Organization of the Petroleum Exporting Countries

2021 World Oil Outlook 2045

15th edition

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2045

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Foreword

When last year's **World Oil Outlook (WOO)** was launched in **October 2020** much of the world was heading into a second wave of the **COVID-19** pandemic. It would see countries enter into renewed lockdowns, with further humanitarian and economic repercussions.

It was a period of continuing massive uncertainty, and for oil, and energy markets, it would require a renewed focus on **balancing supply and demand** and reestablishing **sustainable stability**, such as through the **Declaration of Cooperation (DoC)**.

As we headed into **2021**, beyond the benefits of the **DoC's** production adjustments in bringing down inventory levels, the market was also buoyed by the **rollout of vaccines** and further **global fiscal stimulus**. While this year has not been without its challenges, we have not revisited the roller-coaster ride of **2020**.

We are optimistic about the path ahead, although it is vital we see further **international commitments** to **support developing countries** in acquiring **sufficient vaccines**, and thus improve the chances for a **durable and inclusive recovery**.

The **WOO 2021**, now in its **15th edition**, takes on board the **shifting dynamics** of the past year, particularly those presented by the **COVID-19** pandemic. Our excellent researchers and analysts have produced a thorough and **comprehensive publication** that examines the future prospects for the **global economy**, **energy and oil demand**, **supply**, **refining and oil trade**, as well as other drivers, such as **policies**, **technologies** and **sustainable development concerns**.

Moreover, it also explores a **number of sensitivities** that may shift the outlook in different directions in the years and decades to come.

What is clear in this year's **WOO** is that **energy and oil demand have picked up significantly in 2021**, after the massive drop in **2020**, and continued expansion is forecast for the longer-term.

Global primary energy demand is expected to increase by **28%** in the period between **2020 and 2045**, with all energies required, driven by an expected **doubling in size of the global economy** and the addition of around **1.7 billion people** worldwide by **2045**. All energies witness growth, with the exception of coal. **Renewables** see the largest growth, followed by **gas**, but **oil** is still expected to retain its **number one** position in the **energy mix**.

To meet this demand requires **huge investments**. It is clear that underinvestment remains one of the great challenges for the oil industry and this was exacerbated by the **COVID-19** pandemic. Over the course of **2020**, investments **declined** by around **30%**. Without the necessary investments, there is the potential for further **volatility** and a future energy shortfall, which is **not in the interests of either producers or consumers**.

OPEC Member Countries remain committed to **supporting investments**, which benefit from sustainable **market stability** and the right enabling environment. This is a **core focus** of the **DoC**.

In the lead up to **November's COP26** in **Glasgow**, **Scotland**, held under the presidency of the **United Kingdom**, the **WOO** also examines **climate and environmental policies** and the issues surrounding the **energy transition**. It is clear that the challenge of **tackling emissions** has **many paths** and we need to explore them all; we need to look for **cleaner and more efficient technological solutions** across all available energies.

Directly linked to the energy transition is **energy poverty**, which has been further exacerbated by the knock-on impacts of **COVID-19**. We need to keep in mind that **Sustainable Development Goal number seven** of the **United Nations (UN)** focuses on ensuring access to **affordable, reliable, sustainable and modern energy for all people**.

The core elements of the **UN Framework Convention on Climate Change (UNFCCC)**, particularly **equity**, **historical responsibility and national circumstances**, must be considered at all junctures moving forward.

Once again, this year's **WOO** is an informative and indispensable reference tool for all energy stakeholders, further underscoring the Organization's commitment to **impartial analysis**, **data transparency**, and to the enhancement of **dialogue and cooperation**. This can be viewed in the valuable contribution of our key energy dialogue partner, **India**, in **Chapter 9**.

I would like to personally thank the hard work, drive and steadfastness of the **OPEC Secretariat staff** that have been involved in producing the **WOO**. For the second year it has not been an easy task, given the restrictions on office-based working, but I salute each and every one of you for your **dedication** and **commitment** to delivering this **flagship annual publication**.

As we have reached the end of **OPEC's 60th Anniversary** year, the **WOO 2021** is a fitting bookend, once again highlighting **OPEC's** unshakable focus on evolving a better understanding of our **possible energy futures**, and the **challenges and opportunities** we all face.

Mohammad Sanusi Barkindo
Secretary General

Executive Summary

The **World Oil Outlook (WOO)** presents **OPEC's** medium- to long-term analysis and projections for the **global economy, oil and energy demand, liquids supply and oil refining, as well as related policy and technology matters**. This includes analysis of the energy industry's various linkages and its shifting dynamics. The detailed review in this Outlook includes breakdowns by region, sector and timeframe. The forecast period in this **15th edition** of the Outlook extends to **2045** and the short-term outlook is consistent with the **July 2021 edition of OPEC's Monthly Oil Market Report (MOMR)**.

Signs of strong economic recovery are evident

While the first signs of a strong economic recovery from the COVID-19-induced crisis are evident in quarterly growth rates, declining unemployment, business optimism and stock market valuations, there is also enormous potential for a huge rebound to follow as pent-up demand is satisfied, aided by the lasting effect of huge stimulus and infrastructure packages. On the other hand, worries persist about the pace and trajectory of this recovery, the spread of COVID-19 variants, rising inflation, and how to unwind the massive quantitative easing programmes launched by many central banks that have helped to underpin the rebound.

OPEC and countries participating in the Declaration of Cooperation (DoC) continue efforts to stabilize oil markets

OPEC, together with other countries participating in the DoC, having proved its value in helping stabilize the market in unprecedented circumstances during the pandemic and its fall-out, have extended the decision of the 10th OPEC and non-OPEC Ministerial Meeting (April 2020) until the end of 2022.

The COVID-19 pandemic has affected the global economy in multiple ways

The impact of the pandemic and the response mechanisms that have been developed, will have a considerable impact on medium-term economic growth. It is too early to judge the full consequences, but some trends and dynamics can already be discerned.

An important trend that began beforehand, but was accentuated during the pandemic is the move towards a more localized and less intertwined global economy. Another important consequence of the pandemic has been rapidly rising global debt levels. Fiscal and monetary stimulus including guarantees account for around $24 trillion. The challenges related to escalating debt levels have become an increasing concern, particularly given the active talk around inflation in 2021 and the potential for rising future interest rates and tax levels. Adding to this is the drop-off in travel and tourism and how long this continues, as well as the potential for improving productivity from the pandemic-induced drive towards digitalization and artificial intelligence (AI).

GDP growth is projected to average 3.1% p.a. over the forecast period (2020–2045), slowing from 3.8% p.a. in the medium-term to 2.7% p.a. from 2035–2045

After the 2021 recovery, with gross domestic product (GDP) growth forecast at 5.5%, it is expected that growth will slow to around 4% in 2022 and then move back to levels slightly above 3%. It is then anticipated to move slightly higher to reach 3.2% at the end of the medium-term period in 2026. In OECD economies, growth is forecast to materialize more at the beginning of the medium-term

Long-term annual real GDP growth rates *% p.a.*

	2020–2026	2026–2035	2035–2045	2020–2045
OECD	2.6	1.7	1.6	1.8
Non-OECD	4.8	4.0	3.4	3.9
World	**3.8**	**3.1**	**2.7**	**3.1**

Source: OPEC.

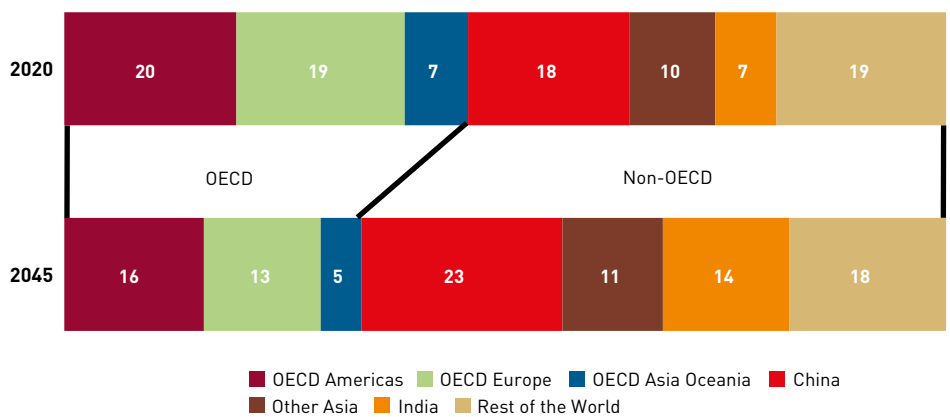
period due to pent-up demand and the massive fiscal stimulus to counter the impacts of the pandemic. The medium-term growth outlook in developing countries is anticipated to be relatively diverse with the highest growth rates projected for India and China.

Global GDP growth between 2020 and 2045 is expected to increase at an average rate of 3.1% per annum (p.a.) Global growth through to 2045 will be largely driven by non-OECD countries. These are expected to expand by 3.9% p.a. on average, on the back of improving labour productivity and a growing working age population, even as the pace of GDP growth begins to slow in the long-term.

The global economy in 2045 will be more than double the size it was in 2020

Based on 2017 purchasing power parity (2017 PPP), global GDP is projected to rise from around $125 trillion in 2020 to almost $270 trillion in 2045. China and India combined are expected to account for 37% of global GDP in 2045. The Organisation for Economic Co-operation and Development (OECD) is set to account for slightly less, at 34%.

Distribution of the global economy in 2020 and 2045 %



Source: OPEC.

Significant demographic shifts will accompany future population growth

The global population is expected to reach 9.5 billion people by 2045. Future demographic trends are marked by an ageing population, a rising working-age population and increases in urbanization and migration rates. The global working-age population (15–64) is projected to rise by around 900 million throughout the projection period, driven by non-OECD countries. However, the relative share of the global working-age population to the world's total population is anticipated to drop from 65% in 2019 to 63% in 2045. By 2045, approximately 66% of the world's population is projected to be urbanized. The OECD is projected to experience a rise in its net migration rate of approximately 4.7% by 2045, whereas the developing world is projected to undergo an outflow of population.

Recent changes in energy policies focus on accelerating energy transition

There is growing awareness among policymakers in many countries that there is a need to accelerate actions to address climate change, which have recently resulted in ambitious new policy intentions to achieve net-zero emissions by 2050. Several major countries and regions – including the European Union (EU), the United States (US), Japan, the United Kingdom (UK), Canada and Brazil – have proposed roadmaps to meet these goals, with China targeting carbon-neutral growth by 2060.

At the same time, there is increased public acceptance of products and services with a lower environmental footprint, and a state of technology development that offers solutions – even if they come at a higher cost. These trends are being observed at a time when the post-COVID-19 recovery plans in some major economies provide significant sources of funding that could accelerate the energy transition.

Global energy demand is set to increase from 275.4 mboe/d in 2020 to 352 mboe/d by 2045

Non-OECD primary energy demand is expected to constitute well over 70% of global primary energy demand in the long-term, growing from 174 million barrels of oil equivalent a day (mboe/d) in 2020 to 250 mboe/d in 2045. This growth is mainly attributable to increasing populations and growing economies in Asia, Africa and the Middle East.

For the OECD region, energy demand is set to flatten in the long-term. This underscores a further decoupling from economic growth due to structural changes and a policy push that continues to place increasing emphasis on energy efficiency and the deployment of low-carbon energy technologies. After a partial recovery from the impact of the COVID-19 pandemic, energy demand in the region is set to peak in the medium-term before declining to around 102 mboe/d by 2045, reaching a level similar to that seen in 2020.

Total primary energy demand per region, 2020–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Share *%*	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
OECD	101.5	107.9	107.0	105.3	103.4	102.1	0.6	0.0	36.9	29.0
Non-OECD	173.9	195.7	212.3	227.0	240.9	249.9	76.0	1.5	63.1	71.0
World	**275.4**	**303.6**	**319.3**	**332.3**	**344.3**	**352.0**	**76.6**	**1.0**	**100.0**	**100.0**

Source: OPEC.

Oil is forecast to remain the fuel with the largest share of the global energy mix until 2045

Primary oil demand is set to increase in the long-term from 82.5 mboe/d in 2020 to 99 mboe/d in 2045. Despite decelerating oil demand growth in the second part of the forecast period and strong growth in other energy sources, such as other renewables, gas and nuclear, oil is expected to retain the highest share in the global energy mix during the entire period. In 2020, oil accounted for 30% of global energy requirements. Alongside post-pandemic oil demand recovery, the share of oil is anticipated to gradually increase to a level of more than 31% by 2025, before it begins a decline and reach 28% by 2045.

'Other renewables' and natural gas are projected to contribute most to future incremental energy demand

Demand for other renewables is projected to expand from 6.8 mboe/d in 2020 to 36.6 mboe/d in 2045, representing the single-largest incremental contribution to the future energy mix. Moreover, it is also the fastest-growing energy source with its share in the global primary energy mix above 10% in 2045, up from just 2.5% in 2020. This is driven by falling costs and policies focused on reducing emissions.

Gas demand is expected to increase by 21.6 mboe/d between 2020 and 2045. This brings total gas demand to 85.7 mboe/d in 2045, thus becoming the second-largest fuel in the energy mix.

World primary energy demand by fuel type, 2020–2045

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Fuel share %	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
Oil	82.5	94.5	97.3	98.6	98.9	99.0	16.5	0.7	30.0	28.1
Coal	72.9	74.4	71.7	67.9	64.4	61.3	–11.7	–0.7	26.5	17.4
Gas	64.2	69.8	74.8	79.5	83.2	85.7	21.6	1.2	23.3	24.4
Nuclear	14.3	16.0	17.5	19.0	20.7	22.0	7.6	1.7	5.2	6.2
Hydro	7.5	8.2	8.9	9.5	10.2	10.5	3.0	1.4	2.7	3.0
Biomass	27.2	29.4	31.7	33.8	35.7	37.0	9.7	1.2	9.9	10.5
Other renewables	6.8	11.3	17.4	24.0	31.2	36.6	29.8	7.0	2.5	10.4
Total	**275.4**	**303.6**	**319.3**	**332.3**	**344.3**	**352.0**	**76.6**	**1.0**	**100.0**	**100.0**

Source: OPEC.

More stringent policies are set to reduce coal demand by almost 12 mboe/d during the forecast period

Medium- to long-term coal demand is forecast to drop meaningfully across all OECD regions. This is most dramatic in OECD Europe, where it falls by 5.5% p.a. over the forecast period. China's coal demand is expected to slow to a plateau in the medium-term and then see a significant drop in the longer-term. At the global level, demand for coal is set to decline by almost 12 mboe/d, primarily due to measures targeting emissions reduction.

Oil demand is projected to reach a level of 104.4 mb/d by 2026

The global oil demand increase over the medium-term period (2020–2026) is estimated at 13.8 million barrels a day (mb/d). However, almost 80% of this incremental demand will materialize within the first three years (2021–2023), primarily as part of the recovery process from the COVID-19 crisis. OECD oil demand is expected to increase by almost 4 mb/d in the period to 2026. However, all of this increase will not be sufficient to return to pre-COVID-19 demand levels. Non-OECD demand is anticipated to increase by almost 10 mb/d over the medium-term, with around half of this increase needed to offset the demand decline in 2020.

Global oil demand is expected to increase by 17.6 mb/d between 2020 and 2045

Global oil demand is forecast to rise by 17.6 mb/d between 2020 and 2045, growing from 90.6 mb/d in 2020 to 108.2 mb/d in 2045. Long-term projections highlight a contrasting demand picture between continued growing demand in the non-OECD and declining demand in the OECD. This trend is set to start already in the medium-term, before intensifying over the long-term. OECD oil demand is projected to peak at levels around 46.6 mb/d in 2023, before it starts a longer-term decline towards a level of 34 mb/d by 2045.

In contrast, oil demand is set to continue to grow in the non-OECD region. Driven by an expanding middle class, high population growth rates and stronger economic growth potential, oil demand in this group of countries is expected to increase by 25.5 mb/d between 2020 and 2045, reaching a level of 74.1 mb/d in 2045.

Oil demand in the Reference Case, 2019–2045 *mb/d*

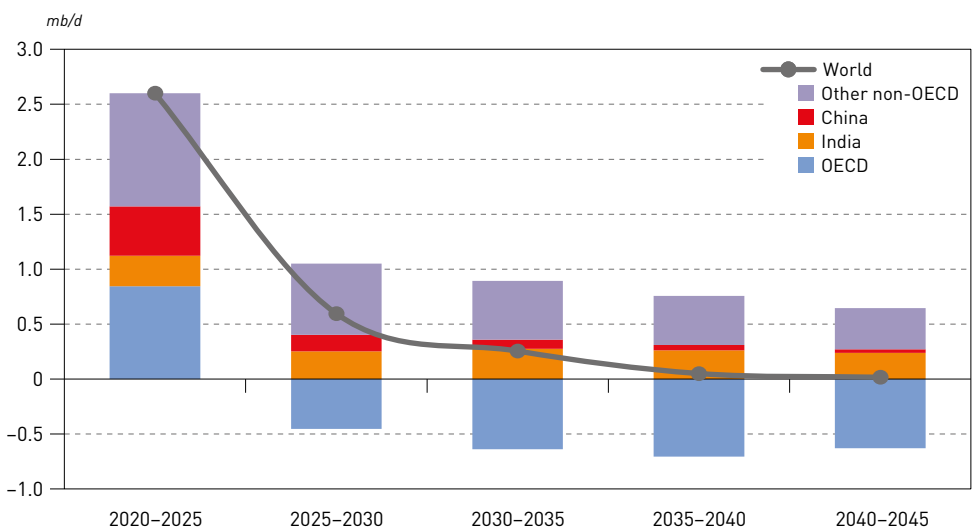
	2019	2020	2025	2030	2035	2040	2045	Growth 2020–2045
OECD	47.7	42.1	46.3	44.0	40.8	37.3	34.2	–7.9
Non-OECD	52.3	48.6	57.3	62.6	67.1	70.8	74.1	25.5
World	**100.0**	**90.6**	**103.6**	**106.6**	**107.9**	**108.1**	**108.2**	**17.6**

Source: OPEC.

Global oil demand set to plateau during the second half of the outlook period

Projections highlight the front-loaded pattern for future demand growth. Annual oil demand growth averages 2.6 mb/d during the first five years of the forecast period. Average annual growth is then expected to slow significantly during the second five-year period to 0.6 mb/d, and further to 0.3 mb/d during the period from 2030–2035. After that, projections indicate a plateauing of oil demand at the global level.

Average annual oil demand increments by region, 2020–2045

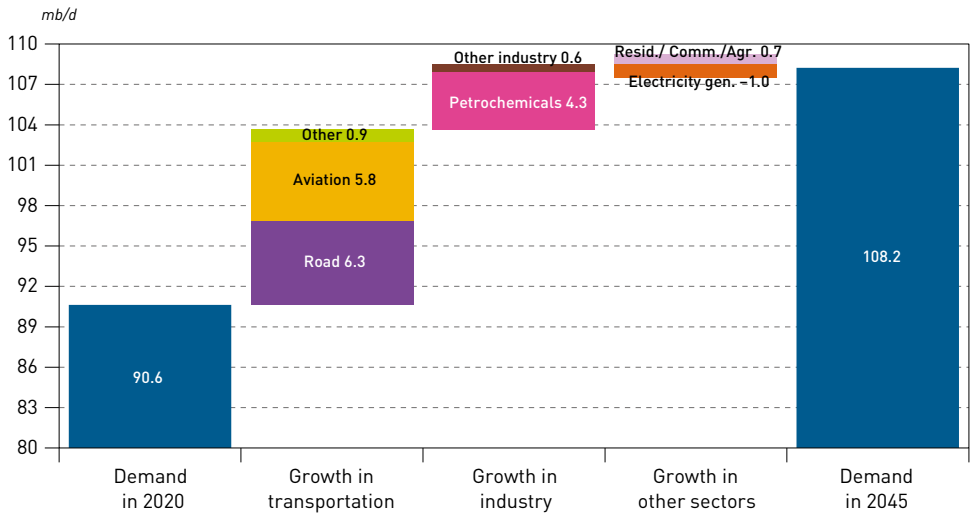


Source: OPEC.

Significant demand increase projected to come from road transportation and aviation sectors

The transportation sector is forecast to be the major contributor to future incremental demand, adding 13 mb/d between 2020 and 2045. More than 90% of this increase is projected to come from the road transportation and aviation sectors, each contributing around 6 mb/d, though a large part of these increases is due to the sharp demand decline in these two sectors in 2020. However, adjusting long-term projections for the demand decline in 2020, the petrochemical sector remains the largest source of incremental demand to 2045, similar to last year's Outlook.

Oil demand growth by sector, 2020–2045

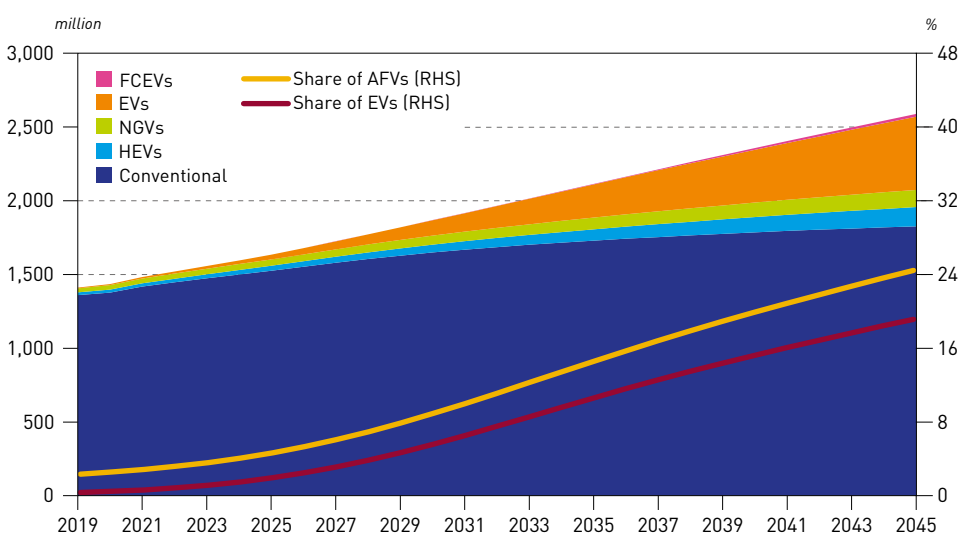


Source: OPEC.

Long-term oil demand growth will be limited by growing penetration of electric vehicles (EVs)

The total vehicle fleet is expected to reach 2.6 billion by 2045, increasing by around 1.1 billion from the 2020 level. EVs are set to approach 500 million by 2045, representing almost 20% of the global fleet. Some growth is also projected for natural gas vehicles (NGVs), with an expected increase of 80 million projected between 2020 and 2045. As a result, internal combustion engine (ICE) vehicles are set to maintain their leading role in the composition of the global fleet. The outlook sees ICEs constitute about 76% of the global vehicle population by 2045, largely sustained by the fleet size

Composition of the global vehicle fleet, 2020–2045



Source: OPEC.

increase in developing regions. These developments are expected to keep road transportation oil demand in a narrow range of 46 mb/d to 46.5 mb/d after 2025.

Non-OPEC liquids to rebound in the medium-term

Non-OPEC liquids supply is set to continue its recovery and regain pre-pandemic levels in the course of 2022. As oil demand picks up again with the world economy expanding rapidly, in addition to the market stabilization efforts of OPEC and other participating countries in the DoC, fundamentals look set to remain stable and supportive, encouraging a return to upstream activity and investments. As such, non-OPEC total liquids supply is projected to rise from 62.9 mb/d in 2020 to 70.4 mb/d in 2026. The key contributors to growth are the US, Brazil, Russia, Guyana, Canada, Kazakhstan, Norway and Qatar.

US tight oil is a key driver of growth in the medium-term but peaks around 2030

Supportive market fundamentals should incentivize a return to growth for US tight oil production from 2022, which is expected to rise from 11.5 mb/d in 2020 to 14.8 mb/d in 2026. Tight oil output is expected to peak at 15.2 mb/d in the late 2020s, with US total liquids hitting a maximum of around 20.5 mb/d around the same time.

In the long-term, non-OPEC liquids supply declines, while OPEC sees an increase in its market share

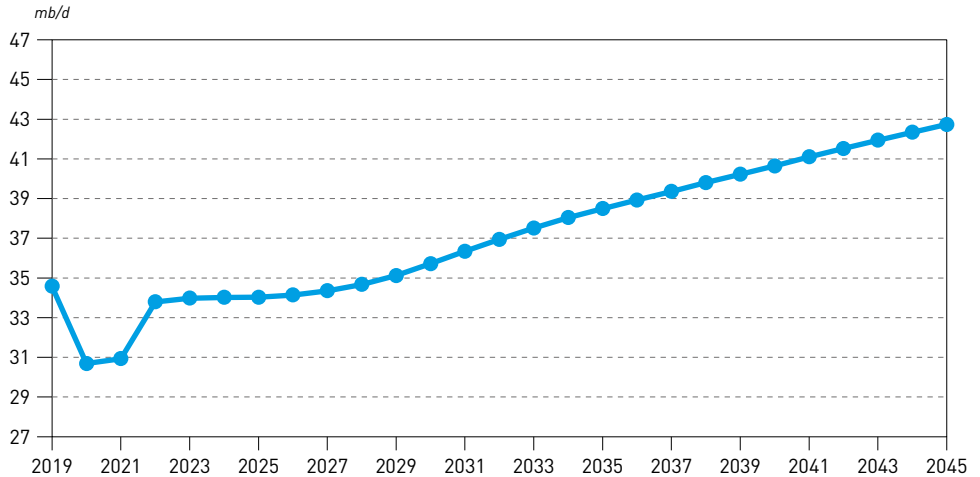
In the long-term, after US liquids supply peaks, total non-OPEC liquids output is set to decline from a peak of 71 mb/d around 2030 to 65.5 mb/d in 2045, basically level with pre-pandemic 2019. As a result, OPEC liquids, which are expected to recover to pre-pandemic levels around the mid-2020s, rise further, increasing from 35.7 mb/d in 2030 to 42.7 mb/d in 2045. OPEC's global market share rises from 33% in 2020, to 39% in 2045.

Long-term global liquids supply outlook *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Change 2020–2045
US	18.4	17.6	20.3	20.3	19.3	18.1	16.9	–0.7
of which: tight liquids	*11.7*	*11.5*	*14.5*	*15.2*	*15.0*	*14.2*	*13.3*	*1.8*
OECD	**30.0**	**29.1**	**32.8**	**32.4**	**31.0**	**29.5**	**28.1**	**–1.0**
Non-OECD	**33.2**	**31.6**	**34.5**	**35.9**	**35.5**	**35.0**	**34.2**	**2.6**
Processing gains	**2.4**	**2.2**	**2.5**	**2.7**	**2.9**	**3.0**	**3.1**	**1.0**
Non-OPEC	**65.5**	**62.9**	**69.8**	**71.0**	**69.4**	**67.5**	**65.5**	**2.5**
Crude	*45.8*	*43.5*	*48.0*	*47.5*	*44.7*	*41.9*	*39.3*	*–4.1*
NGLs	*11.0*	*11.2*	*12.3*	*13.3*	*13.8*	*14.0*	*14.1*	*2.8*
Global biofuels	*2.6*	*2.4*	*2.8*	*3.2*	*3.5*	*3.8*	*3.9*	*1.5*
Other liquids	*3.8*	*3.7*	*4.1*	*4.3*	*4.6*	*4.8*	*5.0*	*1.4*
Total OPEC liquids	**34.6**	**30.7**	**34.0**	**35.7**	**38.5**	**40.6**	**42.7**	**12.0**
World	**100.1**	**93.6**	**103.8**	**106.7**	**107.9**	**108.1**	**108.2**	**14.6**

Source: OPEC.

OPEC total liquids supply



Source: OPEC.

