they bring for energy markets. Ambitious long-term goals are likely to lead to unintended consequences, market volatilities and possible shortages. This is why reconciling long-term targets with short- and medium-term concerns remains the main challenge in the energy sector in the years to come.

Further oil and gas investments are necessary, if future market shocks are to be avoided, and security of supply to consumers is maintained. It should also be noted that security of supply is the mirror image of security of demand for producers, who must have certainty that their investments will be needed. This especially relates to OPEC Member Countries, which traditionally maintain significant levels of spare production capacity.

The future energy landscape requires continuous coordination between major consumers and producers, including an understanding and harmonization of their policies and the increasing application of technological solutions to address sustainability, while simultaneously ensuring energy security.

8.5 Refining and petrochemical industries

The global refining and petrochemical industries are facing several major uncertainties in the medium and long term. These reflect evolving demand trends and related market challenges, technology developments and sustainability challenges.

The global refining sector is expected to follow regional oil demand trends. As discussed in Chapter 5, most of the new long-term refining capacity is required in Asia-Pacific, Africa and the Middle East. Total required refinery capacity additions are estimated at 19.2 mb/d by 2050. In addition, it is assumed that to meet the demand growth and possibly reduce refined product imports, developing regions need to modernize their existing refinery fleet, especially in Latin America and Africa. This requires significant investments and project implementation, which may represent a challenge for some countries. At the same time, energy policy pressure and a related projected oil demand drop in OECD regions could potentially lead to significant refinery closures, or repurposing in the long term.

Chapter 3 discusses the structure of future oil demand and shows that the projected increase in consumption relates mostly to high-quality products with gradually more stringent specifications, especially regarding sulphur. The largest increases are projected for ethane/naphtha and middle distillates over the outlook period, as well as a modest increase for gasoline.

In addition, after the medium term, the global crude slate is poised to become heavier and more sulphurous. This is due to rising heavy supply from Canada, Latin America and the Middle East. This will translate into significant requirements for additional secondary capacity, especially upgrading and desulphurization, not only for new refineries, but also for existing plants.



Refining capacity additions will continue in developing countries with new greenfield refineries. Most new projects, as in previous years, are likely to have high levels of complexity, including petrochemical integration. New technologies, such as crude-to-chemicals, can also help to address the changes in the long-term composition of oil demand. However, toward the end of the outlook period, the rate of refinery capacity additions is likely to decelerate with additions largely representing expansions of existing refining capacity instead of new greenfield plants.

In developed countries, the refining sector is set to face declining demand for traditional fuels already over the medium term. This may lead to refinery closures, but also to novel business models. There are robust efforts to increase the production of biofuels, bio-methane, synthetic fuels (including methanol and ammonia) and potentially low-carbon hydrogen (green and blue). The co-processing of bio-feedstock is also one possibility with many projects being announced.

Furthermore, some potential strategies in the plastics sector, including recycling, the conversion of plastics to fuels and the production of bioplastics are being explored. All this requires the adoption and implementation of new technologies and infrastructure at scale. Consequently, given the required time and investments to scale up new technologies, traditional refining will remain the dominant part of the downstream business in developed regions too.

Concurrently, the growth in demand for petrochemical products in the recent past has provided strong support for the sector. Demand for petrochemical products is set to continue to grow, underpinning demand for ethane/LPG and naphtha (Chapter 3). Nevertheless, the petrochemical industry could face several challenges in the years ahead.

Massive petrochemical capacity expansion in China has raised concerns of the potential of overcapacity, especially in the medium term. This could lead to rationalization and capacity closures elsewhere. Further pressure comes from the demand side and is related to more stringent regulations targeting single use plastics, plastics substitution, as well as recycling.

Despite these caveats, the future for the petrochemical sector looks bright, reflecting the industry's ability to innovate and find new applications for its products. This includes providing more durable plastic products and possibly reducing single-use applications of petrochemical products. There are numerous new applications for durable petrochemical products, including those in the renewable energy industry (e.g. materials for wind turbines and PV panels) and EVs, as well as in the construction industry.

Considering sustainability and CO₂ emissions concerns, the key future focus for the refining and petrochemical industry is lowering the downstream carbon footprint, in developing and developed regions alike. Some countries like China have introduced energy efficiency targets for their refineries, which could possibly lead to a restructuring of the country's refining sector.

Reducing emissions in the downstream and petrochemical sectors is possible through raising energy efficiency, including advancing process optimization and digitalization. Furthermore, the integration of renewables, as well as low-carbon hydrogen (green and/or blue), in downstream operations can also help. CCUS can provide a strong push for emission reductions within the downstream sector too. Novel technologies may help as well. For example, electrically heated steam crackers could help reduce the petrochemical industry's carbon footprint.