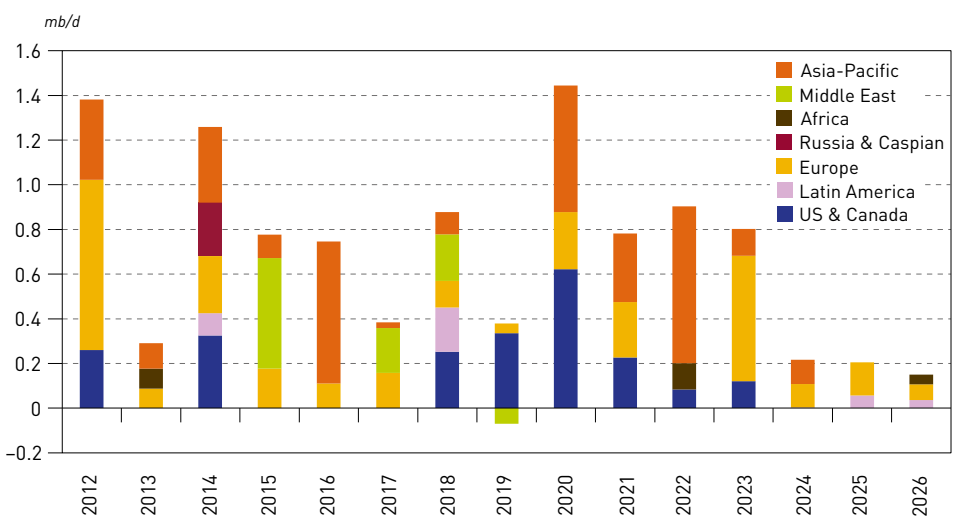
Oil-related investment requirements total $11.8 trillion, 80% of which is needed in the upstream

Cumulative investment requirements in the oil sector amount to $11.8 trillion in 2021–2045. Of this, 80% or $9.2 trillion, is directed towards the upstream, the bulk of which is in North America, as US tight oil, in particular, drives medium-term non-OPEC supply growth. Downstream and midstream investment needs, in order to expand and maintain the associated refinery, storage and pipeline systems required to bring oil to market, necessitate another $1.5 and $1.1 trillion, respectively.

The effect of strong distillation capacity additions is set to be offset by expected medium-term refinery closures of 4.5 mb/d

In the medium-term, 6.9 mb/d of new refining capacity is expected, in line with strong demand prospects in developing regions. Given global oil demand trends, this would lead to a distillation

Refinery closures by region, recent and projected



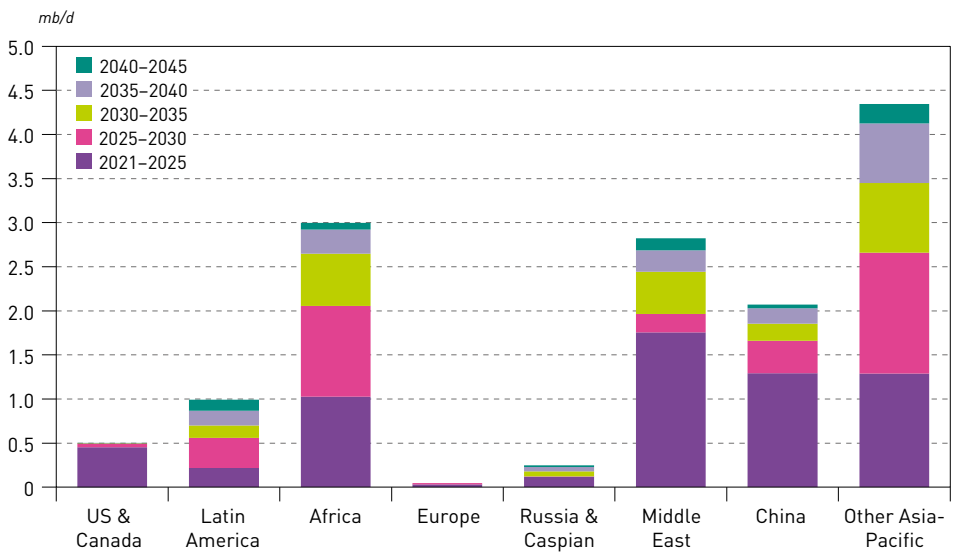
Source: OPEC.

capacity overhang by 2026. However, during the ongoing rationalization wave, accelerated by the 2020 demand shock and the strategy shifts of some oil companies, around 4.5 mb/d of refining capacity could be shut in, mostly in developed regions. This should help balance out the downstream market in the medium-term.

Crude distillation capacity is expected to increase by 14 mb/d between 2021 and 2045, with a significant slowdown in the rate of required additions

Global refining distillation additions are projected at 14 mb/d between 2021 and 2045, of which 6.9 mb/d is in the medium-term (by 2026) and 7.1 mb/d beyond 2026. In line with oil demand patterns, almost 95% of the total additions is expected in developing regions, including the Asia-Pacific (6.4 mb/d), the Middle East (2.8 mb/d), Africa (3 mb/d) and Latin America (1 mb/d). However, the rate of distillation additions is expected to decelerate considerably throughout the outlook period with minor global additions beyond 2040.

Crude distillation capacity additions in the Reference Case, 2021–2045



Source: OPEC.

Significant additions of secondary capacity will be driven by stricter product specifications and a shift to high quality products

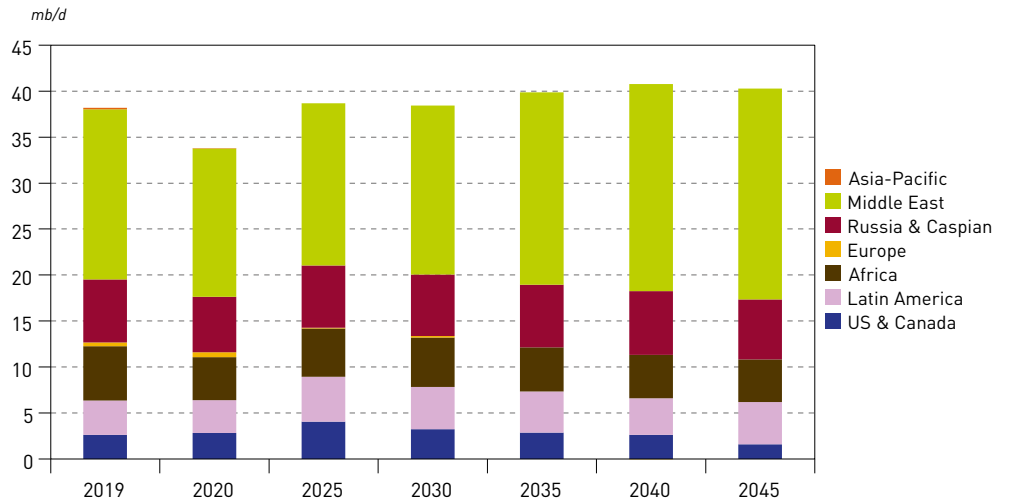
At the global level, projections indicate the need to add some 7.1 mb/d of conversion units, 16.7 mb/d of desulphurization capacity and 4.7 mb/d of octane units in the period 2021–2045, to go with 14 mb/d of new distillation capacity. This is supported by stricter product specifications and a shift to higher-quality refined products.

Global crude and condensate trade set to recover from the 2020 shock with a gradual long-term increase and significant regional shifts

After the drop in 2020, global crude and condensate trade is projected to reach levels above 38 mb/d in 2025 and 2030 and 40 mb/d and above from 2035 onwards. This is supported by increased oil demand in the Asia-Pacific and rising crude and condensate supply in the Middle East. In the longer-term, Middle East crude and condensate exports are projected to increase to almost 23 mb/d in 2045, up from 18.5 mb/d in 2019, and in line with rising demand for OPEC

liquids. Consequently, the share of the Middle East in the global crude and condensate trade increases to 57% in 2045, from 48% in 2019.

Global crude and condensate exports by origin*, 2019–2045



* *Only trade between major regions is considered.*

Source: OPEC.

Asia-Pacific crude and condensate imports are projected to grow in the long-term with an increasing share of imports from the Middle East

Asia-Pacific will remain the most important region in terms of crude and condensate imports in the long-term. The overall import volumes are expected to increase from around 23.5 mb/d in 2019 (22 mb/d in 2020) to almost 30 mb/d by 2045. The Middle East remains the main supplier to the Asia-Pacific, with flows increasing to above 19.5 mb/d by 2045, which is around 4.8 mb/d higher relative to levels seen in 2019.

The pandemic has affected UN climate change and sustainable development processes, with implications for the implementation of the Paris Agreement and the 2030 Agenda

The year 2020 saw little progress in United Nations (UN) climate negotiations owing to COVID-19. Climate diplomacy moved to informal discussions held in virtual mode, whereas COP26 and the sessions of the UN Framework Convention on Climate Change (UNFCCC) subsidiary bodies were postponed until 2021. A number of Parties announced their new targets and measures, yet the estimated emission reductions resulting from their implementation fall far short of what is required to achieve a target well below 2°C.

The fulfilment of developed countries' commitments on critical issues such as climate finance would be required for all countries to be able to enhance their mitigation action and reduce vulnerability to the harmful effects of climate change. Intense negotiations are expected in Glasgow, Scotland, beginning on 31 October 2021, for Parties to resolve outstanding negotiation issues required for the full operationalization of the Paris Agreement.

With the pandemic having undermined years of development efforts, progress made on the implementation of a number Sustainable Development Goals (SDGs) has either stalled or reversed. The

world is still short of achieving universal energy access. Eradication of energy poverty should, therefore, remain an overarching goal for resilient and sustainable development. International cooperation and solidarity are more important than ever. The central principle of the 2030 Agenda – to leave no one behind – must be kept at the heart of efforts toward achieving all SDGs.

Uncertainties on future economic development, energy policies and technology have widened the range of possible oil demand and supply trajectories

Developments during the past year have made it clear that there are a number of uncertainties related to the main factors affecting future oil demand. In respect to the global economy, the risk for oil demand over the medium-term is skewed to the downside and primarily related to a potentially extended pandemic situation. In the long-term, the risk is rather symmetric with each path deviating from the Reference Case by more than 6 mb/d at the end of the forecast period.

The faster implementation of more stringent policies and penetration of energy efficient technologies could reduce future oil demand by more than 8 mb/d in 2045, compared to the Reference Case. Oil demand in the road transportation sector alone could be reduced by some 3 mb/d in 2045.

With regard to non-OPEC supply, different assumptions for investment, project timing, policies and technology are modelled in Lower and Higher Supply Cases, with risks heavily skewed to the downside. In the Lower Case, US tight oil declines gradually until a modest rebound is seen in the latter part of the 2020s, although it never again reaches pre-pandemic levels. This opens up a potential downside of nearly 4 mb/d at peak. In other non-OPEC countries, project cancellations, lower investment and to some extent policy measures curb as much as 3 mb/d in the long-term. The Higher Supply Case projects a US tight oil production upside of around 1 mb/d, while output in other non-OPEC countries adds 2.5 mb/d in the long-term.

Introduction

Reflecting back on 2021, and to the WOO 2020 published one year ago, it is clear that many uncertainties still abound. This past year has seen the global rollout of a suite of COVID-19 vaccines, albeit with an incomplete and highly divergent reach, and much remains to be done in this regard. It is almost certain that countries and regions will face further waves of rising cases, more lockdowns and new measures to combat the pandemic – some of which may persist for quite a while yet. However, the vaccine rollout does appear to mark the beginning of beating back the pandemic and its fall-out.

While the first signs of a strong economic recovery are evident in quarterly growth rates, declining unemployment, business optimism and stock market valuations, there is also enormous potential for a huge rebound to follow as pent-up demand is satisfied, aided by the lasting effect of huge stimulus and infrastructure packages. On the other hand, worries persist about the pace and trajectory of this recovery, rising inflation, and how to unwind the massive quantitative easing (QE) programmes launched by many central banks that have helped to underpin the rebound.

Beyond the short- to medium-term, it remains to be seen whether some of the behavioural changes witnessed during the long lockdowns persist. Question marks abound over where and how we will live and work, and how this will change patterns of commuting, travel and consumption. Technology in its widest sense remains a wildcard, with extended lockdowns having made it clear to many just how dependent we are on it, but also how enabling it can be.

In the longer-term, minds are increasingly focusing on the need to address climate change. One of the Biden administration's first acts was to re-join the Paris Agreement. All G7 countries now have plans to significantly reduce emissions, and to reach 'net-zero' by 2050. China meanwhile has pledged to have emissions peak before 2030 and attain 'carbon-neutral growth' by 2060. In July 2021, the EU Commission spelled out details of an ambitious proposal to reduce emissions by 55% by 2030 (from 1990 levels) in the 'Fit for 55' package, which could, if implemented, bring forward the end of new ICE vehicle sales in the EU. The car manufacturing sector in many cases already appears to be gearing up towards a significant shift to EV sales, investing billions in drivetrain and battery technology. In the EU, a recent surge in EV sales is striking, in the face of overall lower car registrations in 2020.

OPEC and its Member Countries inherently support ambitions to decarbonize the energy mix, but it should be noted that the analysis underpinning this Outlook suggests there are still considerable doubts as to whether all these ambitious climate-mitigation commitments will be met in the proposed timeframe. For example, the EU Commission's 'Fit for 55' plan remains exactly that for the time being, a plan, which still needs to be negotiated and agreed by all EU Member States, leaving ample scope for exceptions and watering-down.

As such, and given developmental needs, this Outlook projects that oil will remain an important part of the mix for years to come, still making up 28% of the global energy mix in the Reference Case by 2045. This is based upon a return to pre-pandemic economic and oil demand levels during 2021–2022, and steady economic growth thereafter. Nonetheless, renewable energy sources will be the fastest-growing source of energy and will represent a vitally important part of the energy mix by 2045.

On the supply side, the DoC, having proved its value in helping stabilize the market in unprecedented circumstances during the pandemic and its fall-out, saw participants extend the decision of the 10th OPEC and non-OPEC Ministerial Meeting (April 2020) until the end of 2022. While non-OPEC supply is set to recover, and meet much of the demand for new oil in the medium-term and beyond, in the long-term, the burden is expected to be on OPEC Members to provide much of the oil to meet the world's needs.

This Outlook reviews and analyzes all these connected trends and shows detailed results for the future energy mix, as well as an in-depth look at oil demand, supply, downstream and trade. For the first time ever, it features a whole chapter dedicated to the outlook for India, the country likely to be key in driving long-term energy needs. Lastly, given as always, the large innate degree of uncertainty when making long-term projections, this year's WOO examines a number of oil demand and supply sensitivities.

Key assumptions

- The global population is expected to increase by around 1.7 billion, from around 7.8 billion in 2020 to 9.5 billion by 2045.
- Non-OECD population growth is much higher than that of the OECD, driven by the Middle East & Africa, with Other Asia, India and OPEC following.
- The COVID-19 pandemic will ultimately influence the demographics of many countries. It is already becoming apparent that it has influenced birth rates across the world.
- The working-age population (15–64) is projected to rise globally by 932 million over the projection period. The relative share of the global working-age population is anticipated to drop from 65% in 2020 to 63% in 2045.
- The global urbanization rate is forecast to rise from 56% in 2020 to approximately 66% by 2045.
- Due to the COVID-19 pandemic and the subsequent lockdown measures, global GDP fell by 3.4% in 2020.
- A recovery in GDP growth will take place in 2021 with a forecast of 5.5%, before settling at 3.2% by the end of the medium-term period in 2026.
- In the long-term, global GDP growth is set to decelerate to an annual rate of 2.7% between 2035 and 2045.
- Based on 2017 PPP, global GDP is projected to rise from around $125 trillion in 2020 to more than $270 trillion in 2045.
- China and India alone are forecast to account for more than a third of global GDP in 2045, whereas the OECD will account for slightly less at 34%.
- This Outlook takes into account currently enacted energy policies while also recognizing their evolving nature.
- Policy instruments that primarily target objectives of the Paris Agreement will continue to drive a transition to renewable energy sources and a reduction in greenhouse gas (GHG) emissions. Nevertheless, energy-related policies differ among countries and respond to changing conditions.
- Both current and future technologies will play a significant role in shaping the future energy landscape. The development, and implementation, of multi-faceted technologies contributes to helping set the scene for the Reference Case.
- Hydrogen is considered in the context of the energy transition as a solution to some of the challenges.

To establish a WOO Reference Case a number of key assumptions must be made and in this first chapter these are highlighted and analyzed. This includes fundamental population and demographic trends shaping the world; forecasts for economic growth and the global recovery from the COVID-19 pandemic; and energy policies and technology that are expected to have an impact on the energy sector.

1.1 Population and demographics

While the world's population is expanding gradually, the average age of the population is rising significantly. With regional variations in the overall trend, different countries are at different phases of a transition to low population growth. Many OECD countries already have low population growth, and many developing countries are likely to transition in the coming decades. Being an essential input to the WOO analysis, demographic elements consisting of population growth rates, working populations, urbanization, and immigration have been thoroughly examined.

Derived from the United Nations Department of Economic and Social Affairs, Population Division projection (UNDESA, 2019), an approximate increase of 1.7 billion is expected in the projected global population by 2045. This leads to a total global population of close to 9.5 billion by 2045, compared to the 2020 level of around 7.8 billion (Table 1.1), the same level as reported in the WOO 2020.

Table 1.1
Population by region

millions

	Levels						Growth
	2020	2025	2030	2035	2040	2045	2020–2045
OECD America	520	537	554	570	583	594	74
OECD Europe	580	584	587	588	589	587	7
OECD Asia Oceania	217	217	215	213	210	207	–9
OECD	**1,317**	**1,338**	**1,356**	**1,371**	**1,382**	**1,388**	**72**
Latin America	474	493	509	523	534	542	67
Middle East & Africa	1,118	1,259	1,406	1,559	1,718	1,881	762
India	1,380	1,445	1,504	1,554	1,593	1,621	241
China	1,439	1,458	1,464	1,461	1,449	1,429	–10
Other Asia	1,218	1,289	1,352	1,408	1,456	1,496	278
OPEC	501	554	609	664	720	778	278
Russia	146	145	143	141	139	137	–9
Other Eurasia	198	201	203	204	205	206	8
Non-OECD	**6,475**	**7,190**	**6,915**	**7,513**	**7,814**	**8,091**	**1,615**
World	**7,792**	**8,181**	**8,545**	**8,885**	**9,196**	**9,479**	**1,687**

Source: United Nations (UN).

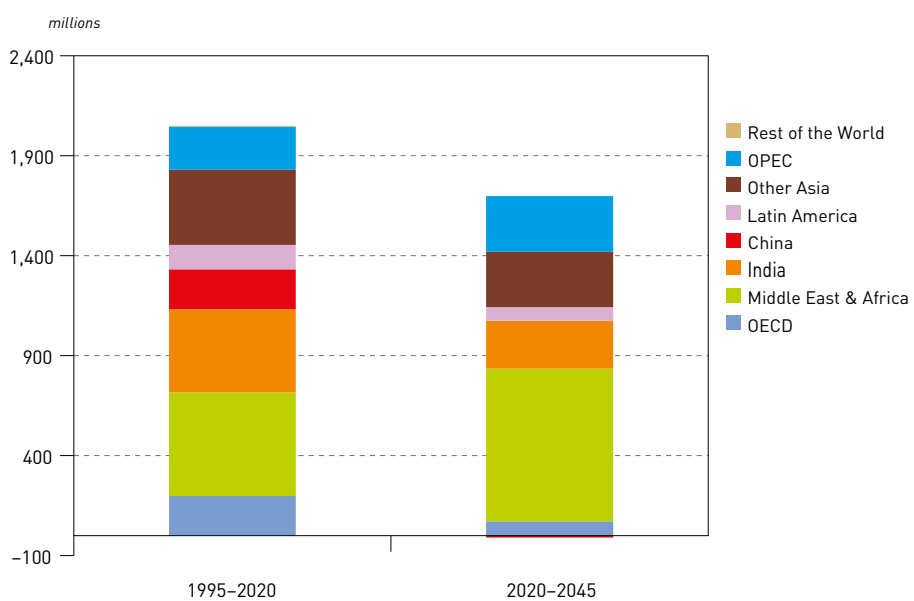
When compared to the OECD region, the population growth projection of the non-OECD region is noticeably disproportionate, accounting for over 95% of the growth. As per OPEC's regional groupings (see Annex B), a significant portion of the population growth will be driven by the Middle East & Africa region (excluding OPEC countries) at approximately 45%. Other Asia, India and OPEC will contribute approximately between 14% and 17% of the growth. It is forecast that 72 million people will be added to the OECD region by 2045, mainly in OECD Americas, with approximately 4% of the global growth.

Compared to population growth of 198 million in the past 25 years (1995–2020), China's population is now projected to decline by ten million over the next 25 years (2020–2045). This is the biggest slowdown in growth among emerging economies. India is projected to see its population expand by 240 million over the period 2020–2045. This is significantly lower than the 416 million added over the previous 25 years. For the OECD, its expected population growth for 2020–2045 is much lower than the 198 million expansion in its population in the 1995–2020 timeframe.

The Middle East & Africa region (excluding OPEC) is currently experiencing a swift rate of population growth, with this trend expected to remain even towards the end of the projection period. The region sees the largest expansion over the period, and by 2045 will be the leading region by overall population. Notably, Middle East & Africa and OPEC are the only regions expected to increase their growth rate, adding 762 and 278 million people in the period between 2020–2045, respectively, compared to the 518 million and 214 million added from 1995–2020.

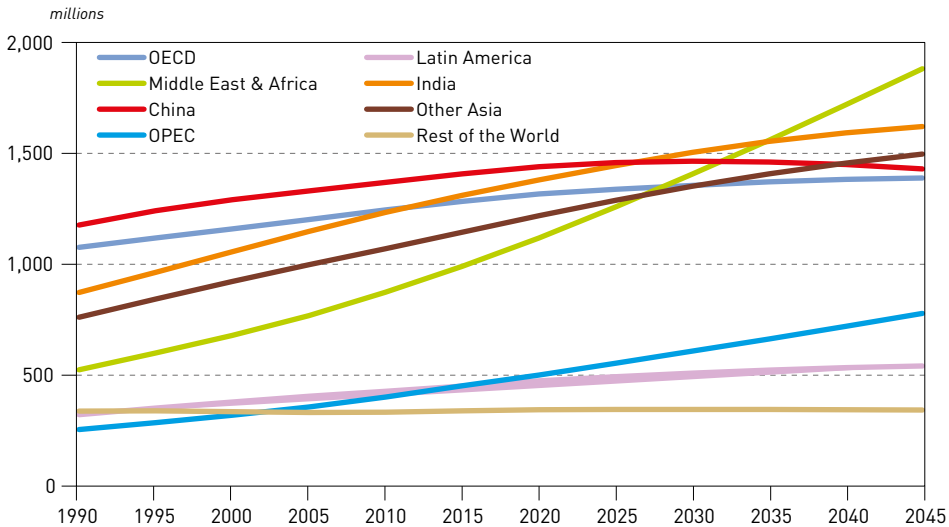
India's population is forecast to exceed that of China in the second half of the 2020s (Figure 1.2), but it is then expected to be surpassed itself by the Middle East & Africa around 2035.

Figure 1.1
World population growth, 1995–2020 *versus* 2020–2045



Source: UN, OPEC.

Figure 1.2
World population trends, 1990–2045



Source: UN, OPEC.

1.1.1 COVID-19 impact on birth-rates

The impact of COVID-19 is not only limited to the direct effects of the virus or the economic consequences related to lockdown measures and restrictions on movement. While it may take many years to be seen and even longer for the impacts to be felt, the pandemic will ultimately influence the demographics of many countries and it is already becoming apparent that the pandemic has influenced birth rates across the world.

Early in the pandemic, reports in the US were already predicting fewer births in 2020 and provisional data from the US Government highlights a drop of 4% from the number of births in 2019, the lowest level in decades. The EU and Japan have also reported a drop off in birth rates when compared to rates prior to the pandemic. However, some countries have registered expectations for an increase in births during the pandemic.

A drop in the birth rate following a major economic or related crisis is not unusual as parents may delay or avoid making decisions on having children given the uncertain environment. For those countries that are already experiencing fewer than 2.1 children born per woman – a figure that is widely used as the birth rate required to maintain a population's size – this could be a further concern. For example, the EU's birth rate was only 1.53 in 2019. Further birth rate drops for regions like the EU would create more challenges given the prospect of dealing with an increasingly aging population. It could even potentially influence immigration levels as countries look to fill gaps in their working age populations.

1.1.2 Working-age population

The global working-age population (15–64) is projected to rise by approximately 932 million throughout the projection period (Table 1.2). The relative share of the global working-age population to the world's total is anticipated to drop from 65% in 2020 to 63% in 2045. Regardless of the often diverse trends, the decline is perceived across all regions.

Table 1.2
Working population (age 15–64) by region

millions

	2020	2025	2030	2035	2040	2045	Growth 2020–2045
OECD Americas	341	348	353	359	365	371	30
OECD Europe	374	370	364	357	349	342	–33
OECD Asia Oceania	136	133	130	125	118	113	–23
OECD	**851**	**851**	**847**	**841**	**833**	**826**	**–25**
Latin America	319	331	339	347	351	351	32
Middle East & Africa	636	730	833	943	1,056	1,170	535
India	928	986	1,029	1,064	1,091	1,108	179
China	1,012	1,007	986	943	898	871	–141
Other Asia	805	854	897	934	964	986	181
OPEC	301	336	374	412	448	483	182
Russia	97	93	90	90	89	86	–11
Other Eurasia	130	131	132	133	133	132	1
Non-OECD	**4,229**	**4,466**	**4,682**	**4,866**	**4,997**	**5,187**	**958**
World	**5,081**	**5,317**	**5,528**	**5,706**	**5,862**	**6,013**	**932**

Source: UN.

China's working-age population is expected to decline by 141 million over the forecast period. This corresponds with China's expected population growth dynamics. Compared to 2020, and with approximately 535 million additional working age people by 2045, the Middle East & Africa is projected to undergo the highest growth, followed by OPEC, Other Asia, and India, all three with an expansion of around 180 million. Notably, the Middle East & Africa (including OPEC) will add more than three-quarters of the world's working-age population by 2045.

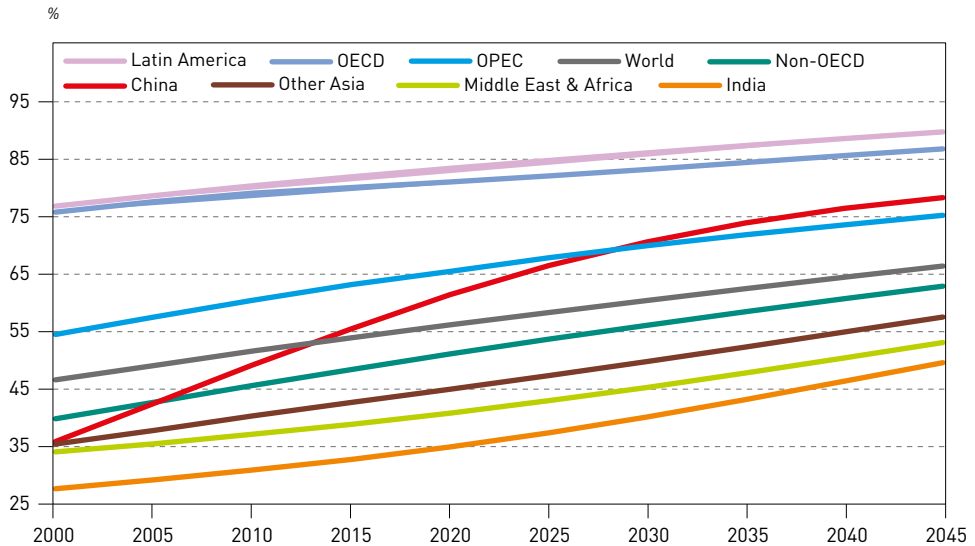
1.1.3 Urbanization

Urbanization trends are essential as these have significant implications on economic development, social issues and energy consumption. Besides, urbanization is closely associated to improved energy access and is an essential factor for mitigating energy poverty. Urbanization in the Outlook is expressed in terms of the urban rate, which measures the level of the total population living in urban areas in percentage terms. In 1950, 30% of the world's population resided in urban areas, but in 2020 more people, now over 56%, live in urban areas than in rural areas. By 2045, approximately 66% of the world's population is projected to be urban.