Endorsing some, or all these pathways, will help to reduce the carbon intensity of refineries and (integrated) petrochemical facilities. This is especially important for complex and integrated plants, whose carbon intensity (Scope 1 and 2) is normally higher. This is due to more extensive processing and higher energy consumption. At the same time, large integrated state-of-the-art refineries have a clear advantage over simpler and older plants due to their size and economies of scale.

To meet the global challenge related to reducing emissions, as well as ensuring energy affordability and energy security, all available technologies should be employed. With established and new technologies, the downstream and petrochemical sectors are well placed to support the further development of the global oil and energy sectors.

8.6 Potential role of CCUS and hydrogen

Reducing GHG emissions, while providing sufficient energy to meet growing needs, requires all types of available technologies, including carbon abatement technology and hydrogen. In addition to their crucial role in mitigating the impact of climate change, they can also contribute to improving energy security, provide solutions in hard-to-abate areas, such as transport and industry, and offer opportunities for hydrocarbons-producing nations to develop cost-competitive new business opportunities that complement existing assets.

Carbon abatement technology

Carbon abatement technology is assumed to significantly contribute to CO₂ emissions reduction in all scenarios considered in this Outlook. A rapid expansion of CCUS capacity is assumed in the Reference Case, while even faster capacity expansion would be required if the global energy system moves in line with the trajectory suggested in the Technology-Driven Scenario (Chapter 7).

Moreover, carbon abatement technology constitutes an integral part of emission reduction efforts in a large majority of other available outlooks, some of them assuming much higher installed capacity by mid-century. Therefore, it is important to create an environment that is conducive to accelerating investments in these technologies, including stationary applications of CCUS, supplemented by other forms of carbon capture, such as DAC, and mobile CCUS applications in the maritime sector and for heavy trucks.

In terms of CCUS, it encompasses a range of processes and technologies aimed at capturing CO₂ emissions from industrial sources or removing it from the atmosphere, then using the captured CO₂ in various applications or storing it underground. One of the successful utilizations of captured CO₂ is to improve enhanced oil recovery (EOR), which provides additional revenue streams.

Moreover, CCUS technology has the added benefit of being able to simultaneously remove other harmful pollutants. Up to a 50% reduction in nitrogen oxide (NO_x) emissions with this method has been observed. This dual benefit strengthens the argument for broader deployment of CCUS technology.

In addition to reducing emissions, CCUS offers the promise of improving the environmental footprint of building blocks that underpin modern life, such as plastics, concrete and steel.

On top of these environmental benefits, if the CCUS industry expands globally, it could help preserve existing jobs and create new ones, and improve the ability of companies to sell or export low-carbon products.

CCUS also positively affects the social cost of carbon. By capturing CO₂ where it is produced, CCUS reduces potential environmental and public health degradation, thereby minimizing the costs associated with climate change. This demonstrates that CCUS is not just a tool for combating emissions, but also has wider societal benefits.

For these reasons it is important to accelerate efforts to remove barriers and create supporting incentives for CCUS deployment. It is important to broaden areas where this technology is applied. Currently, it is deployed primarily in the oil and gas sector; however, large opportunities also exist in the power sector, as well as in cement and chemical production, where the technology has the potential to be a critical mitigation option.

For these sectors, integrating carbon capture takes time because of its complexities. Studies show that it can take six-to-seven years from the time that a project is announced to operationalization. The long deployment lead time poses challenge for stationary CO₂ capturing projects related to securing investment and financing as policies and market conditions could change both during or after deployment and negatively affect the return on investment. Therefore, providing a clear and stable policy setup and shortening the lead times are important preconditions for further progress.

Another challenge relates to cost reduction. Capital and operating costs to integrate carbon capture systems into some of the high-CO₂ emitting sectors currently offer few opportunities to generate revenue, and are often cited as a challenge to deployment. A more widespread deployment of CCUS would also require the development of infrastructure for each of its components, including transport and storage, facilities using CO₂, as well as engagement with communities in areas that have suitable geological structures.

These challenges can be addressed through creative incentive programmes, scaling up research, development, deployment, and enforcing regulations that address CCUS liability issues. Solutions are required to help accelerate investment into CCUS.

Hydrogen

Hydrogen is a versatile energy carrier and feedstock and has the potential to be used in a wide range of applications. These include industrial processes where it could partly substitute the use of coal and gas, in district heating in the residential sector, in road transportation, and there are opportunities to integrate hydrogen into existing natural gas networks. Moreover, hydrogen could also play an important role in supporting the growth of renewable energy due to its potential use as a form of energy storage.