The Latin America and OECD regions are evidently the most urbanized with, on average, more than 80% living in urban areas (Figure 1.3). Currently, the most urbanized regions are Latin America (with 83% of its population living in urban areas in 2020), OECD Americas (82%), OECD Europe (77%) and OECD Asia Oceania (87%).

China has experienced a dramatic change in urbanization. The country's urban population rate was as low as India's before 1990, but since then it has experienced significant growth. Moreover, it is expected to grow further, despite the decelerating rate, to reach close to the global average in 2045. This has helped to drive the current overall urbanization level in Asia to almost 50%.

Figure 1.3
Urbanization rate for selected regions, 2000–2045



Source: UN, OPEC.

Remarkably, India's urbanization rate has been the lowest, and regardless of the considerable rise in the coming decades, it is expected to still remain the lowest regionally in 2045. The Other Asia region is expected to broadly follow the trajectory of India in terms of urbanization levels through to 2045, but it starts from a higher base.

OPEC Member Countries stand at a level above the current global average of around 65%. The Middle East & Africa region is expected to undergo a substantial development in urbanization levels in the coming decades, but Africa is anticipated to remain mostly rural with 43% of its population living in urban areas by 2045.

1.1.4 Migration

Another vital element of demographic variations on a regional basis is the movement of population. Net migration as depicted in Table 1.3 (measured as the variation of population between the medium variant case and zero migration variant case) shows that population inflows are mainly to OECD regions and, to a much lesser extent, Russia. The OECD is projected to experience a rise in its migration rate by 2045 of approximately 4.7%, whereas the developing world is projected to undergo an outflow of population.

COVID-19 impact on migration

In 2020, according to a report by UNDESA, the COVID-19 pandemic dramatically impacted all forms of mobility. Global lockdown measures, including border closures, disrupted international travel, which significantly impacted international migration. The report highlighted that "hundreds of thousands of migrants were stranded, unable to return to their countries, while others were forced to return to their home countries earlier than planned".

Although it could be considered too early to correlate the impact of the pandemic on migration trends, the UNDESA report suggests that the number of international migrants declined by "two

Table 1.3
Net migration by region in the medium variant

% of regional population

	2025	2030	2035	2040	2045
OECD Americas	1.0	2.2	3.6	5.0	6.5
OECD Europe	0.4	0.9	1.6	2.4	3.3
OECD Asia Oceania	0.6	1.2	2.0	2.8	3.7
OECD	**0.7**	**1.5**	**2.5**	**3.6**	**4.7**
Latin America	–0.4	–0.7	–0.9	–1.1	–1.3
Middle East & Africa	0.0	–0.1	–0.3	–0.4	–0.5
India	–0.2	–0.3	–0.5	–0.7	–0.9
China	–0.1	–0.3	–0.4	–0.6	–0.7
Other Asia	–0.3	–0.7	–1.1	–1.5	–1.8
OPEC	0.3	0.4	0.3	0.2	0.1
Russia	0.3	0.7	1.2	1.7	2.2
Other Eurasia	–0.3	–0.5	–0.8	–1.1	–1.3
Non-OECD	**–0.3**	**–0.6**	**–0.9**	**–1.3**	**–1.2**

Source: UN, OPEC.

million globally by mid-2020". This reduction is equivalent to "27% in the growth expected from July 2019 to June 2020" (UNDESA, 2020).

1.2 Economic growth

It is essential to note that all GDP related numbers, estimates and forecasts for regional aggregations were shifted from the 2011 PPP base to 2017 PPP levels, as published by the World Bank's International Comparison Programme (ICP) and applied by the International Monetary Fund (IMF). Consequently, data history has been recalculated and historic comparisons are now also based on this new measurement. The 2017 PPP-based GDPs are used as weights to compute regional and global real GDP growth.

1.2.1 Current situation and short-term growth

The COVID-19 pandemic constitutes a momentous event for the global economy. The pandemic overshadowed most of 2020 and its huge impacts have continued into 2021. Moreover, it will very likely have significant medium- to long-term consequences for the global economy.

It is already obvious that there is a pre-pandemic and a post-pandemic world. The post-pandemic changes to the global economy may be manifold and while some of these trends were already seen pre-COVID-19, a number have been accelerated by it, and others have originated from the pandemic.

For the short-term, it is important to note that there were massive dislocations that may only see a levelling off in the medium- to long-term. The most obvious developments in 2020 were:

- A sudden and extreme drop off in economic activity, particularly in 2Q20;
- This drop-off had severe ripple effects, such as on global goods inventories. For example, supply shortages and disruptions were witnessed in semiconductors, as well as other

vital goods. This has had an impact on economic developments in 2021, and this will likely continue into 2022;
- The contact-intensive services sector almost came to a halt at the global level following the onset of the pandemic. Impairments in this sector are forecast to continue in the short-term and it is likely that the sectors of travel and tourism, hospitality and leisure will only move back to their 2019 levels in 2023, or even 2024;
- The services sector activity saw a significant sub-sectorial shift towards IT, communication, health and financial services;
- Contrary to the contact-intensive services sector, manufacturing picked up quickly in 2H20, leading the rebound. Industrial output recovered quickly too; and
- For the oil market, the severe effects on travel and transportation led to a strong decline in oil demand, and revenues in the sector. This not only impacted oil-producing economies, but the global economy too.

The developments and impacts on the oil market at the onset of the pandemic ultimately led to 20 April 2020, when the US West Texas Intermediate (WTI) oil price turned negative for the first time. It was a visceral moment for the oil market, and the broader global economy.

After a sharp contraction of the global economy in 1H20, unprecedented monetary and fiscal measures across the globe helped support a recovery in 2H20, a momentum that has been carried over into 2021. In 2Q20, OPEC and its non-OPEC partners in the DoC also initiated the largest, and for the longest period, production adjustments in the history of the oil industry. This was focused on rebalancing fundamentals, and helping return a sustainable stability. Moreover, it also provided support to the global economic recovery.

This was a sign not only of the commitment, motivation and dedication of OPEC and the DoC partners in attending to the short-term, but in focusing on the medium- and long-term too. The efforts were also recognized by the G20, who expressed their commitment to energy market stability. These multilateral-led efforts led to an oil market recovery in 2H20 and 2021, again supporting global economic growth.

After the sharp economic decline in 1H20, the global economy recovered swiftly in 2H20, fueled by the large government-led stimulus measures, the OPEC-led rebalancing of the oil market, the use of consumer savings from the 1H20 lock-down periods, and a consequently well-funded cycle of pent-up demand. However, despite the strong rebound in 2H20, the drop in GDP growth for 2020 stood at 3.4%.

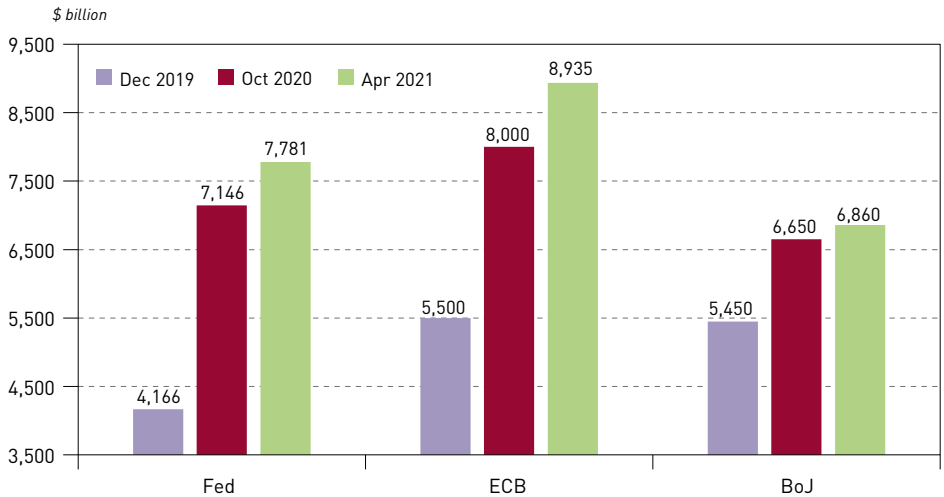
1.2.2 Stimulus efforts

Fiscal and monetary support measures across the globe in 2020 were massive and accounted for more than 20% of global GDP. They have been a key support factor in the swift recovery.

Among the support measures, monetary easing added around $8 trillion (Figure 1.4) to the balance sheets of the G3 central banks, the US Federal Reserve System (Fed), the European Central Bank (ECB) and the Bank of Japan (BoJ). These accommodative policies are forecast to potentially continue for some time, but it is clear it is also dependent on inflationary developments and the dangers of overheating.

The US has led the way, with a massive fiscal drive that will likely have medium- and long-term related growth impacts. Former US President, Donald Trump, signed a $2 trillion stimulus package, named the 'Coronavirus Aid, Relief, and Economic Security (CARES) Act' into law in March 2020. Other measures followed, including Congress passing a $900 billion relief bill in December 2020.

Figure 1.4
G3 central banks' balance sheet assets



Source: Federal Reserve, European Central Bank, Bank of Japan, Haver Analytics, OPEC.

In March 2021, the new US President, Joe Biden, signed into law the 'American Rescue Plan Act of 2021', which amounted to further stimulus of $1.9 trillion. This new package amounts to almost 9% of GDP, but not all the money will end up in GDP-enhancing activity, as up to $500 billion is estimated to cover lost revenues, the repayment of debt, as well as for precautionary savings or for subsidizing certain areas of the economy. These areas include state and local government support, education support, small business relief, as well as other business support in the leisure and agriculture sectors.

By applying a high fiscal multiplier of around 0.7 to the remaining GDP-enhancing $1.4 billion of fiscal stimulus from the plan, the net GDP support in 2021 would stand at around five percentage points (pp) of GDP. The $900 billion package from the end of last year is forecast to support the economy by around 2.5 pp this year too. The new US stimulus support has come at the same time as a strong drive by the newly elected US administration to vaccinate the US population. This led to a strong 1H21 rebound in US growth.

While the US was successful in its early immunization programme, the EU and Japan still faced COVID-19 related challenges and lockdowns in the early parts of 2021, delaying the recovery towards the end of 2Q21 and in to 2H21, although the EU's vaccinations efforts have picked up significantly since the 2Q21.

However, both the EU and Japan have also initiated large stimulus packages to support their economies. The EU issued a fiscal stimulus package of €750 billion, called the Next Generation EU (NGEU) fund for supporting growth in 2021 and beyond. The NGEU consist of two facilities, one facility covers grants at a magnitude of €390 billion and the second facility provide loans at a magnitude of €360 billion. The exact allocation of the funds remains to be seen, but high-debt countries that have been significantly impacted by the pandemic, such as Italy and Spain, will be the largest recipients. Japan saw a fresh economic stimulus package of $708 billion in December 2020 to speed up the recovery from the country's deep pandemic-driven slump, while targeting investment in new growth areas such as green and digital innovation.

1.2.3 Recovery in 2021

The OECD GDP contracted by 4.7% in 2020, but in 2021 OECD growth is forecast to recover to 4.9%, supported, in particular, by growth expectations for OECD Americas, while the Euro-zone and Japan are facing a delayed recovery due to the lockdowns in 1H21. In the emerging economies, India's growth forecast for 2021 stands at 9.5%, taking into consideration some negative 1H21 impacts from the ongoing COVID-19 challenges in the country.

It should be noted that with the changes from the ICP's 2017 PPP adjustments, the weight of OECD economies was lifted by around 3%. Consequently, non-OECD economies were lowered by the same magnitude. Given the shift of the base year and the ICP's consideration of inflation, the PPP-adjusted global GDP increased in the new base year of 2017 from $113 trillion to $122 trillion, with a consequent effect on the whole time-series.

In emerging and developing economies, most key economies continue to face challenges related to the pandemic, the exception so far being China, although it is obviously still impacted by the global situation. India, in particular, faced a strong wave of COVID-19 infections in 2Q21, leading to a considerable decline in 2Q21 growth. Brazil and Russia have recovered slowly in 2021, albeit benefitting from the rebalancing of commodity markets, especially the oil market, a development that was, however, counterbalanced by the ongoing COVID-19 related developments in these two economies. Contrary to the ongoing challenging pandemic situation in most emerging and developing economies, China has up to now successfully contained widespread outbreaks of COVID-19 and posted a strong rebound after its GDP plunged in 1Q20.

India's 2020 GDP growth stood at a negative 7%. Following growth of 2.3% in 2020, China's GDP growth is forecast at 8.5% in 2021. Brazil's GDP growth forecast for 2021 stands at 3.2%, following a contraction of 4.1% in 2020. Russia's GDP growth is forecast at 3%, after contracting by 3.1% in 2020.

It is clear that the US, given its strong rebound, and China are the countries currently driving the recovery. However, it is expected that the Euro-zone, the UK and Japan, among other OECD economies, as well as some emerging and developing economies, will join the momentum in 2H21, leading to global growth of 5.5% in 2021.

Importantly, the underlying assumption for the strong 2H21 recovery is that COVID-19 will be largely contained towards the end of the year, in the sense that the majority of the population in advanced economies will be vaccinated and that the pandemic will not pose a major obstacle for major emerging economies by then. In addition, forced private household savings during the lockdowns are forecast to accelerate global economic growth in 2H21 via pent-up demand, especially in the contact-intensive sectors.

However, there are still some significant uncertainties, particularly in terms of COVID-19. The path the pandemic takes will be the overarching factor impacting the short-term recovery, with the potential emergence of new COVID-19 variants and/or mutations posing a particular risk. This can be viewed in the Delta variant that has become a dominant strain in a number of countries since May/June 2021.

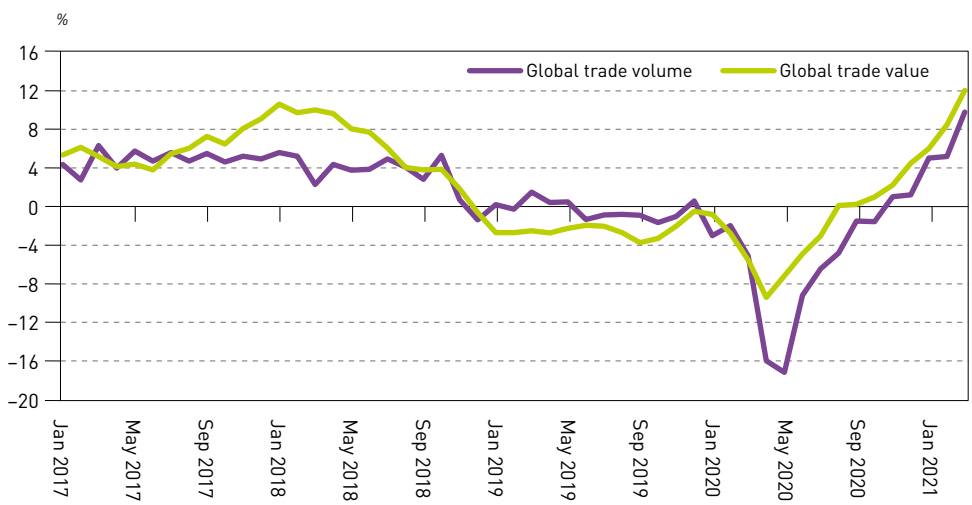
Moreover, sovereign debt in most economies has risen to levels at which a lift in interest rates could cause severe fiscal strain. Global debt increased by $24 trillion in 2020 – more than the size of annual US GDP – and it is forecast to rise further, based on data from the International Institute of Finance (IIF). Global debt now stands at more than $280 trillion, or more than three times the size of annual global GDP based on market exchange rates (more than two times when based on PPP), an unprecedented level.

While key interest rates are still low, and are assumed to stay at a very accommodative level in the near-term, inflation worries have come to the fore, fueling a debate if the low interest rate

environment will have to end soon. It is still too early to conclusively define if rising inflation, with a particular focus on US developments, is indeed temporary, or more permanent, and whether it may become more global. Reopening effects and temporary supply shortages in the US have driven inflation levels higher. It also remains to be seen how the US labour market will develop and if the improving economy will lead to wage-rises, again potentially lifting inflation. Not only did global commodity prices rise as a key price component of the global economy, but as a consequence of the pandemic, semi-conductors have doubled in prices over the last year and led to supply shortages in industrial production, leading to rising prices for a variety of goods.

Another important point to emphasize is that global trade has recovered in 2021 (Figure 1.5), after strong declines during 1H20. There was a base effect, given the drops last year, but there is no doubt that the recovery in commodities trading, in combination with the effects of reopening and pent up demand, have played a role too.

Figure 1.5
Global trade growth year-on-year



Source: OPEC.

Global trade was already in decline pre-COVID 19. Global trade policies in the preceding years that led to a more protectionist environment – at its core the US-China trade frictions, but also other US-centered trade related developments and Brexit – played a role in this trend. So, if adjusting for the strong decline in 2020, the uptick would naturally not have been that strong in volume or value terms, but would have rather continued at a relatively low growth rate. With the ongoing trade and policy-related discussions between the US and China, and an ongoing trend towards more localized and less globally intertwined supply chains, global trade developments, particularly in the merchandise goods sector, remain in a state of flux.

One important area to highlight is that despite some selective efforts to de-globalize, the US's global export share peaked at 14.7% in 2020, according to the United Nations Conference on Trade and Development (UNCTAD), compared to 14% in 2019 and 12.9% in 2018. It remains on an upward trend.

1.2.4 Medium-term economic growth

The impact of the pandemic, and the response mechanisms that have been developed, will have a considerable impact on medium-term growth. It is too early to judge the full consequences and magnitude of the pandemic on economies, but some trends and dynamics can already be garnered.

An important trend that began before the pandemic was the move towards a more localized and less connected global economy, driven by the US-China trade dispute and wider policy issues. While the detailed outcome remains unclear, a less globalized world with more localized supply chains seems likely to materialize. That is not only driven by politics, but also by security reasons as the pandemic has laid bare the risks that are connected to global supply chains in the case that they become disrupted.

However, it is important to note that while external trading will likely become less global, it has, in general, always been regionally dominated with three main large trading hubs. One is the US-centered trade region of the Americas, dominated by North America. Another is the Europe region, with its dominant force of Germany, and the third is the Asian region, centered on China. A potential consequence of less globalized trading may also lead to regional inequalities as wealth transfers via an exports shift.

These changes may take time to evolve, but in the medium-term at least they will possibly affect the trading of goods, while the global trading in services may in fact accelerate as an outcome of the pandemic. During the pandemic it became clear that specific services can be provided cross-border relatively easy via the tools that global digitalization advancements offers. That may also lead to a more international labor market in which private and public entities are increasingly able to source skill sets that are not bound to a certain location or a specific language internationally. For the medium-term forecast, it is assumed that the pre-pandemic low growth pattern of global trade will continue and that, importantly for the oil-sector, the recovery in travel and tourism – as a significant component in services trading – will only reach 2019 levels by around 2023 and 2024.

As mentioned previously, another important consequence of the pandemic has been the rapidly rising global debt level. Fiscal and monetary stimulus, including guarantees, accounted for around $24 trillion. In fact, the increase in global debt, incorporating sovereign and private sector debt, rose a similar amount of $24 trillion, based on data from the IIF. Global debt now stands at more than three times the size of annual global GDP based on market exchange rates (more than two times when based on PPP) and is likely to rise more in the medium-term. This bears tremendous risk, as any revenue shortfall, due to, for example, a slowing global economy, or any major shift in interest rates, may cause considerable dislocations in the world economy. For the medium-term forecast it is assumed that no major debt issues arise and the debt servicing will be well-managed.

The challenges of escalating debt levels have become an increasing concern, particularly given the active talk around inflation in 2021 and the potential for future interest rate rises. While inflation has risen globally, it is US inflation that has been the major focus. It has not only moved significantly above 2% (a level widely accepted to be healthy), but given that the US dollar is the global reserve currency it has caused apprehension elsewhere. Although rising prices may to a large extent be attributable to reopening effects and possibly temporary supply disruptions, underlying forces, such as global wage pressure, could in the medium-term also lead to sustained higher prices with the associated consequences. For the medium-term forecast, it is assumed that inflation remains well-anchored and that the high 2021 levels will normalize and retract to around 2% levels over the medium-term.

It should be noted, however, that it may be in the interest of economies to have slightly elevated inflation levels, and at the same time low key interest rates, or negative real interest rates. This may be helpful in reducing the large debt that has accumulated.

Another important factor that may play a role in reducing debt are rising tax levels. In times of increasing debt, taxes that commonly help to reduce debt include those on wealth, capital gains, property/real-estate, inheritance, top-incomes and corporate taxes. Additionally, environmental taxes are very likely to play a key role in the coming years. Minimum global corporate taxes as introduced by the G7 in 2021, as well as through the US administration's initiative of the 'American Tax Plan', point in this direction. Further tax plans, especially in advanced economies, are expected to follow. For the medium-term forecast, it is assumed that rising taxes will not derail the global economic recovery and that they will be taken from well-established and well-cushioned sources and that the effects of these taxes will turn out to be well-targeted.

A further result of the pandemic are expanding inequalities within economies and across nations. The low-interest rate regime is clearly more beneficiary to the wealthier, for a variety of reasons. Moreover, among nations it is obvious that the global economic recovery has become increasingly divergent. Those economies that are able to gradually contain the pandemic, thanks to vaccination campaigns and other successful containment strategies, and that also have the financial capabilities to provide economic stimulus measures, have rebounded relatively quicker. This is in contrast to those economies that have less access to vaccinations, apply less successful containment strategies and have only limited financial resources for fiscal and monetary stimulus. This may lead to a further rise in global inequality and potentially to political frictions. For the medium-term forecast, it is assumed that there will be no further conflict that may dampen the global economic recovery going forward and, generally, domestic inequalities within economies will be successfully managed via redistribution effects or other policy measures.

A macro trend that began before the pandemic, and one that seems to have gained further traction on the back of it, is the momentum towards environmental, social and governance (ESG) policies in the global economy. This will likely impact the global economy in a variety of ways in the medium-term, and beyond. Investments will be channeled towards ESG-related areas and possibly the financing of non-ESG related investments could become more expensive. In general, it is assumed in the forecast that this is a steady trend and, hence, will only have a gradual impact. However, if the trend develops at a more rapid pace, it could lead to rising energy prices due to the potential lack of investments in conventional fuels.

Another impact of the pandemic has been the drop off in travel and tourism, with 2019 levels only expected to return by around 2023/2024. Looking ahead, non-essential business travel will likely be reduced, private travel curtailed for some time after the pandemic, and ESG-related developments will likely also impact this sector. Considering that travel and tourism accounts for more than 10% of global GDP, the effect will be felt continuously in the medium-term, particularly in regions that have previously relied heavily on tourism.

Additionally, the trend towards increasing home-working seems to be here to stay. The knock-on impact of this is less commuting with gradual impacts on both economic and social dimensions with many areas impacted by these trends. For example, stationary retail sales in office areas will be less frequent, there will be slowing demand for office space, more meetings will be virtual and also crude oil-demand may be impacted, among others.

While emerging and developing economies are forecast to outgrow advanced economies in the medium-term, they will likely also face a decelerating growth momentum amid maturing domestic economies. In addition, a potentially lessening global trade dynamic may support this trend too. In particular, China and India, constituting the two largest emerging economies, are expected to follow this pattern and this is reflected in the medium-term forecast, as well as the long-term too.

Another important topic related to the pandemic is that of productivity. On average, productivity has slowed considerably in advanced economies over the last few decades and the

forecast assumes that any productivity improvements will continue to be at low growth levels. However, there is some potential upside. This may come from the pandemic induced drive towards digitalization and AI, although the effective utilization of these new technologies and improvements in productivity may take some time to materialize.

Reflecting in more detail on the forecast for medium-term GDP growth levels, it is important to highlight that the base assumption is that COVID-19 will not continue to materially impact global economic growth patterns. It is assumed that the pandemic will be widely contained.

After this year's recovery with GDP growth forecast at 5.5%, it is expected that growth will stand at around 4% in 2022. In 2023, the after-effects of the stimulus-induced effects will continue to be felt with growth standing at 3.5%, compared to the last year's forecast of 3.2%, while the forecast for 2024 is unchanged at 3.3%. It is anticipated to be at a level of 3.2% in 2025 and 2026, as shown in Table 1.4.

Last year's WOO forecast saw growth reaching 3.4% at the end of the medium-term period (then ending in 2025).The 2025 forecast in this year's Outlook is 0.2 pp lower, due to the front-loaded growth levels in 2021 and 2022. It is obvious that post-pandemic growth patterns are widely distorted due to the base effect from the 2020 pandemic-led recession, as well as the unprecedented fiscal and monetary stimulus enacted to counterbalance it.

While growth seems to be well supported in the medium-term, numerous uncertainties remain. Evidently, COVID-19 could cause further economic disruptions in the coming years if the virus is not contained effectively and sufficiently, but there is also the possible consequences of rising debt levels on both the sovereign and private household sides of the economy. It could lead to a rising number of defaults and/or a larger-than-anticipated slowdown in consumption, and consequently investment. Such a situation may arise if inflation remains at an elevated level for an extended period, and interest rates rise in tandem. If combined with various tax rises to repay the

Table 1.4
Medium-term annual real GDP growth rate

% p.a.

	2020	2021	2022	2023	2024	2025	2026	Average 2020–2026
OECD Americas	–4.2	6.1	3.4	2.2	2.1	1.9	1.9	2.9
OECD Europe	–5.8	4.3	3.2	2.1	1.9	1.7	1.6	2.4
OECD Asia Oceania	–3.3	3.3	2.4	1.8	1.4	1.3	1.3	1.9
OECD	**–4.8**	**4.9**	**3.2**	**2.1**	**1.9**	**1.7**	**1.7**	**2.6**
Latin America	–6.4	3.9	2.7	2.3	2.3	2.4	2.5	2.7
Middle East & Africa	–2.6	2.9	3.1	3.2	3.2	3.3	3.4	3.2
India	–7.0	9.5	6.8	6.5	6.4	6.3	6.2	6.9
China	2.3	8.5	6.3	5.9	5.5	5.2	5.1	6.1
Other Asia	–2.6	4.5	4.4	4.7	4.6	4.6	4.5	4.6
OPEC	–5.2	2.6	2.5	2.7	2.7	2.8	2.9	2.7
Russia	–3.1	3.0	2.3	2.0	1.6	1.5	1.5	2.0
Other Eurasia	–3.6	3.7	3.4	2.7	2.5	2.5	2.5	2.9
Non-OECD	**–2.3**	**6.0**	**4.8**	**4.6**	**4.5**	**4.4**	**4.4**	**4.8**
World	**–3.4**	**5.5**	**4.1**	**3.5**	**3.3**	**3.2**	**3.2**	**3.8**

Source: OPEC.

very high-debt levels, it could provide a dampening effect on global economic growth. Moreover, the trend towards a less globalized world and associated trade-related issues, as well as the possibility of re-emerging geopolitical issues and a continuation of social conflicts in numerous countries, need to be monitored closely.

Medium-term economic growth by region

In **OECD** economies, growth is forecast to materialize more at the beginning of the medium-term due to pent-up demand and the massive fiscal stimulus to counter the impacts of the pandemic. By the end of the medium-term period, however, growth is forecast to have slowed considerably, standing at 1.7% in 2026. This compares to the forecast of 1.7% in last year's WOO.

OECD Americas is expected to recover swiftly at the beginning of the medium-term period, with the US forecast to lead the growth momentum. After the massive decline in all economies of OECD Americas in 2020, the major fiscal and monetary stimulus in the US, as well as in Canada, combined with COVID-19 containment strategies in 2021, are forecast to build a sound base for medium-term growth. This momentum going forward should build on a continued rebound in labour markets and a strong recovery in consumption and investments.

A recovery in global trade and a sound commodities sector, especially the oil market, will add further support, including Mexico's growth dynamic. Chile is also forecast to benefit from a general recovery in commodity exports, primarily its main export, copper. Further fiscal stimulus in the US via an infrastructure package and a family and social welfare package could add further support to the region's growth. On the flip side, the very high-debt level in the US, in combination with any sustained high inflation level, could challenge the growth momentum.

OECD Europe is forecast to see less of a rebound compared to OECD Americas, but a positive recovery is expected. Supported by the stimulus measures of the European Commission, Member States and the ECB, the negative economic impact of COVID-19 is forecast to be overcome and growth is expected to be relatively high at the beginning of the medium-term. In particular, this is driven by the major economies of Germany and France. This will also be accompanied by a general recovery in the global economy and an increase in global trade. Towards the end of the medium-term, growth tapers off, and by 2026 it is at 1.6%, below that of OECD Americas.

However, debt-related issues in some EU economies, particularly Italy, may re-emerge, although it is anticipated that they will be well-contained. The forecast also assumes a gradual recovery in the car sector, which is particularly important to Germany, Spain and to some extent France and Italy. This will be of particular importance after the semi-conductor-related supply shortages in 2021.

In **OECD Asia Oceania**, Japan is forecast to see decelerating growth in the medium-term, and alongside the region's major trading partner, China, will provide strong guidance for the region's future growth. While the Japanese government, together with the BoJ, introduced an enormous stimulus programme in 2020, accounting for more than 20% of GDP, it is forecast that the Japanese economy will move back to its low-growth pattern after the stimulus efforts taper off in the medium-term. Positively, the recovery in Japan's large trading partners, China, as well as the US and the EU, will continue to support growth, especially at the beginning of the medium-term.

The medium-term growth outlook in **non-OECD** countries will be relatively diverse. Growth levels in Latin America, the Middle East & Africa and OPEC were all relatively limited in the years prior to COVID-19 and, hence, have a lower base level. With generally improving commodity markets, the main export focus for a large majority of the major economies in these regional groups, growth is anticipated to recover from their low levels, especially after COVID-19, although some uncertainties remain. High population growth in these economies will be beneficial too, especially in the longer-term.

In **Latin America**, growth is forecast to be relatively equally distributed over the medium-term period, although significant challenges related to COVID-19 remain. The region should mainly be supported by a continuation of growth in Brazil and a successful rebound in Argentina, anticipating that the country will effectively manage its current sovereign debt challenges. With the exception of 2022, when growth is forecast to reach 2.7%, the dynamic is anticipated to remain at a rate of around 2.5%, due to the medium-term effects of the pandemic. Almost every country in Latin America has been significantly affected by COVID-19 and growth levels remain constrained. Despite the ongoing challenges, further upside may come from a continued strong commodity market. Moreover, a successful outcome of further Brazilian structural reforms could additionally add to the growth momentum.

In the **Middle East & Africa**, medium-term growth is expected to rise slightly. The region is forecast to be a beneficiary of a rebound in the global economy and, hence, will be aided in the medium-term from rising demand for commodities and growing regional domestic demand fueled by the expansion of the middle class. A rebound in the global economy is forecast to lift foreign investment into the region too. China's role as the region's major foreign investor, and its need for natural resources, will continue to be extremely important.

However, some dampening effects may come from any slowdown in China, which may be a challenge for the region, while some countries' high sovereign debt obligations and debt servicing may be another constraint.

After **China** had been impacted severely by the COVID-19 pandemic in early 2020, the country managed a swift rebound, supported by government stimulus measures and its containment of COVID-19. After high growth on the back of the stimulus-induced recovery in 2021, China is forecast to grow at a slower rate as its economy matures. In 2022, the economy is forecast to grow by 6.3% and then continue to drop over the medium-term to stand at 5.1% in 2026, albeit still a relatively high rate.

An important element for China will be developments in its relations with the US, particularly trade-related negotiations and policy discussions. The agreement of the phase one trade deal with the US in 2020 was broadly welcomed, but it remains to be seen to what extent the deal will be fulfilled and how the trade related challenges evolve further. The forecast assumes that no additional frictions in trade relations will materialize in the medium-term.

Additionally, China's shifting focus from external trade and investments towards a more domestically oriented one, led by private household consumption, will likely counterbalance some of the potential shortfalls from external trade. An ongoing challenge will be to balance out the need for an economic rebound and growing imbalances in the private sector, while at the same time reducing domestic debt levels.

India's growth was significantly impaired in 2019, slowing to 4.9%, the lowest growth since the financial crisis of 2009. It was then even more impacted by the COVID-19 pandemic in 2020 when growth fell by 7%. The country put together a large stimulus package in 2020, which filtered into 2021, however, the large wave of COVID-19 cases in 2Q21 dampened the recovery significantly. Despite this negative impact, the economy is forecast to grow by 9.5% in 2021, but is then expected to slow to 6.8% in 2022. A gradual slowdown towards 2026 leads to growth of 6.2% at the end of the medium-term.

Other Asia is forecast to see healthy medium-term growth. Growth is forecast at 4.5% by the end of the medium-term in 2026, unchanged from the previous year's WOO, and with slightly rising momentum. Growth in 2022 is forecast at 4.4%.

OPEC, as a group, was already facing a challenging year in 2019, when GDP declined by more than 1%. The pandemic, therefore, hit already weakening economies and pushed the decline further to reach a negative 5.2% in 2020. The recovery that is forecast in the medium-term period will be

hugely supported by the efforts of OPEC and non-OPEC countries in the DoC to help rebalance the oil market. OPEC's GDP growth is forecast to show a solid appreciation over the medium-term period as a global economic recovery spurs oil demand. Growth at the end of the medium-term period is forecast to be significantly above pre-COVID-19 levels, reaching 2.9% in 2026.

In Eurasia, **Russia** constitutes the most important economy followed by other key oil-producing countries. Producer nations that are participating in the DoC will benefit significantly from the oil market rebalancing witnessed in the 2H20 and into 2021, a very important element in leading to expected stable medium-term growth. On the potential downside, Russia's economy remains hampered by sanctions. Russia's GDP growth is forecast to decelerate slightly, driven in part by its declining population and the resulting drop in consumer demand. Similarly, Other Eurasia is forecast to slow towards the end of the medium-term.

Eurasia is forecast to show growth of 1.9% in 2026, 0.8 pp below expected growth in 2022. Russia is forecast to grow by 1.5% in 2026, 0.8 pp below the anticipated growth in 2022. Other Eurasia is forecast to grow by 2.5% in 2026, also around 0.8 pp below estimated growth in 2022.

These divergent trends in non-OECD countries are expected to lead the group to see growth of 4.4% in 2026, compared to 4.8% in 2022.

1.2.5 Long-term economic growth

As in previous editions of the WOO, the assumptions underlying long-term economic growth developments are primarily based on productivity growth, demographic trends and labour market developments. Within this framework, labour productivity is by far the most important contributor, both at the regional and global level (Figure 1.6). As previously mentioned, further upside may come from the pandemic induced drive towards digitalization and AI and the more effective use of these evolving technologies.

For non-OECD economies, the rise in the working age population will be another important element for growth. A young and thriving population, in combination with advancing education will be vital for future growth in less affluent parts of the global economy. In areas like the Middle East & Africa and OPEC, relatively lower labour productivity will continue to be counterbalanced by the spillover into the labour market from rapidly expanding populations.

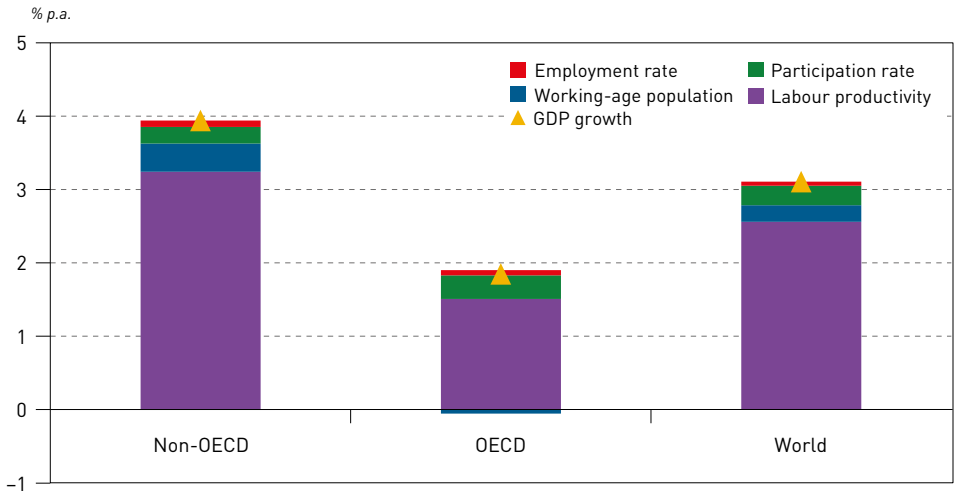
Several economic regions and individual economies will be affected by a decline in the working-age population, especially OECD Europe and OECD Asia Oceania, but in Russia and China too. This dynamic will limit these economies' growth potential, even as labour productivity is forecast to increase.

Global GDP growth between 2020 and 2045 is expected to increase at an average rate of 3.1% p.a., which is slightly above the assumption in the WOO 2020, when the growth forecast stood at 2.9%. This is partially due to the strong recovery at the beginning of the period with expansive governmental-led stimulus lifting growth, and despite the fact that 2020 has been considerably impacted by COVID-19.

Global growth through to 2045 will be largely driven by non-OECD countries, in line with assumptions from previous WOO editions. These countries are expected to grow by 3.9% p.a. on average (Table 1.5), on the back of improving labour productivity and a growing working age population, even as the pace of GDP growth begins to slow. The growth forecast for the whole forecasting period is 0.2 pp above that of last year.

India is expected to remain the fastest growing major developing country with average growth of 6.2% p.a. After the considerable fiscal stimulus in 2020 and 2021, growth is even more front-loaded

Figure 1.6
Long-term GDP growth rates by components, 2020–2045



Source: OPEC.

over the projection horizon. Moreover, it is supported, and in line, with expected demographic growth trends. This compares to the long-term forecast in last year's WOO of 5.6%, clearly an outcome of the strong global recovery in 2021. Nevertheless, this is still slightly below the pre-pandemic WOO 2019 forecast, when India's expected long-term growth average stood at 6.3%.

As in previous WOO editions, China is expected to be the second fastest growing major economy, with average growth of 4% p.a. over the forecast period. This is slightly above the assumption in the WOO 2020, when average growth stood at 3.9%. China's growth pattern has been relatively stable and is not expected to alter significantly in the long-term. It will, however, likely see slowing growth towards the end of the forecast period, also in line with its maturing economy and ageing population. Between 2035 and 2045 growth is at 2.8%, unchanged from last year's WOO.

In the last decade of the forecast period, China's economic growth dynamic will thus be overtaken by numerous single economies and economic regions, including India, the Middle East & Africa, OPEC, as well as Other Asia. In these economies, an expanding working-age population will contribute to faster economic growth compared to China's ageing and gradually declining population.

Economic growth in Other Asia is seen at 3.7% p.a. over the long-term. The momentum is forecast to accelerate to 4% p.a. in the period from 2025–2035 and to then slow to 3% p.a. in the decade preceding 2045. Nonetheless, this is still significantly above the global average of 2.7%.

In the Middle East & Africa, growth is estimated to average 3.9% p.a., a slight upward revision from last year. This region is forecast to benefit not only from a rising population, but also from an increase in income as more people enter the middle class, which provides rising consumption capacity. This is forecast to come in combination with support from commodity markets amid the global growth appreciation. Further upside may materialize if additional structural and economic reforms take place in less productive economies.

In Russia, unfavorable demographic changes and a reduction in the working-age population may be somewhat counterbalanced by labour productivity gains. Economic growth in Russia is expected to rise at 1.6% in the decade up to 2035, after a slightly higher medium-term growth

Table 1.5
Long-term annual real GDP growth rate

% p.a.

	2020–2026	2026–2035	2035–2045	2020–2045
OECD Americas	2.9	2.0	2.0	2.3
OECD Europe	2.4	1.4	1.3	1.6
OECD Asia Oceania	1.9	1.2	1.0	1.3
OECD	**2.6**	**1.7**	**1.6**	**1.8**
Latin America	2.7	2.4	1.9	2.3
Middle East & Africa	3.2	3.9	4.4	3.9
India	6.9	6.3	5.5	6.2
China	6.1	4.0	2.8	4.0
Other Asia	4.6	4.0	3.0	3.7
OPEC	2.7	3.1	3.2	3.0
Russia	2.0	1.6	1.3	1.6
Other Eurasia	2.9	2.5	2.0	2.4
Non-OECD	**4.8**	**4.0**	**3.4**	**3.9**
World	**3.8**	**3.1**	**2.7**	**3.1**

Source: OPEC.

average of 2%. Developments in commodity markets, particularly, in crude oil markets will also play an important role in Russia's growth path. However, the country's declining population is expected to be the main influential force that prevents growth moving beyond the long-term average of around 1.6%. Elsewhere in Eurasia, marginal growth in the working-age population will help maintain GDP growth at an average 2.4% p.a. over the forecast period.

Latin America is forecast to be impacted by a number of structural issues in the medium-term, challenges that may remain influential even beyond this period. The ongoing sovereign-debt challenges in Argentina and related issues will need close monitoring. Furthermore, the pace of structural reforms in Brazil, amid the ongoing domestic political and economic challenges will be of key interest. The forecast anticipates that the financial issues in Argentina will be overcome in the medium-term period. Moreover, gradual reforms in Brazil will help build a sound base for growth above the 2% level in the long-term across the region. As a result, Latin America will see relatively higher growth at the front-end of the curve, and overall it is expected to achieve a 2.3% p.a. growth level over the forecasting period.

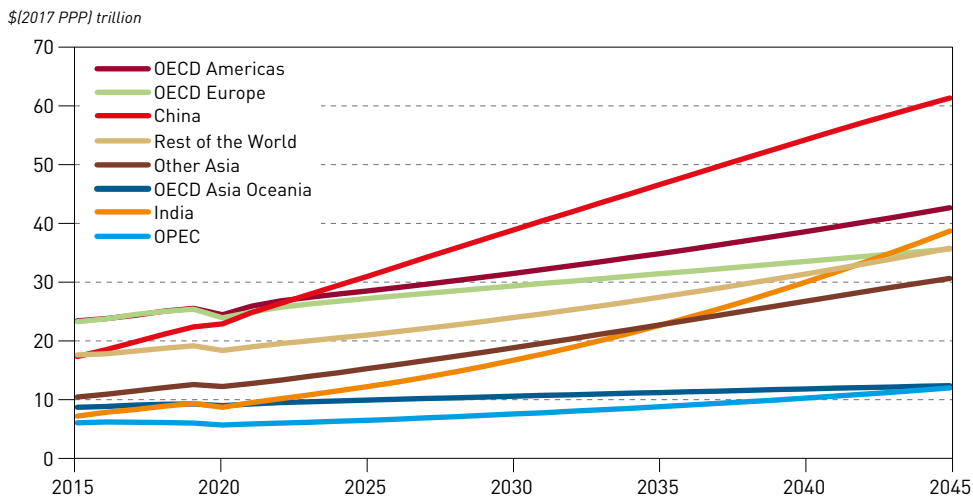
Reviewing further details within the OECD region, economic growth is forecast to average 1.8% p.a. for the period from 2020–2045. Following the unprecedented US stimulus measures to counterbalance the COVID-19 related impacts, OECD Americas is anticipated to continue to lead OECD growth prospects with a stable long-term economic outlook at 2.3% p.a., a rise from last year's WOO 2020 assumption of 2%. Growth in the last decade of the forecasting period is expected to remain at a strong 2% level. Immigration into the US, and to some extent Canada, will help expand the workforce, while labour productivity growth may provide further upside.

In the other OECD regions, particularly OECD Asia Oceania, declining working-age populations will likely drive a deceleration in economic growth, down to 1% p.a. for the final years of

the projection period. This compares to the total long-term average of 1.3% p.a. OECD Europe is also forecast to decelerate, amid population and working-age declines, showing average growth of 1.6% p.a. in the long-term, but dropping to 1.3% for the final years of the forecast period.

The GDP growth figures assumed in this year's WOO imply that the global economy in 2045 will be more than double the size it was in 2020 (Figure 1.7). Based on 2017 PPP, global GDP is projected to rise from around $125 trillion in 2020 to almost $270 trillion in 2045.

Figure 1.7
Size of major economies, 2015–2045



Source: OPEC.

Figure 1.8 indicates that China and India alone will account for 37% of global GDP in 2045. The OECD will account for slightly less at 34%. The largest GDP appreciations are set to come from China and India over the course of the forecasting period. China is expected to add $41.6 trillion to global GDP and India $30.4 trillion. This compares to an addition of $32.6 trillion from the OECD.

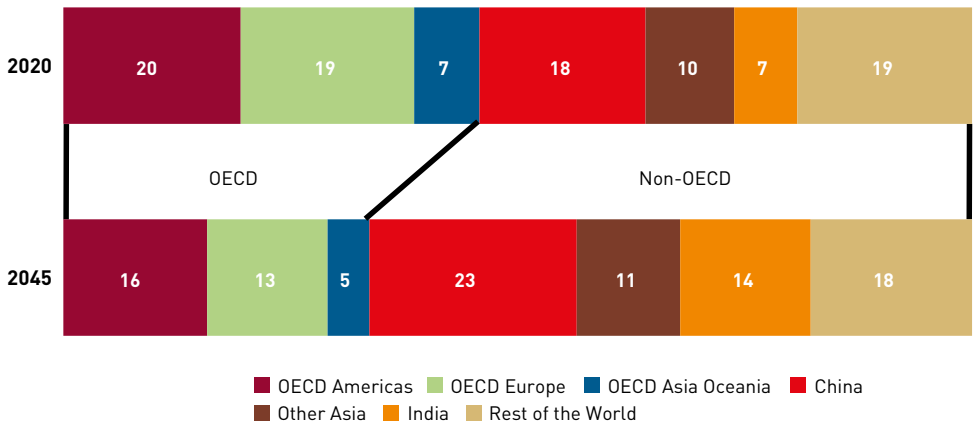
Despite large shifts at the regional level, the global economic picture does not see significant changes in the ranking of average income (measured as GDP per capita). OECD Americas is forecast to remain the region with the highest GDP per capita, followed by OECD Asia Oceania and OECD Europe.

The regional grouping of Middle East & Africa is still expected to have the lowest GDP per capita, as shown in Figure 1.9. It is also set to be the only region where the average income is less than $10,000 (2017 PPP) in 2045. India and China are anticipated to see the biggest changes, with average income in China seen rising, closing some of the gap to OECD countries, and overtaking Russia's GDP per capita level.

The global average income is projected to rise from $16,000 (2017 PPP) in 2020 to more than $28,000 (2017 PPP) in 2045.

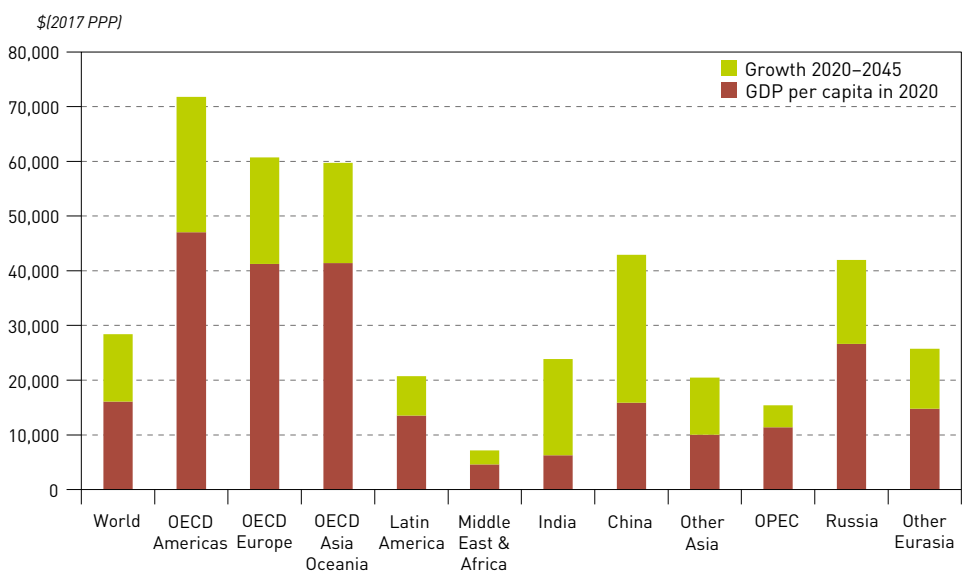
Figure 1.8
Distribution of the global economy, 2020 and 2045

%



Source: OPEC.

Figure 1.9
Real GDP per capita in 2020 and 2045



Source: OPEC.

1.3 Energy policies

A key Reference Case assumption used throughout the WOO is the impact that policies will have on both energy supply and demand. The potential effect of energy policies on the future energy mix, either from those already in place or still in development, continue to garner momentum and is the focus of many countries' post-pandemic planning.

Countries across the globe are striving to meet commitments to limit global warming as part of the Paris Agreement and are using national, regional and international policy mechanisms to achieve their goals. Furthermore, as collectively commitments have so far been found to be insufficient to reach the long-term targets of the Paris Agreement, a significant effort is underway in many major countries to develop more stringent policies, which target the end of this decade, as well as mid-century.

The overall result is that these policies become a driving force – with the potential to accelerate a change in the energy mix with the deployment of low- or zero-emission energy systems, or in their support of the adoption of technologies that are utilized to reduce emissions. The formulation of such policies depends heavily on the national circumstances, priorities and capabilities of individual countries. While some countries are already aspiring to electricity sectors without gas – a fuel source that has been an important transition fuel for moving away from coal – others must first provide reliable, affordable, sustainable and modern energy access to growing populations and may turn to other forms of energy they have readily available.

The COVID-19 pandemic has also brought change to the energy industry with investment in renewable energy sources faring best through the downturn. Some countries are utilizing a share of the fiscal stimulus aimed at boosting economic recovery to support the energy industry and specifically the development of clean technologies, advancements in energy efficiency and an enhanced role for renewables. However, policy makers must also walk a fine line as there is always the potential for energy-related policies to be misdirected or to be unnecessarily burdensome on the economy, with regressive social impacts creating challenges for resilient, just, inclusive and sustainable development.

This section introduces some of the key energy policies that have influenced this year's WOO Reference Case with the assumption that energy policies in major countries will continue to evolve as an extension of recent trends. Broadly, enacted policies are mostly assumed to be met. As the recent past has shown, not every target will be met or met on time, and some major policies may only be implemented partially. However, legally binding targets, as already seen in the likes of the UK and the EU, will likely help ensure adherence to ambitious targets in the future. A summary of key energy policies in major countries is provided in the following sections and more detail on these policies is provided in Chapter 7.

US

The US, the second largest global emitter, officially withdrew from the Paris Agreement on 4 November 2020, and its then administration rolled back more than 100 climate-related rules. However, the newly elected US President, Joe Biden, signed an executive order to rejoin the Paris Agreement on 20 January 2021 – only hours after his inauguration. The US formally rejoined on 19 February 2021, and the new administration has proposed a national climate plan, aiming to phase out fossil fuels by expanding renewable energy capacity while creating jobs. However, the scale of the new administration's shift towards cleaner energy will only be seen in the years to come, and will likely be influenced by a wide range of issues.

Upon assuming office, the current administration signed an executive order on its climate change policy initiatives, giving instructions to various departments of the federal government to begin work towards more ambitious goals for climate change concerns. Returning to the world stage, the US hosted a Leaders' Summit on Climate in April 2021 and submitted its Nationally Determined Contribution (NDC) after re-joining the Paris Agreement, emboldened with a new target for 2030 that aims for a reduction in emissions of 50–52% from 2005 levels. The administration has also moved to reverse many of the Trump administration's changes, directing the government to review regulations and actions undertaken during the four years of the previous administration.

Amongst the headline targets is a plan to create an emission-free electricity sector by 2035. New drilling activity on federal land was again put on hold, while federal-level fossil fuel subsidies are under scrutiny – although it is uncertain what impact this would have on the tax deductions available for exploration and production. Additionally, the permit for the much-opposed Keystone XL oil pipeline between Nebraska, US and Alberta, Canada has been revoked. The oil and gas industry will also be impacted by proposed methane emissions limits, seeking to reduce leaks, venting and flaring, and this could be applied to both new and existing oil and gas operations.

In other policy proposals, the adoption of EVs in the US will receive a boost from the administration's infrastructure plans. While the final size and scope is still under negotiation in the legislature, current proposals are in the trillions of dollars and a share of this is earmarked for investment in the EV industry, including support for a network of 500,000 charging points across the US by 2030, as well as further rebates and tax incentives for buyers.

Delivering on these policy goals, either through regulation (via the Environmental Protection Agency (EPA), for example) or through legislation will not be straightforward and the administration's first term will undoubtedly be challenging. The administration's slim Senate majority (only able to pass legislation with the vice-president's tie-breaking vote) does not guarantee the passing of new pieces of legislation, particularly with the filibuster remaining in place. This could present a barrier to cementing in law the 2050 target for net-zero emissions, which the new administration hopes to do so to join other countries that have already announced this target.

EU

The EU's energy policy in 2020 was dominated by the arrival of the ambitious European Green Deal. This framework, which sets out the EU's aim to become the world's first climate-neutral continent, continues to be developed and reinforced with new legislation and updated proposals. In December 2020, the EU and its Member States submitted their updated NDCs. In April 2021, an important deal was agreed on a Climate Law that once given final approval would put the EU's 2050 target of net-zero emissions into law and require Member States to take the necessary policy action to achieve the target, with systems in place to monitor progress.

In practice, it is likely that the policies of this decade, up to the year 2030, will ultimately determine if the 2050 net-zero emission target can be met. The EU has acknowledged that the speed of progress has to be strengthened, and in September 2020 it proposed to set a 2030 target for GHG emissions reduction to 55%, compared to 1990 levels. This is an increase from the original 40% reduction target. The EU Commission, therefore, asked for proposals to bolster legislation to achieve this and on 14 July 2021 it provided a wide ranging, but interlinked set of proposals known as the 'Fit for 55' package that would revise key energy policies including the Emissions Trading System (ETS), the Effort Sharing Regulation and the Renewable Energy Directive, amongst others, as well as provide proposals for new initiatives

The year 2021 was already an important step for the EU ETS as it entered the fourth phase of its evolution. Operating on a 'cap and trade' system, this latest phase was to reduce the cap – the maximum allowed annual emissions – at a faster rate of 2.2% p.a., while also boosting efforts to reduce the surplus of allowances that have built up over time. This rate will now be increased to 4.2% p.a. and the maritime sector will be phased into the ETS.

It is also important to note that the EU proposes to create a parallel ETS for the buildings and transportation sectors. Furthermore, a Carbon Border Adjustment Mechanism (CBAM) has been proposed, which would require that goods exported to the EU also consider GHG emissions, to help avoid what is known as 'carbon leakage' as businesses move production to regions with lesser environmental restrictions.

In the long-term and for sectors that cannot easily be decarbonized, such as heavy industry, the EU, like other major economies, is looking at the use of hydrogen. The development of hydrogen as a part of the energy mix is at a very early stage and still requires significant development in the areas of technology, infrastructure and investment. In addition, it may not as yet be cost competitive, especially not for the EU's focus on 'green hydrogen' that is made through electrolysis with electricity sourced from renewables.

China

The widely anticipated unveiling of the 14th Five-Year Plan (FYP) took place at China's National People's Congress in March 2021. The overarching strategy sets out the country's broad goals for the period 2021–2025, directing and influencing government policy, as well as energy policy. The plan's target increases were an update of the previous FYP, with some expecting more significant policy changes surrounding climate change, but it instead focused more on ensuring economic growth, building China's domestic market, and the short-term recovery from the pandemic.

China still has much to think about when setting new energy policy. On one hand, its 1.4 billion people are using more and more energy each year, even if population growth is now plateauing. In addition, energy security is a central issue for China as the country imports 70% of its oil. Therefore, the use of nuclear, coal and renewables are logical areas of focus when planning its future energy mix. China has announced its aim to increase its nuclear power capacity by 40% from 50 gigawatts (GW) in 2020 to 70 GW in 2025. In addition, the country intends to get 20% of its total energy consumption from non-fossil fuels by 2025, compared to 15.9% in 2020.

On the other hand, China has announced several targets related to climate change, most notable is the carbon neutrality target for 2060, which is connected to the earlier target of reaching peak carbon emissions by 2030. The 14th FYP does not yet provide many specifics or reforms on how this goal will be met, it is expected that more details will be gradually made available in the near future.