However, the uptake of hydrogen faces various challenges, depending on its position in the value chain. The deployment of blue hydrogen relies on the widespread adoption of CCUS and storage availability and capacity. Significant expansion of CCUS capacity would provide a great opportunity for the refining industry to enter the hydrogen market given the industry possesses a long history of expertise, technological advantage and the required infrastructure to quickly increase hydrogen production at competitive prices, assuming that demand for the product exists.

At the same time, blue hydrogen will need to compete with green hydrogen produced via electrolysis. The economics of green hydrogen are influenced by electricity prices and plant utilization rates. The cost of electrolyzers and renewable power sources needed for green hydrogen production remains a significant barrier. Reducing production costs is crucial to make this type of hydrogen economically competitive. In addition, green hydrogen depends heavily on water availability. It is estimated that to produce 1 kilogramme (kg) of hydrogen around 8.94 kg of water is required. Therefore, water scarcity in some regions around the world remains a major challenge.

In addition, market failure to increase demand for hydrogen thus far, as well as future uncertainties on the demand side, are key factors slowing hydrogen deployment. The combination of high upfront capital expenditures and the lack of short- to long-term demand certainty make clean hydrogen projects a risky investment. Current hydrogen demand remains concentrated in traditional applications, while new applications account for less than 0.1% of hydrogen demand. Despite significant potential and the obvious benefits this energy carrier offers, it has proven a challenge for this energy source to expand into new markets.

Part of this challenge is a dichotomy in seeking the direction of travel between centralized and/or distributed hydrogen production. Centralized production, which involves large-scale production and distribution of hydrogen, benefits from economies of scale, but requires the development of distribution technologies. Establishing robust and extensive hydrogen infrastructure, including pipelines and storage facilities, requires substantial investment and planning.

On the other hand, distributed production involves smaller-scale production units located closer to the point of use, reducing the need for extensive infrastructure. Hydrogen production in refineries is already well-established and cost-effective in centralized applications, while the distributed production of all types of hydrogen is still being explored and faces many challenges.

Regardless of the direction that the energy industry takes in the years to come, it is clear that continued advancements in hydrogen technologies, investments in the deployment of this technology and related infrastructure, as well as stable policy frameworks, are essential to unlock the full potential of hydrogen in the future energy mix.

8.7 Data centres and electricity demand

Data centres and AI are becoming ever more vital for the functioning of everyday life and an increasingly important part of the global economy. While services provided by data centres and AI are mostly taken for granted, many people are not aware of the energy requirements to provide these services. Currently, these services create significant electricity demand and, in some regions and countries, electricity demand from data centres and AI account for a large share of total electricity demand. For example, Ireland's Central Statistics Office stated in July 2024 that the country's growing fleet of datacentres consumed 21% of the country's electricity, which is a higher level than that used by all homes in its towns and cities.

In the not so recent past, global electricity demand from data centres was largely stable or witnessing only a modest increase. It is only since 2020 that rapid developments in this sector have resulted in major electricity demand growth, with more envisaged in the



near future. There are many reasons for this, including the spread of cloud computing, the expansion of cryptocurrencies and the development of new and powerful AI models. Most of these applications are significantly more energy-hungry relative to comparable past applications.

For instance, one ChatGPT request can consume up to 10 times more electricity than a single traditional Google search. Some estimates show that newer versions of generative AI models can use up to 40 times more energy compared to old AI models. Furthermore, studies have found that generating an image via AI can consume as much energy as fully charging a smartphone.

The increasing use of data centres, as well as the continued integration of powerful AI models into many services, such as emails, searches and word processing, has led to a significant increase in processing power, hence, rising electricity demand. All this is pointing towards an exponential demand growth for electricity in the years to come.

In addition, as data centres require continuous cooling, the expansion has led to a significant increase in water demand. For instance, in 2022, water demand from Microsoft and Google increased by an astonishing 34% and 20%, respectively, y-o-y, at least partly due to rising generative AI workloads.

All data centres need continuous, uninterrupted and reliable electricity supply, which is why many new data centres have been built, or will be built, in close proximity to dispatchable electricity sources. In most cases, these are fossil fuel or nuclear power plants. Even though some data centres have dedicated renewable power supply, support from dispatchable electricity generation capacity remains essential.

In 2023, global electricity demand from data centres and AI was estimated between 400 TWh and 500 TWh, more than double the annual levels observed between 2015 and 2019. It is important to note that in the 2015–2019 period, the estimated workload of data centres increased by around 300%, but electricity demand remained mostly flat. This was due to large energy efficiency gains (around 15% p.a.) and economies of scale (i.e. the increasing share of hyperscale data centres) over this period.

However, this trend has been broken since 2020, as energy efficiency gains have slowed considerably in recent years (to around 2% p.a.). As already noted, in some countries, such as Ireland, electricity demand from data centres accounts for more than 20% of total electricity demand. For Ireland, this is around a 400% increase since 2015. There are similar examples in the US, including Northern Virginia, due to the presence of many governmental agencies.

With optimistic expectations related to the development of data centres and AI, electricity demand for these sources is set to continue to rise. The trajectory depends on the development of data centres and AI, computing power growth and potential efficiency gains. Some regions are experiencing a large increase in new data centres, which will necessarily lead to much higher electricity demand. According to the regional system operator (Dominion) in the US state of Virginia, electricity demand from data centres could increase from just above 20 TWh in 2023 to 100 TWh in 2038 (Figure 8.2).

At the global level, some bullish scenarios see electricity demand for data centres rising to around 1,500 TWh by 2030 (excluding cryptocurrencies). This is more than half of today's

EU electricity demand. In some other scenarios, global electricity demand from data centres (including cryptocurrencies) could reach as much as 1,000 TWh by 2026.

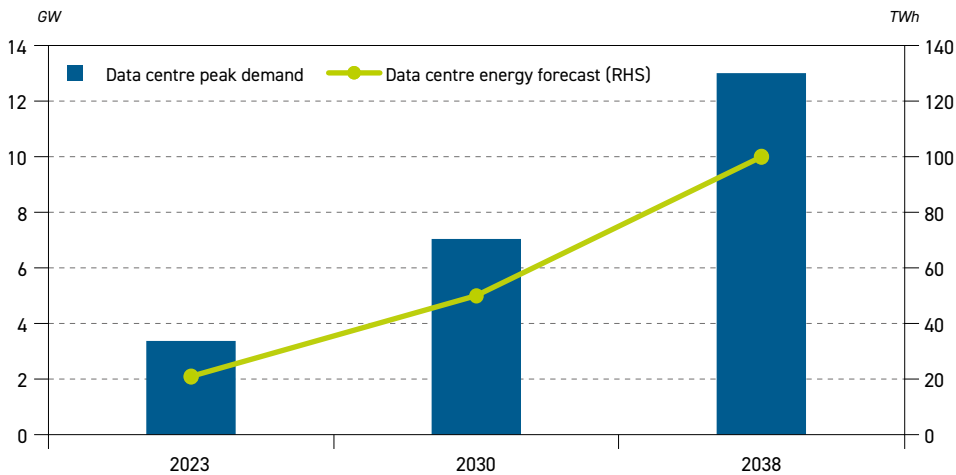
This increase in demand leads to several challenges. Firstly, growing electricity demand from data centres and AI comes on top of already rising demand due to expanding electrification (e.g. from the rising number of EVs, electrification in the residential and commercial sector, as well as industry). Consequently, it is possible that the medium- and long-term outlook for total electricity demand could be significantly elevated and higher-than-expected in the years to come. For example, Goldman Sachs recently increased its US electricity demand outlook for 2030 from 4,700 TWh to more than 5,000 TWh due to rising demand from demand centres and AI. A similar picture could be assumed for other regions, especially China.

Furthermore, data centres require a stable electricity supply and despite intentions to keep the carbon footprint low, it should be noted that they cannot fully rely on renewable energy sources due to their intermittent nature. Some data centres do utilize dedicated renewable projects; albeit often in combination with additional power supplied from the grid if required. Developments will certainly lead to more challenges for transmission and distribution system operators.

Additional requirements for more fossil fuel capacity will potentially emerge, for instance, gas fired CCGTs in the US or coal in China. Even back-up diesel generators could be required in some cases. As a result, this could lead to higher demand for fuels such as natural gas and coal, as well as diesel. Some plans even see the addition of dedicated nuclear power plants (potentially including SMRs) in connection with data centres, but this remains uncertain at the time of writing this report.

Finally, grid requirements will also increase, as more data centres means more grid connections. For instance, in Northern Virginia, the required load from data centres increased on average by 23% p.a. between 2017 and 2022. The growth is expected to decline, but remain

Figure 8.2
Data centre peak demand and energy forecast in Virginia, US, 2023, 2030 and 2038



Source: Virginia Electric and Power Company's Report of its 2023 Integrated Resource Plan, Dominion Energy, May 2023



strong at around 10% p.a. between 2023 and 2030. As a consequence, the required load from data centres in Northern Virginia could increase from 3.3 GW in 2023 to 7 GW in 2030 and further to around 13 GW in 2038 (Figure 8.2).