China has also long planned the launch of a nationwide ETS and following regional pilots in previous years, the national system has been taking shape in 2021. The system will first cover the power sector and around 40% of China's carbon emissions, before future expansion to other sectors. As a key instrument to limit carbon emissions, the system should result in long-term changes to the energy mix. For example, the largest source of CO_2 emissions is coal use in the power sector with 38.4 GW of coal plants being added in 2020, slightly more than what was lost from the phase out of older plants. The ETS should drive an increase in plant efficiency and a switch to fuels with lower carbon emissions.

India

Energy use per capita in India may still be low when compared to other major economies, but India's growing population, urbanization and income levels will ensure that the rapid energy demand increase over the last few decades will continue. Providing power to what will become the largest population in the world in the medium- to long-term will be challenging. In the short-term, however, any policy changes will be considered against the backdrop of the COVID-19 pandemic. It has been an extremely difficult time for India in 2021 with very high numbers of COVID-19 cases, particularly in the 2Q21, and, therefore, the focus remains on combating the pandemic and maintaining economic resilience.

Other priorities for India include improving energy access to all its citizens and, so far, it has been very successful in its endeavours. However, there is still work to be done in moving away from the use of biomass as a cooking fuel, which is a major health concern. Government subsidy programmes continue to support the use of liquefied petroleum gas (LPG) for this purpose, helping

to make the fuel as affordable as traditional biomass. In general, government policies are focused on leveraging more gas with an increase in urban natural gas distribution networks.

In energy policy, the Indian government has shown increased ambition in the area of renewables: not just to meet climate targets, but also to reduce dependency on oil imports. India has the highest dependency on fossil fuels for electricity generation amongst major countries and existing policies are already attempting to boost domestic oil production and increase the share of blended fuels, such as bioethanol, in the transport sector. Amongst the options for reaching the government's headline target of 450 GW of renewable energy capacity by 2030, solar is at the forefront due to its relative low cost.

As a greater share of the population utilize modern household appliances, a number of policy efforts targeting energy efficiency have evolved, for instance, through standards and labelling to help consumers select energy efficient devices, or the India Cooling Action Plan, launched in 2019, which looks at improvements in the efficiency and technology of air conditioning units. Along with other government programmes, such as the distribution of hundreds of millions of Light Emitting Diodes (LEDs), energy efficiency efforts are helping to save a large amount of energy use and lessen the overall increase in energy demand.

Africa

The African energy sector has made progress in recent years regarding energy policies that will enhance the continent's socio-economic development. Many African countries have national energy strategies to be implemented, albeit with differing time horizons. In some cases, these energy strategies are part of a broader strategy to boost the country's economy, and/or to reduce energy poverty. Box 2.1 of this edition of the WOO provides an insight into the potential future energy demand of Africa.

Major regulatory frameworks have been put in place to achieve economic growth and sustainable development in the African energy sector and ensure access to affordable, reliable and sustainable energy for all, with a focus on UN SDG 7. The African Union Agenda 2063, the New Partnership for Africa's Development (NEPAD), in collaboration with the African Development Bank (AfDB), and the Programme for Infrastructure Development in Africa (PIDA) undertake policy development and coordination at the continental and regional levels.

Other countries

Within the OECD group of countries, a recurring and increasingly common theme are stringent energy policies in the medium-term, ultimately focused on meeting climate targets around 2050. Some of the recently announced changes are as follows:

- The UK has increased its emissions reduction target to 78% by 2035, compared to 1990 levels. This is arguably the most ambitious target of major world economies and will be enshrined into law. Amongst others actions, the pathway to meeting this target includes the continued deployment of renewables in the electricity sector and the change to low-carbon alternatives for consumers, such as new vehicle sales to be electric and a move to electric heat pumps in homes. The UK is also set to host COP26 in Glasgow, Scotland, in October/November 2021.
- Canada's NDC is to reduce GHG emissions by 30% below 2005 levels by 2030. However, it was announced at the April 2021 Leaders' Summit on Climate convened by the US administration that Canada will now reduce its GHG emissions by 40–45% below 2005 levels by 2030, and move forward on a path to reach 'net-zero' emissions by 2050.
- Japan announced at the Leaders' Summit on Climate a 2030 target to reduce GHG emissions by 46%, however, this is compared to 2013 levels. Its previous target was 26%, which was largely criticized as being insufficient and unambitious.

- South Korea announced it would raise its 2030 target later this year, which currently aims for a 24.4% emissions reduction by 2030, compared to 2017 levels. The country's electricity sector is the focus of efforts to reduce coal use, which made up around 40% of the energy mix in 2019, by closing coal power plants and converting all others to use gas as a fuel by 2034.

The above countries and several others have announced net-zero emissions targets for 2050.

1.4 Technology and innovation

Both current and future technologies will play a significant role in shaping the future energy landscape. The development, and implementation of technologies covering a multitude of areas contributes to helping set the scene for the Reference Case. The WOO 2021 explores different energy sectors with a specific focus on energy demand, as well as how these might shift or transform the outlook. The WOO assumes a continued evolution of technology. The development and prospects for new technologies related to the global energy business, including possible breakthroughs are also explored, including for a long-term perspective.

1.4.1 Road transportation

This Outlook assumes that internal combustion engines (ICEs) remain the leading technology for both passenger and commercial road transport segments. The fast pace of technology advancement over many decades has contributed significantly to the efficiency of these types of engines. Although electric mobility has undergone some remarkable advancements that are expected to continue, the outlook sees ICEs remaining dominant throughout the forecast period.

While ICEs still represent the largest share of the market for light duty commercial vehicles, a diverse range of electric drive technologies are noticeably becoming more competitive. Improvements in battery technology, and the support of governments to meet fuel efficiency and emission regulations, are helping push electrification in this market segment. However, the other two segments of commercial vehicles will likely be less affected by electrification during the forecast period.

For passenger vehicles, ICEs are expected to continue to dominate this sector, but powertrain electrification is now making inroads into this segment, with battery electric (EV), hybrid (HEV), and fuel cell electric vehicles (FCEV). Moreover, future developments in battery technology are expected to overcome many of the current limitations they face, which places a burden on oil powered ICE to introduce redesigned engines that are more fuel-efficient and meet lower emissions regulations.

As battery technology continues to improve, increasing energy density and range, and the cost of passenger EVs inevitably reaches parity with ICE vehicles in the medium-term (supported by government incentives in the vast majority of countries) the last major area vital to the mass adoption of EVs is infrastructure. Here efforts are needed to incentivize and support the rollout of superfast charging infrastructure.

The commercial vehicle segment in the overall fleet is dominated by diesel powertrains. Demand for this type of vehicles – light, medium and heavy commercial vehicles – has grown in recent years and it is expected to continue growing over the forecast period, especially in developing countries. This is mainly due to diesel being the most economically attractive technology, especially for heavy duty vehicles. Nevertheless, some penetration of liquefied natural gas (LNG) and compressed natural gas (CNG) driven vehicles into this segment is assumed as well. Moreover, CNG vehicles are also set to expand in the passenger cars segment, especially in several Asian countries.

The COVID 19 pandemic has had a negative impact on shared mobility, ride-hailing, and internet-based on-demand mobility services. Demand has plummeted significantly on the back of government lockdown measures, remote working and social distancing measures. However, it is expected that shared mobility will gradually recover in conjunction with lockdown measures being eased, the wide deployment of vaccines, and the return of more employees to their office work environment.

1.4.2 Air transportation

The COVID-19 pandemic has had a major impact on demand for air transportation. The International Air Transport Association (IATA) stated that the global Revenue Passenger Kilometres (RPK) dropped y-o-y to an average of 66% in 2020. The effects on the industry have continued in 2021. In April 2021, Willie Walsh, the IATA's Director General said: "This crisis is longer and deeper than anyone could have expected. Losses will be reduced from 2020, but the pain of the crisis increases."

It is clear that air transport remains challenged, particularly on international routes, there are greater complexities for travel, related to such issues as government policies on quarantine and social distancing measures, there has been a drop off in consumer confidence, and falling global trade volumes.

However, with optimism for a global economic recovery in the coming years, it is expected that the air transport sector will witness a rebound, albeit a slow and gradual recovery in the short-term. Looking more medium- to long-term, a key contributing factor to the air transportation recovery is the rising expansion of the middle class – reflecting the largest segment of demand in the global economy – and the rapid increase in the global population.

While 2020 and 2021 have been extremely tough years for the air transportation sector, it has not stopped the industry from introducing a new generation of aircraft focused on enhanced efficiencies. Aircraft manufacturers have been building more efficient aircraft, ensuring high flight loads, and enacting carbon offsetting schemes. The transition towards Sustainable Aviation Fuel (SAF) has been identified as one of the key factors in reducing GHG emissions across the industry in a step to further reduce its climate footprint. Overall, and relative to 2005, the industry aims by 2050 to reduce net aviation CO_2 emissions by 50%. Other features of the next generation of aircraft includes innovative redesigns of the fuselage and wings to help reduce fuel consumption and increase passenger capacity.

Electrification in this sector is still in its infancy, with it mainly being focused on small (one-to-two seat) aircraft equipped with electric motors running on battery power. There are also a number of companies developing so-called urban air taxis, for short distance flights, but there remain significant challenges for electrification in medium- and long-range flights, as well as for larger applications. Other potential challenges in air transport electrification include redesigning aircrafts to accommodate power-to-weight ratios, and the reliability and certification of new aircraft technology.

1.4.3 Marine transport

The global cap on marine fuel emissions from the International Maritime Organization (IMO), enforced on 1 January 2020 has resulted in a significant demand reduction for high-sulphur fuel oil (HSFO). Known as IMO 2020, the regulations in Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL), set a new cap mandating a maximum sulphur content of 0.5% in marine fuels globally. In June 2021, Argentina became the 100th contracting state to ratify these IMO regulations on cutting air pollution from shipping. The IMO said that with Argentina's ratification, the regulations now apply to 96.65% of world merchant shipping by tonnage.

Other developments focused on emissions and efficiency from the IMO for the marine transport sector, include a reduction in annual GHG emissions from shipping by 50% in 2050, and a reduction in average carbon intensity by 40% in 2030 and 70% in 2050, compared to 2008 levels.

These challenges for the industry have expedited the search for cleaner and more fuel-efficient technologies.

Marine ICEs continue to be the mainstay of the marine transport sector. The modern versions of marine ICEs can achieve efficiency rates above 50%, with less fuel consumption and less exhaust emissions. New modern ICEs can also be dual-fuel operated, using LNG as a secondary fuel. It is projected that LNG usage will expand in marine modern ICEs in the medium- to long-term. In fact, LNG could become the dominant fuel, especially for large ocean-going vessels. The advantage of LNG would be a significantly reduction in carbon dioxide (CO_2) emissions, compared to liquid fuels. Moreover, there is growing interest in the shipping industry to use ammonia as an alternative fuel for large vessels.

Electrification in the marine transport is emerging, albeit slowly. The technology advancement in both electric propulsion and battery storage systems are likely to play a role in emission reductions to meet the IMO's global target. The sector, however, is not necessarily willing to compromise cargo space and range to implement this technology for maritime applications.

1.4.4 Conventional and renewable power generation

The penetration of renewables into the electricity generation sector is set to rise throughout the WOO's forecast period. As part of the energy mix, renewables, led by wind and solar, is expected to gradually phase out mostly coal, as well as some natural gas and oil-fired electricity generation.

Coal-fired power plants have matured and the efficiency advantage brought to the industry by using boilers with supercritical thermodynamic cycles has allowed efficiency to rise above 45%. However, they are being phased out in many regions and countries, such as the EU and the UK, which has also led to a decline in CO_2 emissions. The electricity generation output from coal-fired power plants in the EU and the UK has reduced by 60% since 2000. In conjunction with policy measures and related economics, it is clear that coal-fired power plants will see a further phase-out in the years and decades ahead. In Europe, by 2030, 50% of current coal-fired power plants are expected to be either closed or scheduled to be permanently shut.

China, on the other hand, is taking a different approach to phasing-out coal-fired plants, as well as building new ones. With 1,037 active coal-fired plants, 186, or 18%, have been flagged with deficient performance and are up for early decommissioning. Furthermore, the country is partly replacing old, and inefficient, coal power and heat plants with more efficient and centralized coal plants (so-called 'clean coal'). Approximately 250 GW of coal-fired power plants are under development in China.

Both economics and policy measures are driving the increase in coal-to-gas switching and contributing to a drop in CO_2 emissions. In the US, the switch from coal-to-gas, due to an abundance of natural gas, has been behind the recent decline of CO_2 in the power generation sector. With its large output and high-cycle efficiency, gas-powered combined cycle power plants (CCPPs) will remain by far the least CO_2-emitting fossil-fueled power plants. Such an advantage should not be underestimated as countries and regions look to tackle climate change at low investment costs.

In Europe, for instance, both the increasing competitiveness of gas, along with the EU ETS, are aiding the push for gas-fired generation. Overall, CCPPs are more advantageous (fuel-to-power) than supercritical coal power plants, due to a higher thermal efficiency. Furthermore, enhancing power plant efficiencies can be achieved via cogeneration (power and heat), with gas-fired combined heat and power (CHP) potentially reaching an overall efficiency range between 65% and almost 90%.

Low-emission production is driven by the increasing share of renewables – mainly wind and solar. Hydropower is also an important component of renewables. It is worth highlighting that power generation (and other energy use) may be carbon-neutral, but not necessarily renewable. Moreover, renewable energies can be subject to either climatic disruptions for hydropower, or to weather conditions that make them inherently intermittent (sunshine or wind speed).

The increased share of renewables in the power generation mix has been driven by both energy supply security, and the need to diversify the primary energy base as a whole. The introduction of new technologies, while improving current ones, championed by massive investment and supported by significant direct and indirect subsidies, has contributed to increasing the efficiency of photovoltaic (PV) cells or enlarging the range of useful wind speeds for wind turbines, for instance. The financial backing of renewables has brought down their power-generation costs rapidly to now compete with conventional means of electricity generation. Additionally, and with the leveled costs of generation for both wind and solar declining further, these trends are likely to continue, making them increasingly competitive relative to fossil fuel-based generation.

Energy storage technologies on a large scale are still a missing link to support the strong uptake of renewables, despite the substantial efforts to push advances in this area and the possibilities for electrification in various energy sectors. Battery storage continues to progress in terms of cycle stability and specific costs. However, with current battery technology for industrial-scale power, storage seems unlikely to compete with fossil fueled back-up plants.

Various power-to-fuel concepts propose to store renewable power as a fuel for the use in combustion engines or fuel cells. However, they are currently not economically viable and may only become so when cheaper renewable power is available in the future. Besides, renewable power for industrial-scale use is often generated in larger volumes far from consuming centres – in distant locations, offshore or in the desert. As a result, that energy must be transmitted – by high-voltage systems – from producing to consuming locations. This Outlook takes into account such secondary effects impacting the expansion of renewable power.

The ability to store energy is essential to ensure security of supply and achieve a balance between supply and demand. The management of the electricity network is another dimension to be taken into consideration, since production must adapt instantly to demand, or even anticipate it. However, the lack of energy storage entails a higher rate of back-up power (mostly gas- and coal-based) to offset the intermittency of wind and solar power generation.

As the world takes gradual steps on the pathway to cleaner electricity, the development of blue hydrogen (see below) electricity generation, which could be of interest for future oil applications, is also underway and is subject to the advancements of carbon capture and storage and/or utilization (CCS/CCU).

Refining systems have a traditional role in providing transportation fuels. Yet, recent developments, namely IMO regulations and carbon constraining policies, could force bottom-of-the-barrel fuels like fuel oil to seek other outlets. Steady and favourable oil and carbon pricing could aid the promotion, and development, of stationary fuel cells in a carbon-constrained pathway. Thermodynamic cycles using supercritical CO_2 also has potential in electricity applications, although this is still at a conceptual stage.

1.4.5 Hydrogen

The energy transition may be seen as a structural shift toward a more sustainable energy system and as a pathway toward a transformation of the global energy sector to a net zero-carbon energy system. In the context of the energy transition, hydrogen is also emerging as a solution to

many challenges, playing the role of energy carrier as an alternative to fossil fuels. Furthermore, the fact that hydrogen is a chemical product is very attractive as a means to aid massive energy storage.

In the medium- to long-term, hydrogen could help reduce emissions in many sectors, such as the industrial and transport sectors, and it could be utilized for blending in gas networks. In the longer-term, hydrogen storage can be developed as a complementary solution to enable flexibility in the electricity system, which is a potential issue due to the intermittency of renewable energy sources.

Blue hydrogen is derived from fossil fuels, particularly natural gas, but with emitted CO_2 captured to be reused or stored. Mature technologies exist for the production of 'blue hydrogen', however, it is highly dependent on feedstock costs and the development of carbon capture technology. The continued development of the blue hydrogen business model will help it become cost competitive with other forms of hydrogen. Hydrogen produced from renewable energy sources, or 'green hydrogen', has greater challenges, particularly related to scaling up to overcome cost hurdles, and especially in centralized applications to enable electricity generation at scale and to penetrate hard to abate industrial sectors.

Therefore, blue hydrogen could play a pivotal role in the energy transition in the near future; helping to meet the world's increasing demand for hydrogen. The topic of policies related to hydrogen is covered further in Chapter 7.

1.4.6 Embracing Industry 4.0 and future prospects in technology and cybersecurity

In the midst of the so-called Fourth Industrial Revolution, or Industry 4.0 as it is widely known, the oil and gas industry has huge opportunities to develop, evolve and implement new technologies into its complex value chain. To date, rapid technology advancements have enabled the industry to explore new methods for increasing production, minimizing associated operational costs, and reducing environmental pollution.

Looking ahead, the advancement of cellular networks, via the introduction of 5G, is paving the way to a fully connected world. Coupled with the Internet of Things (IoT), 5G technology will help maximize the potential of diverse modern-day technologies and applications. Combining AI, in addition, will create more opportunities, and help the development of further applications that may reshape the future industry.

The ongoing development of sixth generation wireless communication technology will enable 3D networks and Networks-On-Chip architecture. Such development will further enhance radio access competency and on-demand edge cloud services in the 3D space. Thus, it will enable a hyper-connected world with extremely immersive experiences via haptic experiences.

A further issue in the technology relates to cyber security, which is an existential challenge for the energy sector. The integration of IT systems with operational technology systems can place unique cybersecurity risks on industries, and creates vulnerability throughout the value chain. This was brought to the fore in 2021 following the ransomware attack on the Colonial Pipeline in the US, underscoring the critical importance of cyber resilience for the industry,

The industry is taking a multi-pronged approach to help mitigate potential disruptions from cyberattacks, particularly given the fact that the cyber threat landscape is rapidly evolving and expanding.

Box 1.1

Digitalization in the oil and gas industry: opportunities and risks

Digitalization and other disruptive related-technologies, such as blockchain, cloud computing, the IoT, ultra-high bandwidth networks and AI, have undoubtedly become critical forces influencing the transformational changes shaping the future industry and energy landscapes. For instance, tremendous progress has been made in mobility driven by ultra-reliable and performant wireless networks (i.e.4G/5G radio networks), the continuous increase of computational power and hardware cost reduction validating Moore's law, and the improvements in electrical energy storage with batteries providing sufficient operational autonomy.

The commercialization of technologies and the accelerated digital transformation has been all the more evident during the COVID-19 pandemic. Extensive home office and remote working in many economic sectors during the pandemic were a necessity and pushed the more effective use of digital technologies worldwide. Hence, this crisis constitutes an opportunity to continue shifting information technologies from a role of support enablers to strategic ones. Digital innovation is reinforcing its position as a high priority strategic driver in all economies and in the energy sector in particular.

Improving efficiencies

The 2014–2015 market downturn pushed companies to improve organizational and operational efficiencies by investing heavily in process re-engineering to integrate and automate various technologies to better align overall optimization processes.

In facilities and operations there has been extensive use of advanced data analytics, AI in reservoir modelling to improve oil recovery and reduce the marginal cost of the barrel. Site reachability and remote monitoring is also continually improving through the use of robotics and airborne drones, which improve the management of assets in all terrains and weather conditions, as well as machine-to-machine technologies and sensors.

Another major disruptive technology that has advanced in recent years is blockchain, which has helped revolutionize transactions. Its versatility, and its use of cryptography and Internet Protocol networks to create a distributed leger in which data is impossible to modify or alter, offers significant advantages. Its transparency and its faster transactions could be applied to various areas of the oil and gas industry; an industry with a global reach, with often diverse structures and regulations.

Not only does blockchain allow for improved operations and cost reductions based on smart contracts and asset tracking, it can also be used for monetary transactions. Procurement, ticketing, access to information, optimizing operations and scheduling logistics are just some examples.

Digitalization and blockchain technology is also permeating oil and commodity trading. New technologies are helping improve the storage, logistics and the transaction and transparency of physical commodities like oil, but it is also evident that the impact of algorithmic trading, quantitative trading and high-frequency trading can exacerbate market volatility.

A recurring mistake is to precede with technology adoption before sound change management. Digitalization or digital transformation is first and foremost a change management

process, which aims at optimizing value creation by increasing efficiency and minimizing losses. A successful digital transformation starts with a clear and reasonable vision, it is well formulated and is based on an appropriate strategy.

New technologies, new risks

Security, regulatory challenges and the governance dimension need to be borne in mind when utilizing new technologies. As oil and gas companies rapidly digitize operations, they simultaneously expose themselves to cyber risks. Cyberattacks can come in a variety of forms, with motivations ranging across financial, criminal and/or geopolitical arenas. The US Colonial Pipeline closure due to a cyberattack in early 2021 is just one example in terms of disruptive implications.

Therefore, it is critical for oil and gas companies to consider cybersecurity as an integral part of their business model to protect their activities, industrial operations and assets, especially in a globally interconnected setting. This calls for increased cooperation to enhance awareness for cybersecurity and improve cyber resilience.

Another major concern is the exponentially growing dependence of raw material, such as rare earths to create all type of digital objects. The magnetic, conducting, luminescent and electrochemical properties of around 30 rare earths make them exclusively necessary for wind turbines, batteries, electrical storage and smart grids. Rare earths are scarce, unevenly geographically distributed and require much energy to extract. Not to mention the associated negative environmental impact resulting from their production and purification processes.

Furthermore, digitalization requires more cloud infrastructures that will be needed to satisfy the huge distributed computational and data storage needs of artificial intelligence algorithms. All this will result in Information and Communication Technologies (ICTs) becoming extremely energy consuming. For example, cooling data centres has become a serious issue especially for AI clouds and blockchain mining clusters.

There is a need to raise awareness with respect to the extensive use of ICTs. Huge amounts of energy can be saved by improving software algorithms, eliminating duplicated data, while keeping necessary security redundancies. Deleting unnecessary storages and deploying power management algorithms are just a few ways to reduce ICT power consumption. More important is increasing end user awareness on how to use ICTs in a more efficient way.

Future prospects

Today, 5G is already offering ultra-reliable connected mobility of things; it allows for much more devices within a given area and uses the spectrum resources more efficiently The next generation of mobile networks, 6G, is already undergoing standardization and is expected to be released in the upcoming decade. The use of 6G will underpin AI, blockchain technology, and autonomous machines. It will leverage on improvements in semiconductors that will run at much higher frequencies with more integration densities.

Moore's law is expected to remain valid for the next decade thanks to advancements in multilayer semiconductors integration. This means computational power will continue its rising trend and so will power consumption. The huge amounts of generated data will need more storage, energy and cooling.

All these developments, and the expectations for future ones, will require the industry to continually evolve and transform from a human perspective. Investment in human capital and upskilling in an environment, where data plays a central role, will be vital.

These shifts, as well as changes in the way the world conducts business, has also been exacerbated by the COVID-19 pandemic. Will these new ways of working become new standards? Something is sure; digitalization has gained great momentum and will not be seen the same way.

COVID-19 has further advanced digitalization and new technologies, and in the face of these rapid changes, the oil and gas industry has to work together to leverage its potential and to take full advantage of digitalization in light of the lessons learned from the COVID-19 crisis.

Energy demand

Key takeaways

- Global energy demand is set to increase from 275.4 mboe/d in 2020 to 352 mboe/d by 2045.
- China, India, and other developing nations will continue to drive global energy demand growth.
- Global demand for oil-based products is projected to reach 94.5 mboe/d in 2025 and 99 mboe/d in 2045.
- Oil demand in non-OECD countries is set to increase and, despite decelerating oil demand growth in the second part of the forecast period, oil will retain the highest share in the global energy mix during the entire forecast period.
- Oil demand in OECD countries will be marked by a short period of strong growth in recovering from the COVID-19 pandemic, before entering a long period of slow, albeit steady decline.
- The downward trend for coal demand is accelerated after the pandemic with targeted policies focused on cleaner energy sources. Coal is the only fuel that experiences negative growth over the forecast period.
- Natural gas demand is projected to increase from 64.2 mboe/d in 2020 to 85.7 mboe/d in 2045. However, growth is expected to decelerate throughout the outlook period, due to the rising penetration of renewables and continued efforts to improve energy efficiency.
- Almost 95% of gas demand growth comes from developing countries, mostly Asia and the Middle East, driven by the power generation and industrial sectors. By 2030, gas is expected to overtake coal and become the second largest fuel in the energy mix.
- Global demand for nuclear and hydro increases moderately over the forecast period, but both remain important fuel sources in providing sustainable energy supplies.
- Other renewables driven by policies, technology and the energy transition continue to witness accelerated growth in all regions.
- Other renewables maintain the leading role in the growth forecast with a share in the energy mix moving above 10% in 2045, from just 2.5% in 2020.
- In both OECD and non-OECD regions, energy efficiency in most sectors will continue to advance, outpacing improvements achieved in the past 25 years despite the economic shocks related to COVID-19.

COVID-19 has introduced many new uncertainties and yet another demand-related factor; the post-pandemic recovery. The recovery stage induced various economic stimulus packages that are diverse in nature and vary according to the region. The pandemic has also brought new behavioural patterns, some of which will likely linger for several years, and in some cases, may become the new normal. This includes remote working, a shift in transportation modes, and a re-energized resolve for low-carbon energy deployment. These and other fundamental energy demand drivers will continue to influence present and future energy demand pathways. With the arrival of the COVID-19 pandemic, renewable energy deployment has received additional impetus, through policies and fiscal stimulus. Considerations for the rapid development of clean energies and achieving low emission targets have come to the fore, especially in developed nations.

Despite the disruption caused by the pandemic, primary energy demand and final consumption are continuously guided by economic growth, supply and demand fundamentals, technology, as well as policy and regulatory frameworks. In a way, the pandemic decelerated the growth of some energy sources, while accelerating the energy transition and the deployment of low-carbon sources, especially renewable resources.

This chapter highlights the continued leading role of fossil fuels, particularly oil and gas in the medium- and long-term, but also the significant growth of renewables, albeit from a low starting base. It focuses on the development, expansion, and deployment of primary energy sources at both the regional and global level for the outlook period from 2020–2045. This includes the interconnectivity of key energy demand drivers during the pandemic, at the recovery stage and into the post-pandemic future. It also analyzes the future demand trajectory for each primary energy source, including their inter-play, as well as economic, supply security and sustainability issues.

It is important to note that 2020 is the statistical data baseline for the outlook and for those regions where data is not available, the outlook supplements these data sets with estimations from other available data sets.

2.1 Major trends in energy demand

Energy demand encompasses economic activities, demographic factors, and other key fundamentals, and the constituents of the energy mix can also be shaped by technology, policy, and regulatory frameworks. Moreover, consumer behaviour and preferences can play a vital role in final energy consumption.

The global health emergency and widespread economic lockdowns, induced by the COVID-19 pandemic, hit demand for primary energy dramatically in 2020, and it is clear this will have an impact on future energy deployment and its efficient use. The global economy was devastated during the pandemic and even large economies entered deep recessions, while other economies dependant on revenues from commodities, such as oil, suffered greatly in a time of weakened demand. Consumers spent less money and energy industry investments were hit dramatically. Mobility was temporarily curtailed, as lockdowns to prevent the spread of the virus restricted travel, especially road and air transport.