Necessary generation capacity and grid expansions go in parallel with expansions related to numerous new solar and wind projects, which all require more transmission capacity and higher grid flexibility, including reserve capacity and energy storage. Additional transmission and distribution capacity is also needed if stated electrification targets in many countries and regions (including the accelerated adoption of EVs) are to be met. Insufficient grid expansion could potentially lead to network congestion and result in unmet demand. This is especially the case in regions with ageing energy infrastructure, including the US.

Renewable electricity generation has increased strongly in recent years and is poised to accelerate in the years to come. For many countries, renewable electricity represents a potential silver bullet when it comes to CO₂ emission reductions. Yet, the expansion of renewable electricity is also a huge challenge at many levels, including increased land usage, grid expansion, energy storage, reserve capacity and, consequently, rising overall system costs. The emergence of new demand sources such as data centres and AI could complicate the picture even further, as future electricity demand could turn out to be significantly higher-than-expected.

Annex A

Abbreviations

AC	Alternating current
AI	Artificial intelligence
ASEAN	Association of Southeast Asian Nations
boe	Barrels of oil equivalent
BPCL	Bharat Petroleum Corporation Limited
BRICS	Brazil, Russia, India, China, South Africa, IR Iran, Egypt, Ethiopia, Saudi Arabia and the UAE
bt	Billion tonnes
CBDR-RC	Common but differentiated responsibilities and respective capabilities
CCE	Circular carbon economy
CCGT	Combined cycle gas turbine
CCUS	Carbon capture, utilization and storage
CO₂	Carbon dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CSP	Concentrating solar power
CTLs	Coal-to-liquids
DAC	Direct air capture
DC	Direct current
DoC	Declaration of Cooperation
ECOSOC	Economic and Social Council
EOR	Enhanced oil recovery
EPA	Environmental Protection Agency (US)
ESG	Environmental, social and governance
ETBE	Ethyl tertiary-butyl ether
ETS	Emissions Trading System
EVs	Electric vehicles
FCC	Fluid catalytic cracking
FCEV	Fuel cell electric vehicle
FID	Final investment decision
FPSO	Floating Production Storage and Offloading vessel
FPV	Floating photovoltaic
FYP	Five-year Plan
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GHG	Greenhouse gas
GoM	Gulf of Mexico
GST	Global stocktake
GW	Gigawatt
HEV	Hybrid electric vehicle
HLPF	High-Level Political Forum
HPCL	Hindustan Petroleum Corporation Limited
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICE	Internal combustion engine
IMO	International Maritime Organization
IOC	Indian Oil Corporation Limited

ANNEX A: ABBREVIATIONS

IRA	Inflation Reduction Act
kg	Kilogramme
kgoe	Kilogramme oil equivalent
LCOE	Levelized cost of electricity
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
LTAG	Long-term global aspiration goal
LT-LEDS	Long-term low-emission development strategies
mb/d	Million barrels per day
mboe/d	Million barrels of oil equivalent per day
MOMR	Monthly Oil Market Report (OPEC)
mt	Million tonnes
MTBE	Methyl tertiary butyl ether
mtpa	Million tonns per annum
NDCs	Nationally Determined Contributions
NDRC	National Development and Reform Commission
NGLs	Natural gas liquids
NGV	Natural gas vehicle
NNPC	Nigerian National Petroleum Corporation
Non-DoC	Non-Declaration of Cooperation
NOx	Nitrogen oxides
p.a.	Per annum
PHEV	Plug-in hybrid electric vehicle
pp	Percentage point
PPP	Purchasing power parity
PUE	Power usage effectiveness
PV	Photovoltaic
RCEP	Regional Comprehensive Economic Partnership
SAF	Sustainable aviation fuel
SDG	Sustainable Development Goal
SMR	Small modular reactors
SUV	Sport utility vehicle
tb/d	Thousand barrels per day
TWh	Terawatt hour
ULS	Ultra low sulphur
UNDESA	United Nations Department of Economic and Social Affairs
UNGA	UN Framework Convention on Climate Change
VGO	Vacuum gasoil
VLCC	Very large crude carrier
VLSFO	Very Low Sulphur Fuel Oil
WOO	World Oil Outlook (OPEC)
WTO	World Trade Organization
y-o-y	Year-on-year
YPF	Yacimientos Petrolíferos Fiscales





Annex B
OPEC World Energy:
regional definitions

OECD**OECD Americas**

Canada
Chile
Colombia
Costa Rica
Guam
Mexico
Puerto Rico
United States of America
United States Virgin Islands

OECD Europe

Austria
Belgium
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Iceland
Ireland
Italy
Latvia
Lithuania
Luxembourg
Netherlands
Norway
Poland
Portugal
Slovakia
Slovenia
Spain
Sweden
Switzerland
Türkiye
United Kingdom

OECD Asia-Pacific

Australia
Japan
New Zealand
OECD Asia Oceania, Other
Republic of Korea

NON-OECD COUNTRIES**Latin America**

Anguilla
Antigua and Barbuda
Argentina
Aruba
Bahamas
Barbados
Belize
Bermuda
Bolivia (Plurinational State of)
Brazil
British Virgin Islands
Cayman Islands
Cuba
Dominica
Dominican Republic
Ecuador
El Salvador
French Guiana
Grenada
Guadaloupe
Guatemala
Guyana
Haiti
Honduras
Jamaica
Martinique
Montserrat
Netherlands Antilles
Nicaragua
Panama
Paraguay
Peru
St. Kitts and Nevis
St. Lucia
St. Pierre et Miquelon
St. Vincent and the Grenadines
Suriname
Trinidad and Tobago
Turks and Caicos Islands
Uruguay

Middle East & Africa

Angola
 Bahrain
 Benin
 Botswana
 Burkina Faso
 Burundi
 Cameroon
 Cape Verde
 Central African Republic
 Chad
 Comoros
 Côte d'Ivoire
 Democratic Republic of the Congo
 Djibouti
 Egypt
 Eritrea
 Eswatini
 Ethiopia
 Gambia
 Ghana
 Guinea
 Guinea-Bissau
 Jordan
 Kenya
 Lebanon
 Lesotho
 Liberia
 Madagascar
 Malawi
 Mali
 Mauritania
 Mauritius
 Mayotte
 Morocco
 Mozambique
 Namibia
 Niger
 Oman
 Qatar
 Réunion
 Rwanda
 Sao Tome and Principe
 Senegal
 Seychelles
 Sierra Leone
 Somalia
 South Africa
 South Sudan
 Sudan
 Syrian Arab Republic

Togo
 Tunisia
 Uganda
 United Republic of Tanzania
 Western Sahara
 Yemen
 Zambia
 Zimbabwe

India

India

China

People's Republic of China

Other Asia

Afghanistan
 American Samoa
 Bangladesh
 Bhutan
 Brunei Darussalam
 Cambodia
 China, Hong Kong SAR
 China, Macao SAR
 Cook Islands
 Democratic People's Republic of Korea
 Fiji
 French Polynesia
 Indonesia
 Kiribati
 Lao People's Democratic Republic
 Malaysia
 Maldives
 Micronesia (Federated States of)
 Mongolia
 Myanmar
 Nauru
 Nepal
 New Caledonia
 Niue
 Pakistan
 Papua New Guinea
 Philippines
 Samoa
 Singapore
 Solomon Islands
 Sri Lanka



Thailand
Timor-Leste
Tonga
Vanuatu
Viet Nam

OPEC

Algeria
Republic of Congo
Equatorial Guinea
Gabon
IR Iran
Iraq
Kuwait
Libya
Nigeria
Saudi Arabia
United Arab Emirates
Venezuela

EURASIA

Russia

Russian Federation

Other Eurasia

Albania
Armenia
Azerbaijan
Belarus
Bosnia and Herzegovina
Bulgaria
Croatia
Cyprus
Georgia
Gibraltar
Kazakhstan
Kyrgyzstan
Malta
Montenegro
Republic of Moldova
Romania
Serbia
Tajikistan
Republic of North Macedonia
Turkmenistan
Ukraine
Uzbekistan

Note: For Chapter 4 'Liquids supply' the DoC regional grouping is shown, which includes the following countries: Algeria, Azerbaijan, Bahrain, Brunei, Congo, Equatorial Guinea, Gabon, IR Iran, Iraq, Kazakhstan, Kuwait, Libya, Malaysia, Mexico, Nigeria, Oman, Russia, Saudi Arabia, Sudan, South Sudan, the United Arab Emirates and Venezuela.