The rebound of energy demand in 2021 followed the successful development and production of vaccines, and lower new infection numbers in many parts of the world. Although it is clear that the spread of COVID-19 variants, particularly the Delta variant from June 2021 onwards, saw cases rise again in some parts of the world. Post-pandemic recovery packages, totalling around $26 trillion in fiscal and monetary stimulus, including guarantees, have also helped economic activity and, in turn, impacted on the demand rebound.

The pace of the recovery is different for each energy source, however, coal is unlikely to recover to pre-crisis levels, with fuel-switching in electricity generation and policies focused on the

phase-out of coal, limiting any prospects for a post-pandemic coal rebound. Every region has different priorities for the recovery, as well as energy transition pathway objectives. This is particularly true when looking at the differing challenges of developed and developing nations, therefore, energy demand also varies on a regional basis. Countries are left with a delicate balancing act, with options to optimize between emissions reduction, the economic recovery, as well as ensuring energy access for all. The pandemic, therefore, exposes the vulnerability of the energy system and its overall fragility.

It is a fact that falling costs for solar and wind power are making renewable electricity generation more competitive globally relative to coal- and gas-fired generation. In some regions, the levelized cost of generation is already lower for renewable sources. However challenges such as accessibility, scale and capacity for renewable power generation remain important considerations.

Even if renewables are the current focus for carbon neutrality and low emission aspirations, it is important to recognize that solutions to reduce emissions can be found in a plethora of technologies, such as CCUS and others, as well in the promotion of the Circular Carbon Economy (CCE) to improve overall environmental performance. It is clear that all energies have a role to play.

Demand for all energy sources fell during the pandemic, with the exception of renewables that proved resilient after an initial stagnation at the start of the 2020 crisis. Moreover, the pandemic also provided further opportunities to strategize and plan for the further penetration of low-carbon alternative energy sources, particularly from policymakers in developed countries and regions. The European Green Deal is a key example of this, providing a springboard to drive the development and deployment of sustainable low-carbon renewable energy sources in the EU, to help accomplish its aspiration to attain carbon-neutrality by 2050. More details on the policies of major countries and regions are provided in Chapter 7.

In this Outlook, the electrification of the transportation sector progresses at a quicker pace than anticipated in the previous WOO. Although the global market for automobiles suffered a setback due to the pandemic, the year-on-year (y-o-y) decline did not affect EVs. Charging for these additional electric vehicles will require additional electricity generation, likely from low-carbon sources and renewables, and will hit the share of oil in the energy mix. This fuel substitution is set to proceed, not only in the transport sector, but in industries, as well heating and electricity generation. The transportation sector is discussed in greater detail in Chapter 3.

Global emissions significantly declined during the pandemic in 2020 because of mobility restrictions and lower industrial outputs. Emissions, however, were quick to rebound following the easing of restrictions that increased mobility, and in 2021, as the vaccination roll-out gathered pace.

Table 2.1 outlines the expected energy demand trends in the medium- and long-term. Global energy demand is set to increase from 275.4 mboe/d in 2020 to 352 mboe/d by 2045. Global energy demand contracted 4.5% in 2020 due to the pandemic, but 2021 has thus far seen a significant recovery, albeit not to pre-pandemic levels. The 2045 figure is more than 9 mboe/d below that in the WOO 2020. This is as a result of the expected continued medium-term impacts of COVID-19, GDP revisions, and anticipated further energy efficiency gains.

In terms of the sources and shares for primary energy demand, oil is expected to retain its leading position even though its share declines.

Between 2020 and 2045, the largest decline in the share of the energy mix is projected for coal, dropping from 26.5% in 2020 to 17.4% by 2045. This is impacted not only by the pandemic, but predominately through the strengthening of policy and regulatory measures that will likely lead to fuel switching and more coal-fired plant shutdowns. It should also be noted that even China and

Table 2.1
World primary energy demand by fuel type, 2020–2045

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Fuel share %	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
Oil	82.5	94.5	97.3	98.6	98.9	99.0	16.5	0.7	30.0	28.1
Coal	72.9	74.4	71.7	67.9	64.4	61.3	–11.7	–0.7	26.5	17.4
Gas	64.2	69.8	74.8	79.5	83.2	85.7	21.6	1.2	23.3	24.4
Nuclear	14.3	16.0	17.5	19.0	20.7	22.0	7.6	1.7	5.2	6.2
Hydro	7.5	8.2	8.9	9.5	10.2	10.5	3.0	1.4	2.7	3.0
Biomass	27.2	29.4	31.7	33.8	35.7	37.0	9.7	1.2	9.9	10.5
Other renewables	6.8	11.3	17.4	24.0	31.2	36.6	29.8	7.0	2.5	10.4
Total	**275.4**	**303.6**	**319.3**	**332.3**	**344.3**	**352.0**	**76.6**	**1.0**	**100.0**	**100.0**

Source: OPEC.

India, the largest global coal users, are adopting technologies that increase coal plant efficiencies and reduce pollution, while also shutting down inefficient plants gradually.

Natural gas is anticipated to see its share increase slightly. In terms of volume growth, gas is second to other renewables, adding over 21.5 mboe/d to demand by 2045. Gas demand was also relatively well shielded from the impacts of the pandemic in 2020, for a number of reasons. Firstly, natural gas prices were already declining due to a glut in the market that saw gas prices close to parity with coal, thus making fuel-switching economical. Secondly, regional, and local policies support low-carbon natural gas deployment in power generation and space heating. Lastly, LNG and CNG are finding further applications in heavy trucking, shipping and clean cooking, especially in China and India. Therefore, the decline of natural gas during the pandemic is somewhat offset by a combination of these other short- and longer term factors.

Other renewables maintain the leading role in the growth forecast with its share in the energy mix in 2045 moving above 10%, from just 2.5% in 2020. This is driven by falling costs and policies focused on reducing emissions. Biomass reaches a similar level to that of other renewables in 2045, at approximately 37 mboe/d, however, with biomass use already at 27.2 mboe/d in 2020, its growth over the forecast period is much smaller.

While a decline in electricity demand reduced the output of nuclear plants during the pandemic, nuclear energy suffered less of a setback than fossil fuels in 2020. Output has recovered in 2021, and in the long-term the role of nuclear energy will be important for climate mitigation and energy security with plants producing a large amount of reliable energy to help meet the baseload needs of countries. In terms of primary energy demand, nuclear is expected to increase from the current level of 14.3 mboe/d to 22 mboe/d by 2045, growing at high rate of 1.7 % p.a. during the projection period.

Developments around hydro remain similar to the previous outlook, expanding gradually throughout the forecast period, but making up only 3% of the world's energy mix by 2045. Limited opportunities for new sources of hydro energy and the need for large capital investments temper growth prospects, especially if investments are deferred due to the pandemic.

Turning to the regional outlook, with an anticipated increase in economic prosperity and the urbanization of a growing population, energy demand in the non-OECD region is set to expand significantly.

As shown in Table 2.2, energy demand growth in the long-term is almost entirely attributed to these developing regions. The figures in 2045 indicate that non-OECD demand will constitute over 70% of global primary energy demand, expanding from around 174 mboe/d in 2020 to reach almost 250 mboe/d at the end of the projection period. The main drivers for this growth are the Other Developing countries and India regions, at 27.8 mboe/d and 20.4 mboe/d, respectively.

Table 2.2
Total primary energy demand by region, 2020–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Share *%*	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
OECD Americas	51.0	55.3	55.1	54.5	53.7	53.4	2.4	0.2	18.5	15.2
OECD Europe	33.5	34.8	34.0	33.1	32.2	31.4	–2.1	–0.3	12.2	8.9
OECD Asia Oceania	17.0	17.9	17.9	17.8	17.5	17.3	0.3	0.1	6.2	4.9
OECD	**101.5**	**107.9**	**107.0**	**105.3**	**103.4**	**102.1**	**0.6**	**0.0**	**36.9**	**29.0**
China	66.0	73.1	75.7	76.5	77.0	78.1	12.2	0.7	23.9	22.2
India	17.5	21.7	25.8	30.3	34.3	37.9	20.4	3.1	6.3	10.8
OPEC	19.0	21.7	24.7	27.6	30.2	32.0	13.0	2.1	6.9	9.1
Other non-OECD	49.3	55.8	62.2	68.5	74.8	77.1	27.8	1.8	17.9	21.9
Russia	14.7	15.1	15.0	15.0	14.9	14.7	0.0	0.0	5.3	4.2
Other Eurasia	7.4	8.3	8.8	9.2	9.7	10.1	2.7	1.2	2.7	2.9
Non-OECD	**173.9**	**195.7**	**212.3**	**227.0**	**240.9**	**249.9**	**76.0**	**1.5**	**63.1**	**71.0**
World	**275.4**	**303.6**	**319.3**	**332.3**	**344.3**	**352.0**	**76.6**	**1.0**	**100.0**	**100.0**

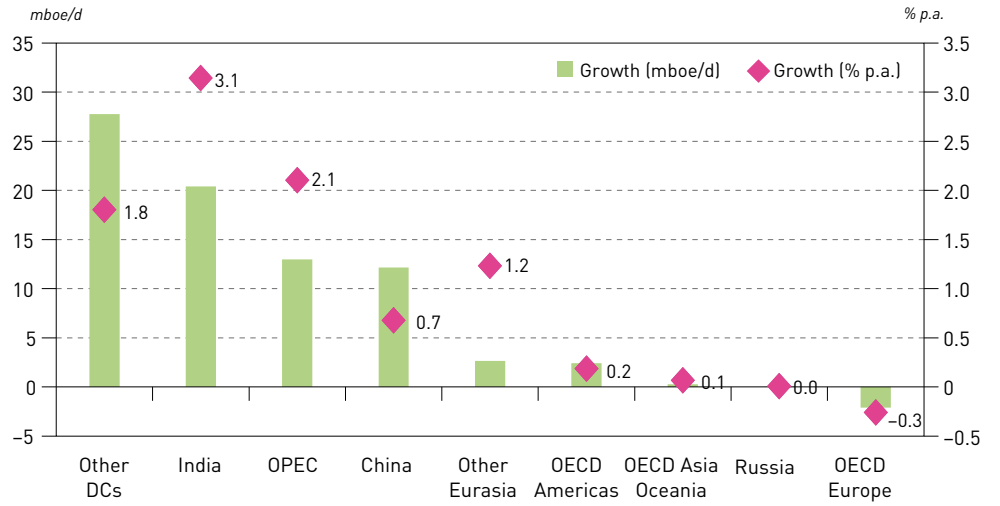
Source: OPEC.

For the OECD region, energy demand flattens in the long-term due to the energy transition and a policy push that continues to place increasing emphasis on energy efficiency and the deployment of low carbon energy technologies. After a partial recovery from the impact of the COVID-19 pandemic, medium-term energy demand in the region is set to peak before declining to 102.1 mboe/d by 2045, reaching a level similar to that seen in 2020 during the pandemic (101.5 mboe/d). OECD Europe is forecast to record a drop of 2.1 mboe/d in energy demand between 2020 and 2045, while OECD Americas is forecast to see a similarly sized increase of 2.4 mboe/d.

Figure 2.1 depicts the growth of primary energy demand by region covering the forecast period. OECD regions continue to see a decline in primary energy demand with increasing energy efficiency, a reduction of energy intensity in industries and the deployment of low-carbon technologies. OECD energy demand starts to decline from 2025 with OECD Europe spearheading the drop at 0.3% p.a. between 2020 and 2045.

On the contrary, non-OECD energy demand grows throughout the outlook period since the region's energy intensive industries flourish. This growth is attributable to increasing populations and expanding economies mainly in Asia, Africa and the Middle East. The energy use reduction in OECD regions is offset by energy demand from the developing regions. India's energy growth is set to overtake China's during the outlook period. This is because of the saturation effects of China's economy and the shift away from energy intensive industrialization, as well as the introduction of more efficient coal powered technologies that replace non-efficient old coal installations. India's economy is on a growth trajectory that requires substantial additional energy, with

Figure 2.1
Growth in primary energy demand by region, 2020–2045

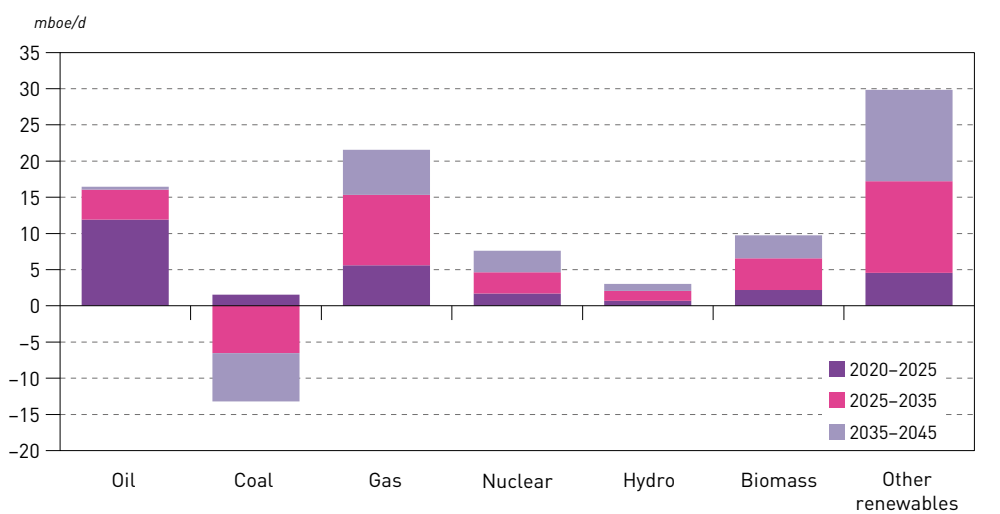


Source: OPEC.

an anticipation of more energy intensive industrial output driven by population expansion and increasing urbanization.

Energy use in the OPEC region is set to increase during the outlook period given expectations for increasing per capita income and higher energy intensity. Additionally, the use of natural gas and renewables (mainly solar PV) continues to expand in the region. Petrochemical expansion in Middle East countries is responsible for some of the additional energy requirements, while the direct use of oil is expected to drop in the region. Other Eurasia energy demand grows marginally, at above 1% p.a. for the projection period, despite the fall off related to the pandemic at the start of the forecast period.

Figure 2.2
Growth in primary energy demand by fuel type, 2020–2045



Source: OPEC.

In terms of global primary energy growth by fuel, the WOO sees the continued dominance of renewables and gas in comparison to other fuels. The sustained growth of natural gas is due to policy support and accessibility in some regions, as well as expanding infrastructure and market mechanisms that favour gas over coal for power generation. These advantages mean that gas witnesses the second largest growth from 2020–2045, behind renewables. Figure 2.2 depicts the position of energy growth by fuels for the forecast period.

Other low-carbon fuels with noticeable growth are nuclear and biomass, both of which can support the global decarbonization drive.

2.2 Energy demand by region

Primary energy demand continues to vary from region-to-region, and the impact of COVID-19 has reshaped a number of regional energy components, sustainable priorities and energy security considerations. The demand disruption resulting from the global pandemic affected all primary energy sources, in all regions. The onset of the pandemic saw a significant drop in energy demand in every region, which rebounded in earnest when lockdown restrictions were partially lifted or eased. China was the first to witness a rebound in energy demand. The post-pandemic rebound has varied across regions with some recovering faster than others, and this goes for fuel types too.

Despite the pandemic, the regional trends for energy use and demand growth seen in previous WOOs are maintained this year. In developed regions, the continued deployment of energy efficient technologies and the lower intensive industrial complex is expected to see lower primary energy requirements on an annual basis in the longer-term. Although energy demand recovers following the pandemic in the OECD region, demand remains below pre-crisis levels and there is a nascent growth shift towards renewables, especially in OECD Europe. Furthermore, lower population expansion, for instance, in OECD Europe and OECD Asia Oceania, saturation levels in the transportation sector, and expected GDP growth rates, translate into lower energy demand growth.

Developing countries see a more diversified and uneven pattern in terms of the energy rebound. The recovery in weaker non-OECD economies is anticipated to progress at a slower rate, reflecting the effects of the pandemic and the subsequent staggered recovery in economic activities.

As noted, the OECD (Table 2.3) continues to deploy less energy intensive solutions and add further renewable generation capacity that drives decarbonization toward low emission targets. Primary energy demand in developed regions is forecast to decline for some fossil fuel types over the

Table 2.3
OECD primary energy demand by fuel type, 2020–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Fuel share *%*	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
Oil	36.3	39.8	37.7	34.8	31.6	28.7	–7.5	–0.9	35.7	28.1
Coal	14.0	13.1	11.2	9.6	8.3	7.2	–6.8	–2.6	13.8	7.0
Gas	28.6	29.9	30.0	30.0	29.9	29.7	1.0	0.1	28.2	29.1
Nuclear	10.1	10.3	10.5	10.7	10.8	10.9	0.7	0.3	10.0	10.6
Hydro	2.5	2.6	2.7	2.8	2.9	3.0	0.4	0.7	2.5	2.9
Biomass	6.7	7.4	8.1	8.7	9.4	10.0	3.3	1.6	6.6	9.8
Other renewables	3.2	4.8	6.8	8.7	10.6	12.6	9.5	5.7	3.1	12.4
Total	**101.5**	**107.9**	**107.0**	**105.3**	**103.4**	**102.1**	**0.6**	**0.0**	**100.0**	**100.0**

Source: OPEC.

projection period. This trend has been further assisted by a re-strategizing in the pandemic recovery stage to consolidate and place more emphasis on low-carbon and green-energy solutions, thus substituting fossil fuels. The OECD stimulus packages and incentives favour deployment and further investment into renewables and transport electrification, with some countries setting targets beginning in 2030 to limit or ban the sale of new fossil fuel cars in the transport sector.

Primary energy demand in the OECD region contracted by 7.4% in 2020 in the wake of COVID-19. In general, the energy demand rebound began in early 2021 on the back of the vaccine rollout and as lockdown measures were gradually eased. The OECD's three main regions – the US, Europe and Japan – have responded to the pandemic differently, each seeing a specific recovery path in terms of the energy mix. However, despite the varied recovery paths, the common longer-term regional characteristic is a strengthening of the deployment of renewables and the declining use of coal and oil in most OECD energy systems. As already noted, the long-term projection does not foresee an energy demand rebound to pre-COVID 2019 levels in the OECD.

OECD primary energy demand in 2045 is estimated to remain at almost the same level as that of 2020. As depicted in Table 2.3, OECD energy demand increases on the verge of 0.6 mboe/d. Other renewables and bioenergy further penetrate the OECD energy mix, increasing by 5.7% and 1.6% p.a., respectively. Oil and coal see the largest declines, as those fuels are affected by efficiency improvements and fuel-switching, while gas sees a slight increase over the forecast period. Oil sees a drop of 7.5 mboe/d, and the use of coal is anticipated to almost half. In terms of overall levels, however, oil and gas are expected to remain dominant with a share of over 57% of OECD primary energy demand by 2045.

In contrast, expanding populations, increasing urbanization and growing economic activities pushes energy demand upwards in non-OECD regions. The majority of the growth is driven by India and China, and there are differing trends regarding fuel types related to resource sustainability and affordability. Consequently, regional and country-specific energy demand growth is generally focused on the deployment of available resources, security of supply and affordable prices.

Primary energy demand in the non-OECD region dropped by 2.3% during the pandemic in 2020, compared to pre-crisis levels, but the region has witnessed a significant rebound in 2021. Non-OECD energy demand in 2025 is envisioned to be 10.8% higher than 2020 levels.

The non-OECD energy mix is dominated by fossil fuels (Table 2.4), although the combined shares drop from around 81% in 2020 to just over 72% by the end of the forecast period due to a rising

Table 2.4
Non-OECD countries primary energy demand by fuel type, 2020–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Fuel share *%*	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
Oil	46.3	54.6	59.6	63.8	67.3	70.3	24.0	1.7	26.6	28.1
Coal	58.9	61.4	60.5	58.3	56.1	54.1	–4.8	–0.3	33.9	21.6
Gas	35.5	39.8	44.9	49.5	53.4	56.0	20.5	1.8	20.4	22.4
Nuclear	4.2	5.7	7.0	8.3	9.9	11.1	6.9	4.0	2.4	4.4
Hydro	5.0	5.5	6.1	6.7	7.3	7.5	2.6	1.7	2.8	3.0
Biomass	20.5	22.1	23.6	25.1	26.4	26.9	6.4	1.1	11.8	10.8
Other renewables	3.6	6.5	10.6	15.3	20.6	24.0	20.4	7.9	2.1	9.6
Total	**173.9**	**195.7**	**212.3**	**227.0**	**240.9**	**249.9**	**76.0**	**1.5**	**100.0**	**100.0**

Source: OPEC.

share for low-carbon fuels. All energies, expect coal, see growth over the forecast period, with other renewables and nuclear witnessing the fastest growth rates, at 7.9% and 4%, respectively.

China and India are both forecast to see considerable growth in renewables as they explore decarbonization and clean energy transition initiatives, but potential expansion is also foreseen within OPEC Member Countries, Africa and Latin America. However, the development and deployment of renewables is subject to capital availability, especially in the post-pandemic recovery phase.

Overall, non-OECD energy demand is set to add about 76 mboe/d to reach 250 mboe/d at the end of the outlook period, well over twice the demand of the OECD region.

While China's energy demand is expected to continue to expand in the coming decades, surpassing OECD Americas in 2045, growth slows over the forecast period. The slowdown is due to expected structural changes in the economy, leading to less long-term consumption growth.

China's energy mix is dominated by fossil fuels, mainly coal, which constituted over a 60% share of its primary energy demand in 2020 (Table 2.5). However, China is strategizing to reduce coal's share in the long-term. This is principally achievable by increasing renewable generation, but also through the replacement of older inefficient coal plants with newer energy-efficient units, which, in turn, lowers coal demand. At the end of the projection period in 2045, coal's share in China's primary energy demand is forecast to drop to around 35%, which translates to an absolute level of more than 27 mboe/d. While coal witnesses a drop, oil and gas rise, given the expanding middle class, further urbanization, and rising mobility levels.

Table 2.5
China primary energy demand by fuel type, 2020–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Fuel share *%*	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
Oil	12.6	14.5	15.1	15.4	15.6	15.6	3.1	0.9	19.0	20.0
Coal	39.8	39.9	37.3	33.5	30.2	27.6	–12.1	–1.4	60.3	35.4
Gas	5.0	6.7	8.1	9.1	9.8	10.1	5.1	2.8	7.6	13.0
Nuclear	1.9	3.0	3.9	4.7	5.7	6.6	4.8	5.2	2.8	8.5
Hydro	2.1	2.3	2.5	2.6	2.8	3.0	0.8	1.3	3.2	3.8
Biomass	2.6	3.0	3.5	4.0	4.3	4.6	2.0	2.3	3.9	5.9
Other renewables	2.0	3.5	5.3	7.1	8.7	10.5	8.5	6.9	3.0	13.5
Total	**66.0**	**73.1**	**75.7**	**76.5**	**77.0**	**78.1**	**12.2**	**0.7**	**100.0**	**100.0**

Source: OPEC.

There is an increasing shift to the electrification of passenger cars in China that will displace oil-based ICE vehicles, but it is expected that the country's oil requirements in this sector will continue to grow. China's overall oil requirements expand at an average annual rate of 0.9% till 2045, when it is expected to plateau due to the further electrification of the transport sector, lower energy-intensive industries, as well as additional efficiency improvements.

China's nuclear capacity is forecast to increase by 2030 in support of its low-carbon deployment initiatives. With an annual growth rate of 5.2% over the outlook period, nuclear is the second fast-growing fuel in the primary energy-mix after renewables. China's 14th FYP announced in 2021 indicates actions and strategies to add 70 GW of nuclear capacity by 2025. Nuclear generation is

projected to reach 6.6 mboe/d by 2045, representing an 8.5% share of the fuel mix, up from just 2.8% in 2020

Other renewables is expected to be the fastest growing fuel in China, expanding on average by almost 7% p.a. from 2020–2045. It is forecast to have a 13.5% share of China's primary energy demand at the end of the forecast period. In fact, about half of the non-OECD's renewable energy growth is forecast in China. It should also be noted that China is home to many rare-earth elements, critical components for the energy transition, which provides the country with an advantage as it looks to be a global leader in renewables.

Table 2.5 indicates that China's energy demand is forecast to expand at a rate of 0.7% p.a., adding over 12 mboe/d by 2045.

India is the key centre for global energy growth, with demand expected to grow at 3.1% p.a. over the forecast period. In early 2021, it was anticipated that India's economy would achieve double-digit growth, but the devastating second wave of COVID-19 in the 2Q21 dramatically hit the economy, and raised uncertainties as to short-term energy demand. Moreover, it is clear that the ongoing effects of the pandemic, including vaccination rates, will impact on short-term energy demand.

Although coal, oil and traditional biomass currently dominate India's energy mix, the country possesses inherent capacity for diversification and flexibility as it looks to satisfy domestic energy requirements. An expanding working-age population, urbanization and industrial capacity are the major drivers for India's energy demand and economic prosperity.

Most of India's coal resources are utilized for electricity generation, which is on the rise to satisfy demand from a growing population and as a result India is a global leader in electricity expansion. The expansion in new electricity connections and the government supported LPG development campaigns are helping reduce energy poverty through the expansion of access to electricity and clean cooking fuels, in line with the UN's SDG 7 initiatives. Moreover, the government's energy reforms in 2020 are putting key structures in place to drive the development of secure, affordable, and sustainable energy systems to help fuel economic growth.

India's future energy map includes provisions to further expand gas infrastructure networks to support growing gas-based industries. The outlook (Table 2.6) sees India's gas demand growing at 5.4 % p.a. to reach 3.8 mboe/d by 2045. Oil and coal are forecast to remain the mainstays in

Table 2.6
India primary energy demand by fuel type, 2020–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Fuel share *%*	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
Oil	4.4	5.8	7.1	8.4	9.7	10.8	6.4	3.7	25.2	28.6
Coal	7.6	9.4	10.9	12.4	13.4	13.8	6.1	2.4	43.7	36.3
Gas	1.0	1.5	2.0	2.6	3.2	3.8	2.8	5.4	5.9	10.1
Nuclear	0.2	0.4	0.5	0.8	1.0	1.3	1.0	6.8	1.4	3.4
Hydro	0.3	0.4	0.4	0.5	0.5	0.6	0.3	3.0	1.6	1.6
Biomass	3.6	3.7	3.8	3.9	3.9	4.0	0.3	0.4	20.7	10.4
Other renewables	0.3	0.6	1.0	1.7	2.5	3.6	3.4	11.1	1.5	9.6
Total	**17.5**	**21.7**	**25.8**	**30.3**	**34.3**	**37.9**	**20.4**	**3.1**	**100.0**	**100.0**

Source: OPEC.

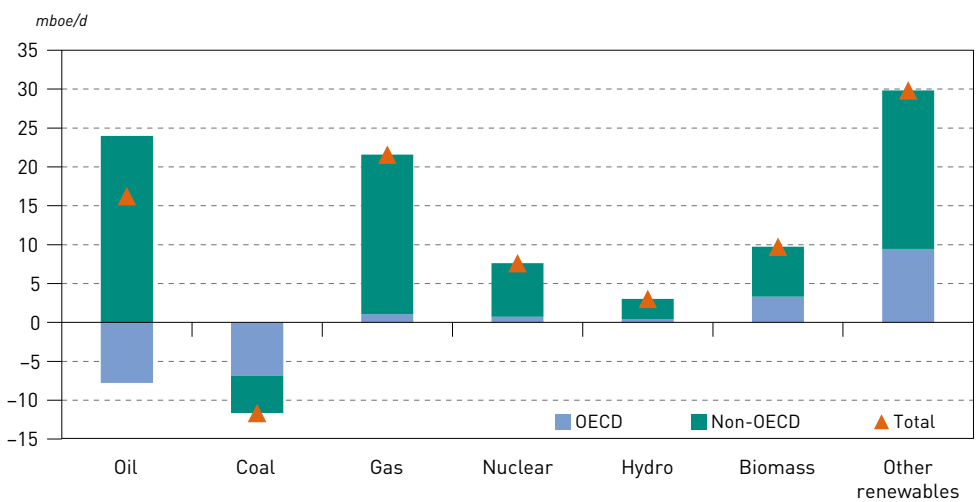
India's energy mix, and combined are still expected to meet well over 60% of the country's energy requirement by 2045. Oil is seen expanding by 3.7 % p.a., adding about 6.4 mboe/d to reach 10.8 mboe/d by 2045. Coal demand grows too, but at a lower annual rate, due to the energy transition and efficiency improvements in coal-powered generation.