Annex C
World Oil Refining Logistics and Demand:
regional definitions

US & CANADA

Canada
United States of America

LATIN AMERICA**Greater Caribbean**

Anguilla
Antigua and Barbuda
Aruba
Bahamas
Barbados
Belize
Bermuda
British Virgin Islands
Cayman Islands
Colombia
Costa Rica
Cuba
Dominica
Dominican Republic
Ecuador
El Salvador
French Guiana
Grenada
Guadeloupe
Guatemala
Guyana
Haiti
Honduras
Jamaica
Martinique
Montserrat
Netherlands Antilles
Nicaragua
Panama
Puerto Rico
St. Kitts & Nevis
St. Lucia
St. Pierre et Miquelon
St. Vincent and The Grenadines
Suriname
Trinidad and Tobago
Turks And Caicos Islands
United States Virgin Islands
Venezuela

Mexico

Mexico

Rest of South America

Argentina
Bolivia (Plurinational State of)
Brazil
Chile
Paraguay
Peru
Uruguay

AFRICA**North Africa/Easter Mediterranean**

Algeria
Egypt
Lebanon
Libya
Mediterranean, Other
Morocco
Syrian Arab Republic
Tunisia

West Africa

Angola
Benin
Cameroon
Republic of Congo
Côte d'Ivoire
Democratic Republic of Congo
Equatorial Guinea
Gabon
Ghana
Guinea
Guinea-Bissau
Liberia
Mali
Mauritania
Niger
Nigeria
Senegal
Sierra Leone
Togo

East/South Africa

Botswana
Burkina Faso
Burundi
Cape Verde
Central African Republic

Chad
Comoros
Djibouti
Eritrea
Eswatini
Ethiopia
Gambia
Kenya
Lesotho
Madagascar
Malawi
Mauritius
Mayotte
Mozambique
Namibia
Réunion
Rwanda
Sao Tome and Principe
Seychelles
Somalia
South Africa
South Sudan
Sudan
Uganda
United Republic of Tanzania
Western Sahara
Zambia
Zimbabwe

EUROPE

North Europe

Austria
Belgium
Denmark
Finland
Germany
Iceland
Ireland
Luxembourg
Netherlands
Norway
Sweden
Switzerland
United Kingdom

South Europe

Cyprus
France
Gibraltar
Greece
Italy
Malta
Portugal
Spain
Türkiye

Eastern Europe

Albania
Belarus
Bosnia and Herzegovina
Bulgaria
Croatia
Czech Republic
Estonia
Hungary
Latvia
Lithuania
Montenegro
Poland
Republic of Moldova
Romania
Serbia
Slovakia
Slovenia
Republic of North Macedonia
Ukraine

RUSSIA & CASPIAN

Caspian Region

Armenia
Azerbaijan
Georgia
Kazakhstan
Kyrgyzstan
Tajikistan
Turkmenistan
Uzbekistan

Russia

Russian Federation



MIDDLE EAST

Bahrain
 IR Iran
 Iraq
 Jordan
 Kuwait
 Oman
 Qatar
 Saudi Arabia
 United Arab Emirates
 Yemen

Lao People's Democratic Republic
 Maldives
 Micronesia, Federated States of
 Mongolia
 Myanmar
 Nauru
 Nepal
 New Caledonia
 Niue
 Pakistan
 Papua New Guinea
 Samoa
 Solomon Islands
 Sri Lanka
 Timor-Leste
 Tonga
 Vanuatu
 Viet Nam

ASIA-PACIFIC**Pacific Industrialized**

Australia
 Japan
 New Zealand

Pacific High Growth

Brunei Darussalam
 Indonesia
 Malaysia
 Philippines
 Republic of Korea
 Singapore
 Thailand

China

People's Republic of China

Rest of Asia

Afghanistan
 American Samoa
 Bangladesh
 Bhutan
 Cambodia
 Cook Islands
 Fiji
 French Polynesia
 Guam
 India
 Democratic People's Republic of Korea
 Kiribati