Other renewables see the highest expected annual growth of just over 11% p.a., expanding from 0.3 mboe/d in 2020 to reach 3.6 mboe/d by 2045, as India looks to further decarbonize energy systems and electrify the transport sector. With current installed renewables capacity of about 100 GW, India plans to reach a target of 450 GW of renewable power capacity by 2030.

Traditional biomass is experiencing marginal growth in India, tempered by the effects of LPG penetration and improved clean energy for cooking. Biomass is, therefore, expected to grow by a small 0.4% p.a. over the outlook period.

For comparison, Figure 2.3 illustrates regional growth patterns for the OECD and non-OECD by fuel type, which underscores some significant differences. Firstly, it is noticeable that the non-OECD dominates demand requirements with growth in all energy sources, with the exception of coal. In the OECD, both coal and oil see declines on the back of environmental policies and improving efficiencies, and the growth of gas is limited. Coal, and to some extent gas, are seeing their market share in electricity generation shift to renewables in the OECD, especially in OECD Europe.

Figure 2.3
Growth in energy demand by fuel type and region, 2020–2045



Source: OPEC.

2.3 Energy demand by fuel

2.3.1 Oil

The global COVID-19 pandemic, the subsequent economic downturn and the various lockdowns and mobility restrictions across the world resulted in an unprecedented oil demand decline in 2020. Measured on an energy content basis, global oil demand fell by 8.8 mboe/d, compared to 2019 levels. In fact, oil was by far the most impacted primary fuel.

In 2021, however, the situation has changed somewhat. The second and third waves of infections at the end of 2020 and into 2021 affected most countries, albeit with varying intensity. Mobility restrictions continued in many countries and regions, especially during the first half of the year. Nevertheless, the roll out of vaccines and a drop in infection rates during the 2Q21, especially in developed regions, saw a gradual easing of lockdown measures leading to a recovery in economic activity and increased mobility. This also had a positive effect on oil demand, which has rebounded significantly in 2021.

Despite the demand recovery, it is not expected that primary oil demand will fully recover to 2019 levels in 2021. The WOO sees demand growth of around 5.5 mboe/d in 2021, with prospects for the recovery to continue in 2022, and potentially 2023. Lower incremental demand growth is expected in the following years, with global demand for oil-based products forecast to reach 94.5 mboe/d in 2025, representing an overall increase of almost 12 mboe/d between 2020 and 2025 (Table 2.7 and Figure 2.4).

Table 2.7
Oil demand by region, 2020–2045

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
OECD Americas	18.6	21.1	20.3	18.9	17.2	15.7	–3.0	–0.7	22.5	15.8
OECD Europe	11.1	11.9	11.1	10.2	9.3	8.5	–2.6	–1.1	13.5	8.6
OECD Asia Oceania	6.5	6.8	6.3	5.7	5.1	4.6	–1.9	–1.4	7.9	4.7
OECD	**36.3**	**39.8**	**37.7**	**34.8**	**31.6**	**28.7**	**–7.5**	**–0.9**	**43.9**	**29.0**
China	12.6	14.5	15.1	15.4	15.6	15.6	3.1	0.9	15.2	15.8
India	4.4	5.8	7.1	8.4	9.7	10.8	6.4	3.7	5.3	10.9
OPEC	7.8	9.1	10.0	10.7	11.2	11.6	3.9	1.6	9.4	11.7
Other DCs	16.9	19.7	21.7	23.5	25.2	26.7	9.8	1.9	20.4	27.0
Russia	3.1	3.5	3.5	3.5	3.5	3.4	0.3	0.4	3.7	3.4
Other Eurasia	1.6	2.0	2.1	2.1	2.1	2.1	0.5	1.0	2.0	2.1
Non-OECD	**46.3**	**54.6**	**59.6**	**63.8**	**67.3**	**70.3**	**24.0**	**1.7**	**56.1**	**71.0**
World	**82.5**	**94.5**	**97.3**	**98.6**	**98.9**	**99.0**	**16.5**	**0.7**	**100.0**	**100.0**

Source: OPEC.

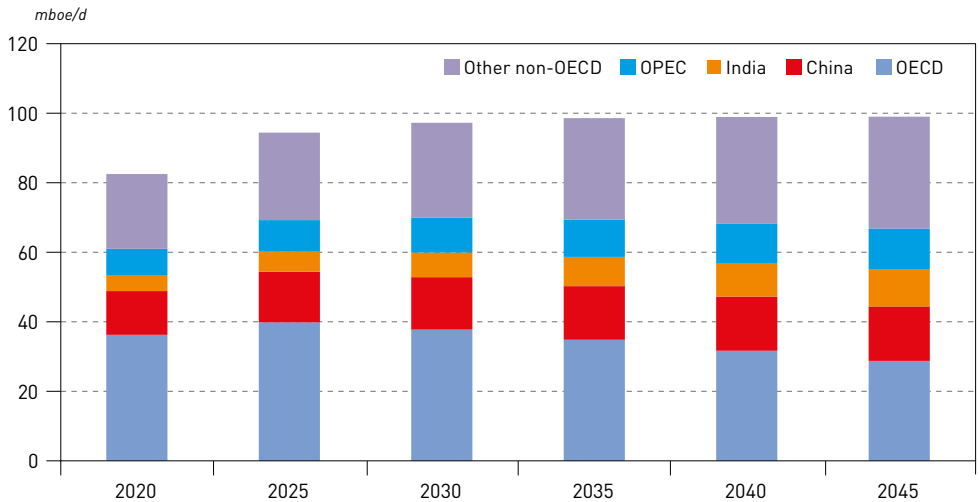
Beyond 2025, global growth in primary oil demand is anticipated to decelerate. During the period 2025–2035, global incremental demand is forecast in the range of around 4 mboe/d, while almost no growth is projected for the last ten years of the forecast period.

Overall, primary oil demand is set to increase in the long-term from 82.5 mboe/d in 2020 to 99 mboe/d in 2045. This represents an increase of 16.5 mboe/d. As already noted, however, more than 70% of this growth is expected to materialize during the first five years of the forecast period, largely related to the demand recovery from the large 2020 decline.

Despite decelerating oil demand growth in the second part of the forecast period and strong growth in other energy sources, such as other renewables, gas and nuclear, oil is expected to retain the highest share in the global energy mix during the entire timeframe (Table 2.1). In 2020, oil accounted for 30% of global energy requirements. Alongside the oil demand recovery, the share of oil is anticipated to gradually increase to a level of more than 31% by 2025, before it begins a decline to reach around 28% by 2045.

A review of the major drivers underlying the outlook for future oil demand, including sectoral developments and demand for specific oil-based products, is presented in Chapter 3. In this

Figure 2.4
Oil demand by region, 2020–2045



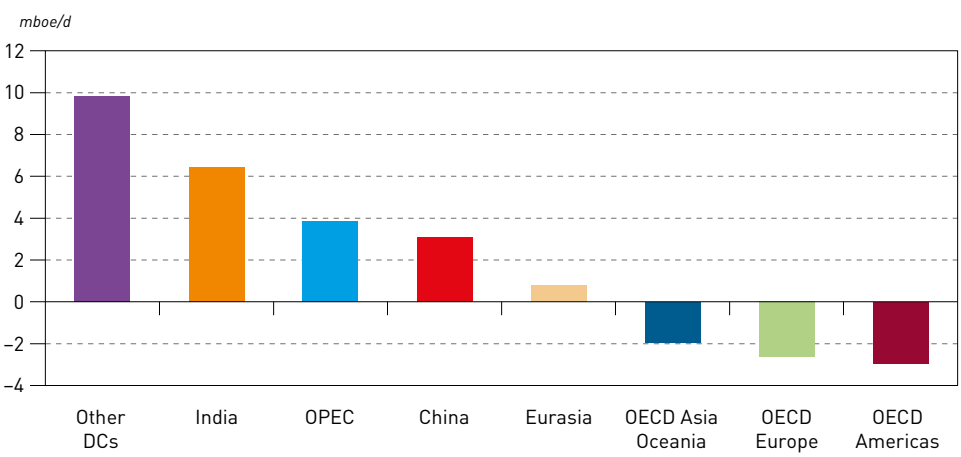
Source: OPEC.

respect, it is also important to note that the figures shown in this chapter are not directly comparable with those shown in other chapters.

There are two main reasons for this. Firstly, Chapter 2 uses energy equivalent units (mboe/d) to allow for a comparison between the different fuel types. In other chapters, however, oil is expressed in volumetric units (mb/d). Secondly, the definition of oil in Chapter 2 is different from that used in Chapters 3 to 6. While Chapter 2 deals with primary energy sources, other chapters consider the outlooks for all liquid fuels. In that sense, in this chapter, biofuels is considered as biomass, coal-to-liquids (CTLs) as coal and gas-to-liquids (GTLs) as gas, but they are all part of the liquids outlook in Chapter 3 to 6. Moreover, a gradual shift in the demand structure towards lighter products leads to higher volumes, even without increasing demand, if measured on an energy content basis.

Figure 2.5 provides an overview of the major trends at the regional level. The largest incremental oil demand is forecast to come from Other Developing countries. Driven by strong population

Figure 2.5
Incremental oil demand by region, 2020–2045



Source: OPEC.

growth, fast expanding economies, further urbanization and the related expansion of the middle class, this large group of countries has incremental oil demand in the range of almost 10 mboe/d over the forecast period. Similar trends also apply to India and OPEC Member Countries in which corresponding increments are in the range of 6 mboe/d and 4 mboe/d, respectively.

Some oil demand growth is also projected for China and Eurasia. However, demand in these countries will likely mature over the current decade and thereafter enter a relatively long period of plateauing. Thus, the demand increase in China is forecast to be just slightly above 3 mboe/d, while the overall increase in Eurasia is less than 1 mboe/d.

In terms of OECD countries, oil demand in this group is marked by a short period of strong growth on the back of a recovery from the impacts of the COVID-19 pandemic, before entering a long period of slow, but steady decline. The largest demand decline is projected for OECD Americas, at a negative 3 mboe/d, followed by OECD Europe with a drop of 2.6 mboe/d and then OECD Asia Oceania with a decline of 1.9 mboe/d. Contrary to most non-OECD countries, the prevailing factors driving the demand decline in the OECD are the substitution of oil by electricity and natural gas in various sectors of consumption, technology driven efficiency improvements, adopted policy measures, demographics and consumer-led developments.

It is important to note that Figure 2.5 uses 2020 as the basis for the calculation of incremental oil demand over the forecast period. Depending on the impact of the COVID-19 pandemic on specific countries and regions, this calculation could either amplify the contribution of countries/regions to future oil demand or 'hide' part of the real demand decline over the forecast period. For example, if the basis for comparison were pre-pandemic demand levels in 2019, overall demand growth in India would be at 5.9 mboe/d, instead of the 6.4 mboe/d presented in Figure 2.5, and the overall demand decline in the OECD would stand at 12.5 mboe/d, instead of the reported 7.8 mboe/d. In this case, the global growth number would change to 7.7 mboe/d.

2.3.2 Coal

Demand for coal accounts for 26.5% of total global energy demand, which is equivalent to almost 73 mboe/d (Figure 2.6). However, the COVID-19 pandemic has hit many coal companies hard, and the ongoing drive to reduce CO_2 emissions, political pressure and policies focused on the phasing out of coal powered plants, with gas and renewables substituting, and the retirement of many old plants, is impacting demand considerably.

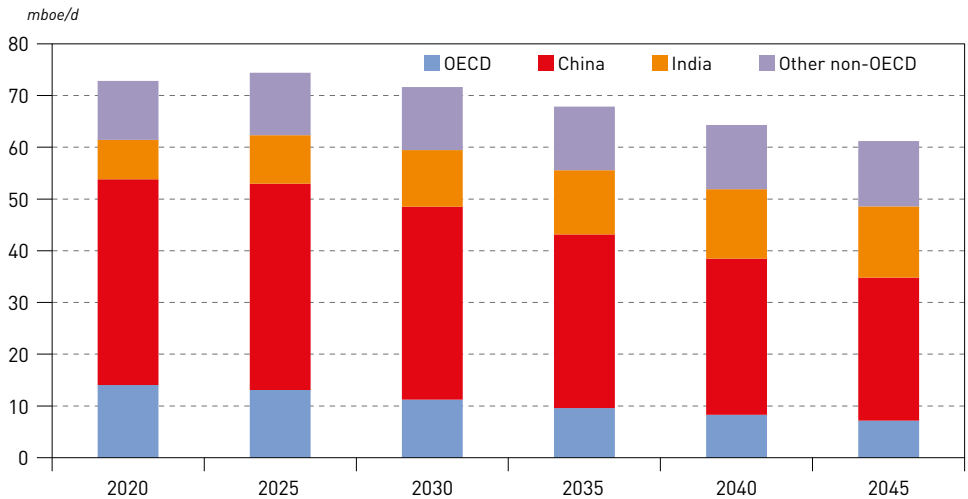
The downward trend for global coal demand has accelerated during the pandemic and targeted policies for a transition toward cleaner energy sources is further placing restrictions on coal consumption.

Coal consumption in the US, which peaked in 2005, has faced a dramatic decline over the past decade, especially from 2015 onwards. Coal-fired plants have been replaced by cheaper natural gas and renewables, investments have been reduced, and despite efforts by the previous US administration to support the industry, demand has continued to decline. The policies of the new US administration are expected to impact the coal sector even deeper.

Medium- to long-term coal demand is forecast to drop meaningfully across all OECD regions. This is most dramatic in OECD Europe, where it falls by 5.5% p.a. over the forecast period, which brings down coal's share in the energy mix from 12% to nearly 3%. The decline rate in the entire OECD region is about 2.6% p.a.

India is the second largest importer of coal and among the few countries where demand for coal will continue to rise, alongside the increasing use of renewables and nuclear. The share of fossil fuels in India's total energy demand is still strong, with coal at nearly 44%. With the country

Figure 2.6
Coal demand by region, 2020–2045



Source: OPEC.

growing rapidly in terms of electricity requirements, the need to expand energy access, and given the fact that energy demand per capita is relatively low, coal is expected to play a key role in meeting India's electricity demand growth.

India's coal use is forecast to increase by 2.4% p.a. from 2020–2045 (Table 2.8), with coal consumption increasing from 7.6 mboe/d to almost 14 mboe/d by the end of forecast period. It should be noted, however, that the share of coal in India's total energy demand is expected to shrink, as nuclear, gas and other renewables increase their shares.

Table 2.8
Coal demand by region, 2020–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Share *%*	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
OECD Americas	5.4	5.2	4.5	3.8	3.3	2.8	–2.6	–2.6	7.4	4.6
OECD Europe	4.1	3.4	2.6	1.9	1.4	1.0	–3.1	–5.5	5.6	1.6
OECD Asia Oceania	4.6	4.4	4.2	3.9	3.7	3.4	–1.2	–1.2	6.2	5.5
OECD	**14.0**	**13.1**	**11.2**	**9.6**	**8.3**	**7.2**	**–6.8**	**–2.6**	**19.2**	**11.7**
China	39.8	39.9	37.3	33.5	30.2	27.6	–12.1	–1.4	54.6	45.1
India	7.6	9.4	10.9	12.4	13.4	13.8	6.1	2.4	10.5	22.5
OPEC	0.1	0.1	0.1	0.1	0.1	0.1	0.0	–0.1	0.1	0.1
Other DCs	7.5	8.0	8.4	8.7	9.1	9.6	2.1	1.0	10.3	15.7
Russia	2.3	2.3	2.1	1.9	1.7	1.5	–0.7	–1.5	3.1	2.5
Other Eurasia	1.7	1.8	1.7	1.6	1.6	1.4	–0.2	–0.5	2.3	2.3
Non-OECD	**58.9**	**61.4**	**60.5**	**58.3**	**56.1**	**54.1**	**–4.8**	**–0.3**	**80.8**	**88.3**
World	**72.9**	**74.4**	**71.7**	**67.9**	**64.4**	**61.3**	**–11.7**	**–0.7**	**100.0**	**100.0**

Source: OPEC.

The strong growth in India's power sector includes ambitious targets for additional renewable electricity, which may affect the future of coal and limit its growth while a small number of new thermal power plants are planned for construction in the coming years.

China is the largest producer and consumer of coal, with 60% of its total energy demand coming from this source. However, coal's dominant position is set to shrink. China's economy and industrial activities are gradually recovering from the lockdown impacts of COVID-19, with rising capacity utilization of both thermal and coking coal mines and government support, such as the special green pass for coal transits within country. However, it can be projected that coal imports in China will continue to decline due to restrictions and political pressures to support local production.

In the medium-term, China's coal demand is expected to slow to a plateau, and in the longer-term it is expected to see a significant drop. It falls from a 2025 level of nearly 40 mboe/d to less than the average global drop of 0.7% p.a.

The medium- and especially the long-term future of coal will be driven by the evolution of policies, fiscal measures and the flow of public investments for financing new or existing coal projects, especially within key consumers, such as China, Japan, South Korea and India. It is important to note, however, that the negative impact of COVID-19, and its financial and economic consequences, could see some countries relax policies and restrictions on coal consumption.

2.3.3 Natural gas

Gas demand y-o-y, mostly in power generation and industry, dropped by more than 1.5% in 2020 due to the COVID-19 pandemic and subsequent declining economic activity. This was less than initially expected, partly due to the swift demand recovery in Asia and the cold weather in the northern hemisphere in 4Q20.

As a result of declining demand, global natural gas spot prices dropped dramatically and were temporarily at levels around $2/Million British Thermal Units (Mbtu) in late spring and the early summer of 2020, with regional spreads virtually disappearing. This led to production declines, as well as shut-ins of some LNG production, mostly in the US.

Nevertheless, demand started recovering in 3Q20, driven by Asia, mostly China, but also other countries, such as India. Further support came from cold weather in the northern hemisphere, which boosted demand in Europe and North America too. The upward trend continued in 2021 with demand supported by the further reopening of economies, as well as cold spring weather in Europe and China. Natural gas prices recovered with Asian spot prices climbing to $12/Mbtu and European gas prices reaching $10/Mbtu in mid-June 2021.

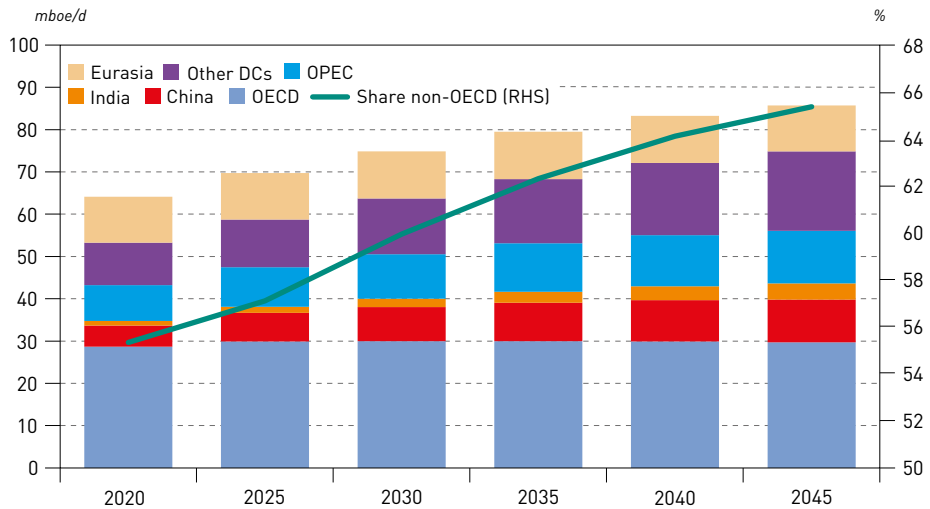
The gas price rally continued during summer 2021 with spot gas prices reaching levels above $16/Mbtu in Europe and close to $18/Mbtu in Asia in August 2021. This was due to several reasons, including continuing strong Asian demand, a temporary drop in Russian deliveries to Europe, lower LNG supplies from several countries and tight European gas storage ahead of the winter season.

Natural gas demand is expected to continue growing in the medium- to long-term, in line with expanding economies and rising energy demand. This includes the increasing use of gas in power generation and industry (including non-energy use). In line with efforts to reduce carbon footprints and to tackle the issue of local air pollution, natural gas, as already noted, is also expected to substitute for coal in power generation and industry.

In total, gas demand is expected to increase by around 21.5 mboe/d between 2020 and 2045 (Figure 2.7). This brings total gas demand to 85.7 mboe/d in 2045, thus becoming the second largest fuel

in the energy mix. Consequently, the share of natural gas in the energy mix increases from around 23% to almost 24.5% between 2020 and 2045.

Figure 2.7
Natural gas demand by region, 2020–2045



Source: OPEC.

However, this year's outlook for 2045 has been revised down by around 5.5 mboe/d, compared to last year's WOO. This is due to the increasing number of energy polices supporting renewables – including financial/fiscal subsidies – and stated carbon neutrality commitments of several large consuming countries/regions, which are likely to affect natural gas demand in the long-term.

These policies and commitments are also supported by cost reductions related to renewables, such as solar and wind. In some regions, renewable projects, for example, large solar PV or onshore wind, are already more competitive relative to combined cycle gas turbine (CCGT) plants on a full-cost basis, even without subsidy support. Future expectations point at further cost reductions for renewables, which are likely to improve their competitive position relative to natural gas. In addition, the investment push for renewable hydrogen, as well as biogas, is expected to lower gas demand in industry, where decarbonization is not easy.

Finally, the future of LNG in marine bunkers remains uncertain for the time being, as some have voiced doubt about its long-term sustainability in view of CO_2 emission reduction targets and have called for the increasing use of renewable hydrogen or ammonia instead. Consequently, some orders of LNG-fuelled vessels have been cancelled amid these concerns.

At the regional level, the majority of the gas demand increase is set to come from non-OECD countries, which increases by 20.5 mboe/d from 2020–2045, with the largest increments in China and India.

In China, gas demand is expected to double to 10 mboe/d by 2045, driven by economic growth, increasing energy and electricity demand, higher industrial demand and rising levels of urbanization. Furthermore, efforts to achieve peak GHG emissions by 2030 are expected to give additional support to gas relative to coal in the generation mix. This is related not only to power generation, but also to the residential and commercial sector, where gas is likely to replace coal and LPG.

India's natural gas demand is projected to increase by 2.8 mboe/d to 3.8 mboe/d in 2045, almost tripling over the forecast period. India is actively promoting the role of gas in the energy mix with an official target of 15% by 2030, from a current share of around 6%. This is in line with objectives to reduce air pollution and affects sectors, such as power generation, residential, as well as the transportation sector, for example with the expanding network of CNG stations. In order to increase the availability of natural gas, India is expanding its gas network, raising the gasification rate and supporting competition in the market.

A significant demand increase in gas is also expected in the OPEC region, which rises by around 4 mboe/d to almost 12.5 mboe/d over the forecast period. Several OPEC Member Countries are seeking to increase the share of natural gas in their power generation sector, as well as for water desalination projects. Increasing gas consumption is also favoured due to the availability of gas in these countries at relatively competitive price levels. Furthermore, some countries are also planning to explore the possibilities of blue hydrogen production from natural gas, some of which would be destined for export markets.

Gas demand in Other Developing countries is projected to increase by nearly 9 mboe/d, led by emerging economies in the Asia-Pacific. Power generation and industry are the main sectors driving this. Furthermore, some countries, such as Vietnam, are looking to reduce the share of coal in the energy mix giving further support for natural gas in the long-term. Several countries in Latin America and the Asia-Pacific also see gas as a solution for small-scale LNG in power generation. The availability of competitive gas supplies in some countries in the Middle East, Africa and Latin America also favours its use in the long-term.

In Russia, where gas is the dominant fuel in the energy mix, demand is expected to decline by around 1 mboe/d between 2020 and 2045. The drop in gas demand is based on the significant potential for energy efficiency measures in the power and heat generation sector. At the same time, gas consumption in the Other Eurasia region is set to expand by around 1 mboe/d, supported by industrial and residential demand.

Gas demand in OECD regions is anticipated to increase by 1 mboe/d from 2020–2045, reaching levels close to 30 mboe/d at the end of the forecast period. OECD Americas is the region that is expected to see significant demand growth of 2.2 mboe/d, supported by the continuous replacement of coal in power generation. The high availability of gas at competitive price levels is another supporting factor in this region.

In OECD Asia Oceania, gas demand is seen stable between 2020 and 2045. The support for gas demand again comes from the substitution of coal in the generation mix, in countries such as Australia, Japan and South Korea. At the same time, energy efficiency measures and a push for renewable hydrogen are expected to offset some of the growth potential in this region.

Finally, as shown in Table 2.9, OECD Europe is projected to see declining gas demand throughout the outlook period, dropping by 1.2 mboe/d to just above 7 mboe/d in 2045. The EU Green Deal and a number of energy policies at the national level are expected to lead to the substitution of natural gas in various sectors. This includes replacement by renewables in power generation, complemented by rising energy efficiency measures. Furthermore, several countries have announced significant investments into renewable hydrogen, which may also be blended into gas pipelines and can limit gas usage in industrial applications. The residential and commercial sector is also set to see the declining utilization of gas, partly due to energy policies, some of which foresee an end of gas-fired heating in the residential sector, or a phasing out of subsidies for gas heating systems. All these measures are expected to contribute to a long-term decline in gas consumption in OECD Europe.

In line with efforts to reduce the carbon footprint of natural gas, several companies including Shell, TotalEnergies, Mitsui and Gazprom have started offering so-called carbon-neutral LNG

Table 2.9
Natural gas demand by region, 2020–2045

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
OECD Americas	16.8	18.0	18.2	18.5	18.7	19.0	2.2	0.5	26.2	22.1
OECD Europe	8.3	8.4	8.2	7.9	7.5	7.1	–1.2	–0.6	13.0	8.3
OECD Asia Oceania	3.5	3.5	3.5	3.6	3.6	3.6	0.0	0.1	5.5	4.2
OECD	**28.6**	**29.9**	**30.0**	**30.0**	**29.9**	**29.7**	**1.0**	**0.1**	**44.7**	**34.6**
China	5.0	6.7	8.1	9.1	9.8	10.1	5.1	2.8	7.9	11.8
India	1.0	1.5	2.0	2.6	3.2	3.8	2.8	5.4	1.6	4.5
OPEC	8.5	9.4	10.5	11.4	12.1	12.4	3.9	1.5	13.2	14.4
Other DCs	10.0	11.3	13.2	15.2	17.1	18.8	8.8	2.5	15.6	21.9
Russia	7.9	7.7	7.5	7.4	7.2	6.9	–1.0	–0.5	12.3	8.0
Other Eurasia	3.0	3.3	3.5	3.8	3.9	4.0	1.0	1.1	4.7	4.7
Non-OECD	**35.5**	**39.8**	**44.9**	**49.5**	**53.4**	**56.0**	**20.5**	**1.8**	**55.3**	**65.4**
World	**64.2**	**69.8**	**74.8**	**79.5**	**83.2**	**85.7**	**21.6**	**1.2**	**100.0**	**100.0**

Source: OPEC.

cargoes (on a spot basis), with several cargoes already delivered to customers. Related CO_2 emissions from these cargoes (scope 1, 2 and 3) were reportedly offset in ways such as verified emission certificates related to reforestation projects and emission reductions from coal-based power. The industry, however, still does not have a uniform methodology on how to measure and verify offsets, which could be the next step if demand for carbon-neutral LNG cargo increases.