Annex D

Major data sources

AG Energiebilanzen
 Airbus
 American Chemical Society (ACS)
 American Petroleum Institute (API)
 Argus Media
 Asia-Pacific Economic Cooperation (APEC)
 Baker Hughes
 Barclays Research
 Bloomberg
 Boeing
 Brazil, Ministry of Mines and Energy
 Brookings Institute
 Bunkerworld
 Canada, National Energy Board
 Canadian Association of Petroleum Producers
 Canadian Energy Research Institute
 Center for Strategic and International Studies (CSIS)
 China National Petroleum Corporation (CNPC)
 Citigroup
 Climate Action Tracker
 Consensus forecasts
 Deloitte
 Deutsche Bank
 E&P Magazine
 The Economist
 Economist Intelligence Unit
 Energy Institute Statistical Review of World Energy
 Energy Intelligence Group
 Energy Research Institute of the Russian Academy of Sciences (ERI RAS)
 EnSys Energy & Systems, Inc
 Equinor
 Ernst & Young
 EUREL
 European Automotive Manufacturers Association (ACEA)
 European Commission (EC)
 European Council
 European Environment Agency
 Eurostat
 Financial Times
 FrauenHofer Institute
 Gas Exporting Countries Forum (GECF)
 Global Carbon Capture and Storage Institute (GCCSI)
 Global Commission on the Economy and Climate
 Global Wind Energy Council
 Goldman Sachs
 GSMA Intelligence
 Harvard Business Review
 Haver Analytics
 HSBC
 Hydrocarbon Processing
 International Commodities Exchange
 IEA Monthly Oil Data Service (MODS)
 IEA Oil Market Report
 IEA World Energy Outlook
 IHS Markit
 IMF, Direction of Trade Statistics
 IMF, International Financial Statistics

ANNEX D: MAJOR DATA SOURCES

IMF, Primary Commodity Prices
IMF, World Economic Outlook
India, Ministry of Petroleum & Natural Gas
India Times
Institute of Energy Economics, Japan (IEEJ)
Institut Français du Pétrole (IFP)
Interfax Global Energy
Intergovernmental Panel on Climate Change (IPCC)
International Air Transport Association (IATA)
International Association for Energy Economics (IAEE)
International Atomic Energy Agency (IAEA)
International Civil Aviation Organization (ICAO)
International Council on Clean Transportation (ICCT)
International Maritime Organization (IMO)
International Monetary Fund (IMF)
International Renewable Energy Agency (IRENA)
International Road Federation, World Road Statistics
International Union of Railways (UIC)
Japan, Ministry of Economy, Trade and Industry (METI)
Japan Automobile Manufacturers Association, Inc (JAMA)
Joint Aviation Authority (JAA)
Joint Organisations Data Initiative (JODI)
Journal of Petroleum Technology
Kennedy School of Government, Harvard University
McKinsey Global Institute
National Development and Reform Commission (NDRC)
National Energy Administration of the People's Republic of China (NEA)
National Renewable Energy Laboratory
Natural Gas World Magazine
New York Mercantile Exchange
OECD Trade by Commodities
OECD/IEA, Energy Balances of non-OECD countries
OECD/IEA, Energy Balances of OECD countries
OECD/IEA, Energy Statistics of non-OECD countries
OECD/IEA, Energy Statistics of OECD countries
OECD/IEA, Quarterly Energy Prices & Taxes
OECD, International Trade by Commodities Statistics
OECD International Transport Forum, Key Transport Statistics
OECD, National Accounts of OECD Countries
OECD Economic Outlook
Oil & Gas Journal
OPEC Annual Statistical Bulletin (ASB)
OPEC Fund for International Development (OFID)
OPEC Monthly Oil Market Report (MOMR)
OPEC World Oil Outlook (WOO)
Oxford Economics
Oxford Institute for Energy Studies
Petrobras
Petroleum Economist
Petroleum Intelligence Weekly
Platts
PricewaterhouseCoopers
pv Europe
Reserve Bank of Australia
Reuters
Rystad Energy
Seatrade



Siemens AG
 Society of Petroleum Engineers (SPE)
 Solomon Associates
 Sustainable Energy for All
 The Economic Times
 Turner Mason and Company
 UN Department of Economic and Social Affairs
 UN Energy Statistics
 UN Food and Agriculture Organization (FAO)
 UN International Trade Statistics Yearbook
 UN National Account Statistics
 UN Conference on Trade and Development (UNCTAD)
 UN Development Programme (UNDP)
 UN Economic and Social Commission for Asia and the Pacific (UNESCAP)
 UN Educational, Scientific and Cultural Organization (UNESCO)
 UN Environment Programme (UNEP)
 UN Framework Convention on Climate Change (UNFCCC)
 UN International Labour Organisation (ILO)
 UN Statistical Yearbook
 UN World Tourism Organization (UNWTO)
 US Bureau of Labor Statistics
 US Department of Energy (DoE)
 US Department of the Interior (DoI)
 US Energy Information Administration (EIA)
 US Environmental Protection Agency (EPA)
 US Geological Survey (USGS)
 Wall Street Journal
 World Bank
 World Coal Association
 World Coal Institute
 World Energy Council
 Wood Mackenzie
 World Economic Forum
 World Nuclear Association
 World Resources Institute
 World Trade Organization (WTO), International Trade Statistics



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