2.3.4 Nuclear

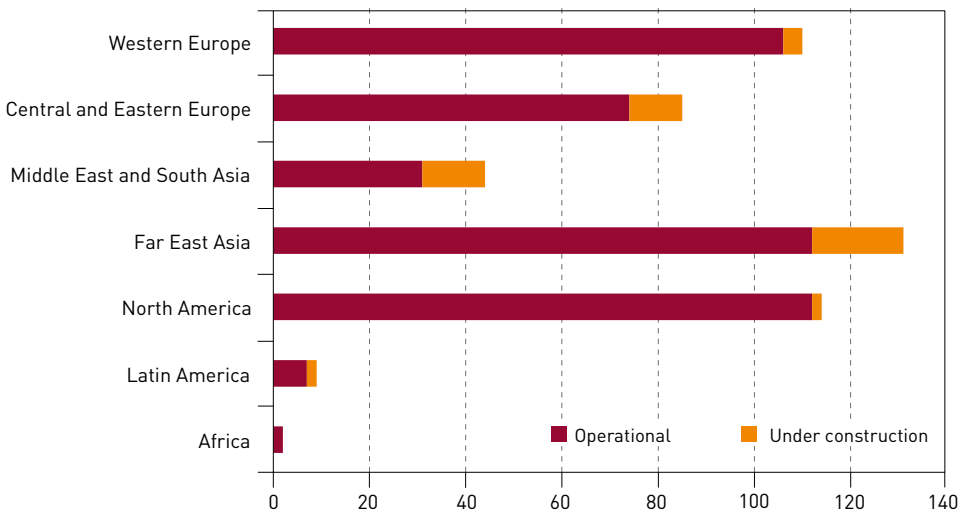
The pace of growth for electricity demand is almost double that of overall energy demand, as the global population expands and becomes more urbanized, and there is an expanding need for power. Moreover, there is an increasing need for this to be achieved in an ever more sustainable way, with reduced emissions.

The nuclear industry has been a reliable provider of power generation for several decades, especially in the OECD region, and increasingly in some non-OECD countries too. It is clear that nuclear has the capabilities to be a key component of a transition towards a cleaner and more sustainable energy system.

Additionally, according to a study conducted by the Massachusetts Institute of Technology (MIT), the system cost of electricity without nuclear power is twice as high in the US and four times as high in China. The report warned: "Failing to take timely decisions on nuclear power ... would raise the costs of a net-zero emissions pathway and add to the risk of not meeting the goal." However, it is also important to be cognizant of the large capital investments for nuclear, safety, maintenance and future decommissioning costs, as well as public perceptions.

According to the International Atomic Energy Agency (IAEA), there are currently 443 reactors operational around the world (Figure 2.8) from which 302 reactors are Pressurized Light-Water Moderated and Cooled Reactors (PWR), 63 reactors are Boiling Light-Water Cooled and Moderated Reactors (BWR) type and 49 are Pressurized Heavy-Water Moderated Cooled Reactors (PHWR). The majority are installed in North America, Far East Asia and Western Europe.

Figure 2.8
Number of nuclear reactors by region, 2021



Source: IAEA.

There are also 53 reactors (mostly PWR) under construction, mainly in China, India and South Korea, as well as OPEC Member Country, the UAE, which will add 53 GW of additional net capacity. Asia alone has 33 reactors under construction, with a capacity of 33.5 GW.

China, as the main engine of growth for nuclear power, is becoming more independent in fuel cycle and reactor design technologies. It powered up Hualong One, its first indigenous nuclear reactor in 2020, and is taking significant steps to expand its supply chain for nuclear technology

Table 2.10
Nuclear demand by region, 2020–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Share *%*	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
OECD Americas	4.9	4.7	4.7	4.7	4.8	4.7	–0.2	–0.1	34.2	21.6
OECD Europe	4.1	4.1	4.1	4.0	4.0	4.0	–0.1	–0.1	28.8	18.2
OECD Asia Oceania	1.1	1.5	1.7	1.9	2.0	2.1	1.0	2.6	7.7	9.6
OECD	**10.1**	**10.3**	**10.5**	**10.7**	**10.8**	**10.9**	**0.7**	**0.3**	**70.7**	**49.4**
China	1.9	3.0	3.9	4.7	5.7	6.6	4.8	5.2	13.1	30.2
India	0.2	0.4	0.5	0.8	1.0	1.3	1.0	6.8	1.7	5.8
OPEC	0.1	0.1	0.2	0.2	0.3	0.5	0.4	8.2	0.5	2.2
Other DCs	0.4	0.4	0.5	0.5	0.6	0.3	–0.1	–1.3	2.7	1.3
Russia	1.0	1.1	1.2	1.3	1.4	1.5	0.5	1.6	6.9	6.6
Other Eurasia	0.6	0.7	0.8	0.8	0.9	1.0	0.3	1.7	4.4	4.4
Non-OECD	**4.2**	**5.7**	**7.0**	**8.3**	**9.9**	**11.1**	**6.9**	**4.0**	**29.3**	**50.6**
World	**14.3**	**16.0**	**17.5**	**19.0**	**20.7**	**22.0**	**7.6**	**1.7**	**100.0**	**100.0**

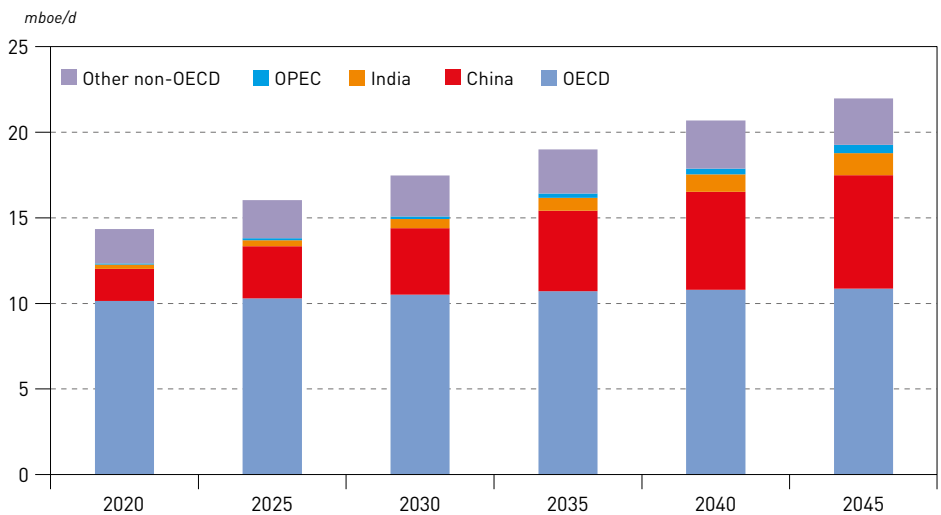
Source: OPEC.

exports. India also has a large and ambitious nuclear programme, which is locally developed and is part of a large-scale national development programme to secure a sustainable energy supply for the country.

Demand for nuclear energy in China, which currently has 14 reactors under construction, is expected to expand by over 5% p.a. from 2020–2045. For the same timeframe, India is expected to see a faster growth rate of about 7%, albeit from a much lower base.

Among OECD regions, OECD Asia-Oceania is the centre for growth at 2.6% p.a. over the forecast period. This is expected to result in a 7% increase in the contribution of nuclear energy to the region's total energy demand. It should be noted, however, that Japan's decision in 2019 to permanently shut down five reactors, saw total global capacity drop by some 4.5 GW compared with 2018. Figure 2.9 presents the nuclear demand forecast for each major region.

Figure 2.9
Nuclear energy demand by region, 2020–2045



Source: OPEC.

The issue of shutdowns is also prevalent in OECD Europe and OECD Americas, where the future of nuclear power is less optimistic than in developing countries. Demand for nuclear power in these two regions is expected to drop by 0.1% p.a. from 2020–2045.

Developing countries (excluding China) are anticipated to see average 3.7 % p.a. growth, in response to rising electricity demand. According to the Reference Case, combined growth of 1 mboe/d is expected in these countries till 2045, although 60% of this is expected to be offset by drops in demand for nuclear in the OECD region.

In terms of new technologies, Small Modular Reactors (SMR) may become increasingly attractive to investors and policy makers in the medium-term, although they will require the support of industry and governments.

Depending on such issues as policies, technology and safety enhancements, nuclear has the potential to play an important role in future, sustainable energy supplies. In the Reference Case,

demand for nuclear power is projected to rise by 1.7% p.a. between 2020 and 2045, bringing an additional 7.6 mboe/d.

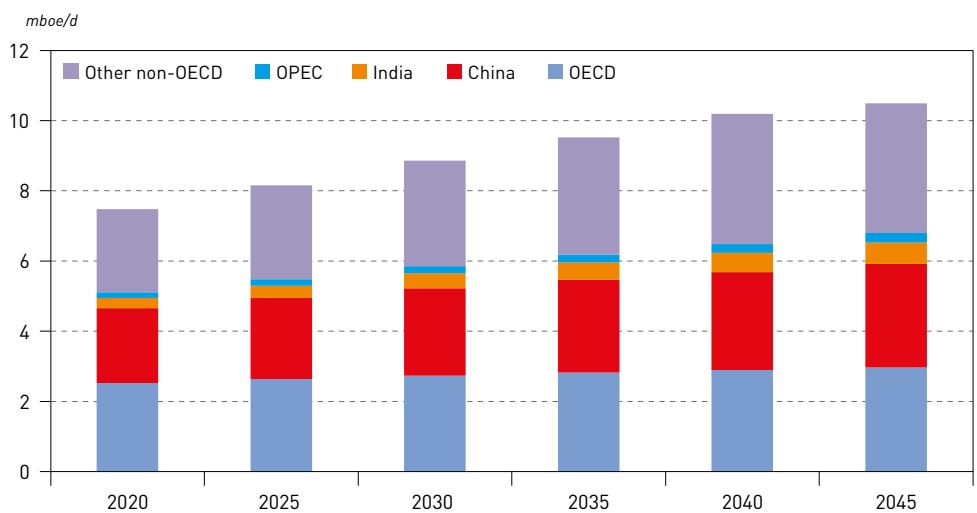
2.3.5 Hydro

Hydropower is considered the largest global source of clean power generation today, and has low operational costs that make plants cheaper to run than coal-fired ones. However, they do have significant upfront capital costs, are dependent on weather conditions, and can also be disruptive to the environment, including upstream and downstream residents. Moreover, the lack of available land and locations are an additional challenge in some countries.

The construction of some hydro plants was delayed or even halted during the pandemic and demand for hydropower and the addition of new capacity are expected to be hampered in the post-COVID era. The sudden reduction in demand during the pandemic was also a serious challenge for economies with a large percentage of hydropower in their energy mix, such as Brazil, India and China, although supply ramped back up as economies recovered and demand increased.

In the OECD, where most of the potential for hydro has already been explored, there is no expectation for growth except in some countries, such as Norway and Austria. Demand in the OECD increases from levels of 2.5 mboe/d in 2020 to 3 mboe/d in 2045 (Figure 2.10), an increase of 0.7% p.a.

Figure 2.10
Hydro demand by region, 2020–2045



Source: OPEC.

The pace is even higher within non-OECD countries where demand for hydro is expected to increase by 50% from 2020–2045 to reach 7.5 mboe/d, from the current base of 5 mboe/d (Table 2.11). China is expected to witness growth of 1.3% p.a. increasing from 2.1 mboe/d to 3 mboe/d over the forecast period, while India and Russia start from a much lower base, but see growth of 3% and 1% p.a., respectively.

Table 2.11
Hydro demand by region, 2020–2045

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
OECD Americas	1.3	1.4	1.4	1.5	1.5	1.6	0.3	0.8	17.4	15.2
OECD Europe	1.0	1.0	1.1	1.1	1.1	1.1	0.1	0.4	13.4	10.6
OECD Asia Oceania	0.2	0.2	0.2	0.2	0.3	0.3	0.0	0.6	3.0	2.5
OECD	**2.5**	**2.6**	**2.7**	**2.8**	**2.9**	**3.0**	**0.4**	**0.7**	**33.7**	**28.3**
China	2.1	2.3	2.5	2.6	2.8	3.0	0.8	1.3	28.6	28.1
India	0.3	0.4	0.4	0.5	0.5	0.6	0.3	3.0	3.8	5.7
OPEC	0.2	0.2	0.2	0.2	0.2	0.3	0.1	2.0	2.2	2.6
Other DCs	1.8	2.1	2.4	2.7	3.0	3.0	1.1	2.0	24.4	28.3
Russia	0.3	0.4	0.4	0.4	0.4	0.4	0.1	1.0	4.5	4.2
Other Eurasia	0.2	0.2	0.2	0.2	0.3	0.3	0.1	1.4	2.7	2.8
Non-OECD	**5.0**	**5.5**	**6.1**	**6.7**	**7.3**	**7.5**	**2.6**	**1.7**	**66.3**	**71.7**
World	**7.5**	**8.2**	**8.9**	**9.5**	**10.2**	**10.5**	**3.0**	**1.4**	**100.0**	**100.0**

Source: OPEC.

2.3.6 Biomass

The COVID-19 pandemic saw growth in bioenergy in the OECD, China, and India. The use of traditional biomass and organic matter also increased in lower income countries, as the economic stress resulting from a drop in the residual income of many in Sub-Saharan Africa and Southeast Asia, compelled a return to cheaper solid biomass from clean cooking fuels.

Biomass is increasingly being viewed as an important component of the energy transition, driven by policies and government-led initiatives, advancements in technology, fuel-flexibility and environmental credentials. Growth is seen in CHP generation, heating, bio-gasification, and other end-use applications, as well as in transport fuels in OECD Europe and OECD Americas, specifically giving the increasing Renewable Fuel Standard (RFS) mandates in the US.

Global biomass demand is set to grow at 1.2% p.a. over the forecast period to reach 37 mboe/d (Table 2.12). This represents close to a 10% share of global primary energy demand by 2045. Both the OECD and non-OECD deploy biomass as part of clean energy initiatives, as well as for energy supply security, access and affordability.

The OECD continues the development of advanced biomass for the transport sector and the deployment of bioenergy for cogeneration in CHP units. The region is set to increase biomass demand by an additional 3.3 mboe/d over the 2020–2045 period, with growth mainly in OECD Europe and OECD Americas, but OECD Asia Oceania sees some expansion too. By 2045, biomass in OECD primary energy demand is projected to reach about 9.9%, a significantly higher share than coal. Most biomass resources in developed regions are part of clean energy deployments. Bioenergy and organic waste in developed nations are also being utilized in heating, and as components for transport fuels.

For the non-OECD, the main biomass growth centres are China and India, as well as Other Developing countries. It is expected that non-OECD biomass demand expands by an additional 6.4 mboe/d to reach 26.9 mboe/d by 2045, with most growth attributed to China, India and Sub-Saharan Africa.

India's renewable energy roadmap includes a national biofuel policy that mandates greater expansion of biofuels and other bioenergy components including biogases. China's 14th FYP includes the development of bioenergy for energy security and as a vital component for low-carbon fuels as it targets an 18% reduction in carbon intensity to attain a carbon peak by 2030.

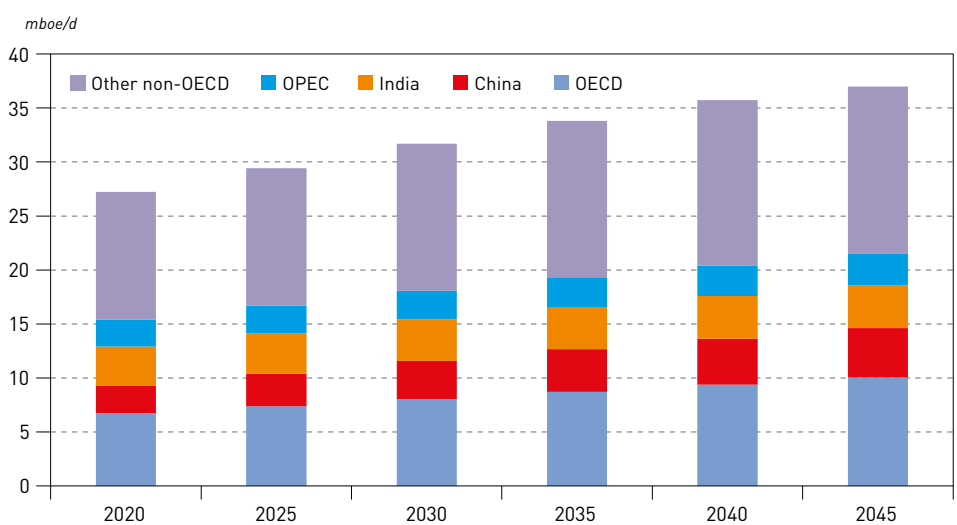
Table 2.12
Biomass demand by region, 2020–2045

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
OECD Americas	2.8	3.0	3.2	3.5	3.7	4.0	1.3	1.5	10.2	10.9
OECD Europe	3.4	3.7	4.1	4.4	4.8	5.1	1.8	1.7	12.3	13.8
OECD Asia Oceania	0.6	0.7	0.7	0.8	0.9	0.9	0.3	1.6	2.2	2.4
OECD	**6.7**	**7.4**	**8.1**	**8.7**	**9.4**	**10.0**	**3.3**	**1.6**	**24.7**	**27.1**
China	2.6	3.0	3.5	4.0	4.3	4.6	2.0	2.3	9.4	12.4
India	3.6	3.7	3.8	3.9	3.9	4.0	0.3	0.4	13.2	10.7
OPEC	2.5	2.6	2.7	2.8	2.8	2.9	0.4	0.7	9.1	7.9
Other DCs	11.4	12.3	13.1	13.9	14.6	14.7	3.2	1.0	41.9	39.6
Russia	0.2	0.2	0.2	0.3	0.3	0.4	0.2	3.1	0.6	1.0
Other Eurasia	0.3	0.3	0.3	0.4	0.4	0.5	0.2	2.1	1.0	1.2
Non-OECD	**20.5**	**22.1**	**23.6**	**25.1**	**26.4**	**26.9**	**6.4**	**1.1**	**75.3**	**72.9**
World	**27.2**	**29.4**	**31.7**	**33.8**	**35.7**	**37.0**	**9.7**	**1.2**	**100.0**	**100.0**

Source: OPEC.

Figure 2.11 depicts evolving biomass trends and regional distributions, which underscores that biomass is focused mostly in non-OECD regions. Over the forecast period, however, the share of non-OECD in global biomass falls from 75.3% in 2020 to below 73 % by 2045. This is mainly attributable to further urbanization in both India and China, given increasing electricity connections and the expansion of clean fuels for cooking.

Figure 2.11
Biomass demand by region, 2020–2045



Source: OPEC.

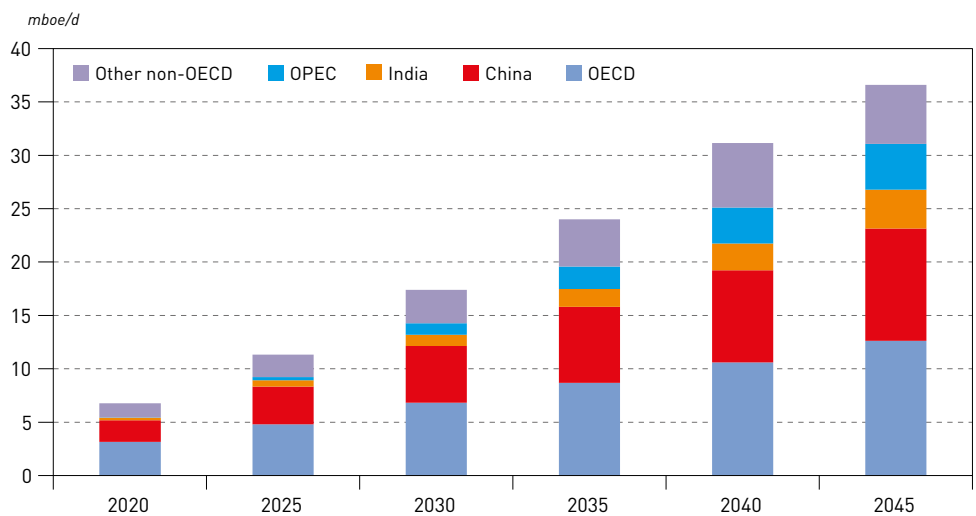
2.3.7 'Other renewables'

Investment in renewables has expanded significantly in recent years. The Frankfurt School-UNEP Centre/BNEF reported that in 2019 the amount of new renewable power capacity added (excluding large hydro) was the highest ever, at 184 GW, 20 GW more than in 2018. This included 118 GW of new solar systems, and 61 GW of wind turbines.

The trend for global investment in renewables continued during 2020 despite the pandemic, lockdowns and disruptions to supply chains. This was the result of a focus on the energy transition, toward a more affordable and sustainable energy system and net zero emission reduction targets.

Technological advancements, economies of scale, improved efficiencies and supply chain management, the energy transition and policy developments have shifted the dial for renewables, particular wind and solar, and improved their cost competitiveness against other forms of energy in recent years. However, grid connectivity, storage and electricity transmission over long distances remain challenges in most regions. Figure 2.12 demonstrates the expected regional expansion for other renewables.

Figure 2.12
'Other renewables' demand by region, 2020–2045



Source: OPEC.

China is the global backbone of renewables investment and additional capacity. According to the country's National Energy Administration (NEA), China installed more than 48 GW of new solar capacity and 72 GW for wind in 2020. This is the highest ever yearly growth and nearly triple 2019 levels.

Further renewables expansion in China is expected in the coming decades, with wind set to be the key driver in the country's long-term carbon neutral plan. Other renewables are forecast to remain the fastest growing source of energy in China with demand growth of nearly 7% p.a. from 2020–2045. This will result in an additional 8.5 mboe/d of demand in absolute terms over the forecast period. The contribution of other renewables in China's energy mix is set to increase from 3% to 13.5% by 2045.

India, with its expected massive increase in electricity demand, is another engine of promotion for other renewables and its government has ambitious development plans and timelines. However,

regulatory issues, grid connectivity, and supply chain challenges due to COVID-19, with China the supplier of many raw materials, have proven problematic and capacity expansion plans have recently run behind schedule.

Despite these challenges, however, India will see a robust demand increase for power, and has the advantage of government policy support and investment plans running into hundreds of billions dollars over the medium- to long-term. It is projected that demand for other renewables in India will rise by over 11% p.a. between 2020 and 2045, which results in more than 3 mboe/d of additional demand in the country's overall energy mix. As a result, the share of other renewables in India's total energy demand is forecast to increase from 1.5% in 2020 to close to 9.6% in 2045.

OECD countries are also a key player in other renewables. The region accounted for nearly 47% of global demand for other renewables in 2020 and is projected to witness 5.7% growth p.a. from 2020–2045. It is expected that OECD Americas will lead this demand growth in absolute terms, followed by OECD Europe, although OECD Asia Oceania is set to see the largest p.a. expansion on a percentage basis.

In recent years some OPEC Member Countries have also invested heavily in other renewables, especially solar and wind, which has supported the demand increase for these clean sources of energy.

Demand for energy generated from other renewables is forecast to increase massively in non-OECD countries, from a current level of 3.6 mboe/d to 24 mboe/d by 2045. This translates to a growth rate of 7.9% p.a. and a rise in the share of these countries in global demand for other renewables from 53.3% to 65.5%.

Globally, demand for other renewables (Table 2.13) is projected to expand from 6.8 mboe/d in 2020 to 36.6 mboe/d in 2045. Consequently, other renewables are the fastest and largest source of growth over the forecast period. The average global growth rate of 7% p.a. is above the average pace of development in the OECD, near the rate for China, although much below that of India.

Table 2.13
'Other renewables' demand by region, 2020–2045

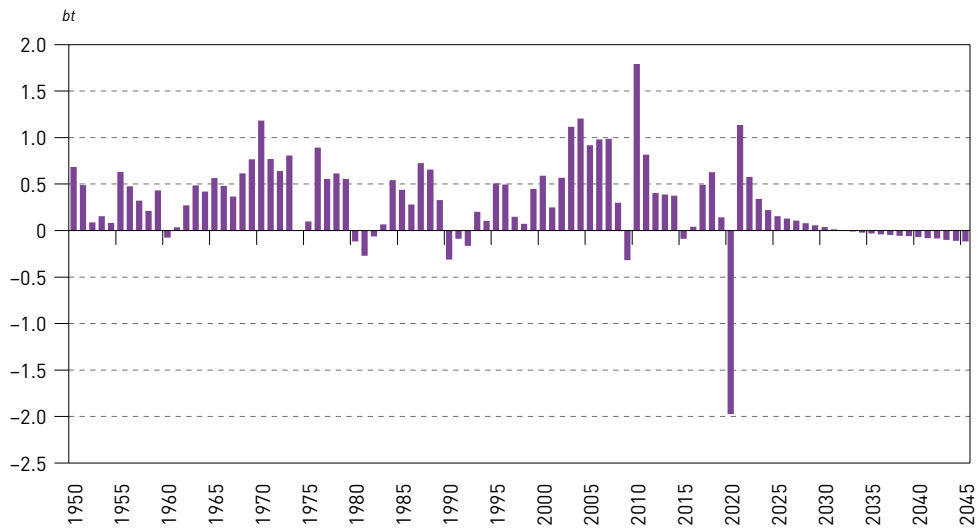
	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Share *%*	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
OECD Americas	1.2	1.9	2.7	3.6	4.5	5.6	4.4	6.4	17.4	15.3
OECD Europe	1.6	2.2	3.0	3.5	4.1	4.6	3.0	4.4	23.1	12.6
OECD Asia Oceania	0.4	0.7	1.1	1.6	2.0	2.4	2.0	7.3	6.2	6.6
OECD	**3.2**	**4.8**	**6.8**	**8.7**	**10.6**	**12.6**	**9.5**	**5.7**	**46.7**	**34.5**
China	2.0	3.5	5.3	7.1	8.7	10.5	8.5	6.9	29.6	28.8
India	0.3	0.6	1.0	1.7	2.5	3.6	3.4	11.1	3.8	9.9
OPEC	0.0	0.3	1.1	2.1	3.4	4.3	4.3	25.2	0.2	11.7
Other DCs	1.3	2.0	2.9	3.9	5.2	4.0	2.8	4.7	18.9	11.0
Russia	0.0	0.0	0.1	0.2	0.4	0.7	0.7	18.8	0.1	1.8
Other Eurasia	0.0	0.1	0.1	0.3	0.5	0.8	0.8	12.8	0.6	2.3
Non-OECD	**3.6**	**6.5**	**10.6**	**15.3**	**20.6**	**24.0**	**20.4**	**7.9**	**53.3**	**65.5**
World	**6.8**	**11.3**	**17.4**	**24.0**	**31.2**	**36.6**	**29.8**	**7.0**	**100.0**	**100.0**

Source: OPEC.

2.4 Energy related CO_2 emissions

Downward revisions to primary energy demand for all fossil fuels incorporated in this Outlook, compared to the WOO 2020, results in lower energy-related emissions than anticipated a year ago. This starts already with a declining level of global CO_2 emissions in 2020, given the economic downturn and COVID-19 containment measures that led to lower demand for coal, gas and oil, during the year. Consequently, energy-related emissions declined by around 2 billion tonnes (bt) in 2020, the largest annual emissions decline ever recorded (Figure 2.13).

Figure 2.13
Annual change in energy related CO_2 emissions, 1950–2045



Source: OPEC.

However, part of this decline will be offset in 2021 as energy demand gradually recovers. The continuation of the recovery process in the years thereafter is expected to result in a further increase in overall CO_2 emissions, albeit, with a clear growth deceleration. Moreover, emissions are expected to stabilize in the range of 35 bt towards the end of the current decade and then start declining during the last ten years of the forecast period. In absolute terms, as presented in Table 2.14, global energy-related emissions are projected at 34.4 bt by 2045, around 2 bt higher than in 2020.

Turning to specific fuels, coal-related CO_2 emissions were at a level of 14.9 bt in 2019. Emissions declined sharply to 14.2 bt in 2020 and, despite a projected partial recovery in coal demand over the next two-to-three years, related emissions are expected to remain below 2019 levels. After the short-term revival in coal demand, emissions related to coal use are projected to start declining systematically to fall to around 14 bt in 2030, and further to below 12 bt by 2045.

Table 2.14
Energy-related annual CO_2 emissions by energy source, 2020–2045 *billion tonnes*

	2020	2025	2030	2035	2040	2045
Coal	14.2	14.5	14.0	13.2	12.5	11.9
Oil	11.2	12.8	13.2	13.4	13.5	13.3
Gas	6.9	7.5	8.0	8.5	8.9	9.2
Energy-related emissions	**32.4**	**34.8**	**35.2**	**35.2**	**34.9**	**34.4**

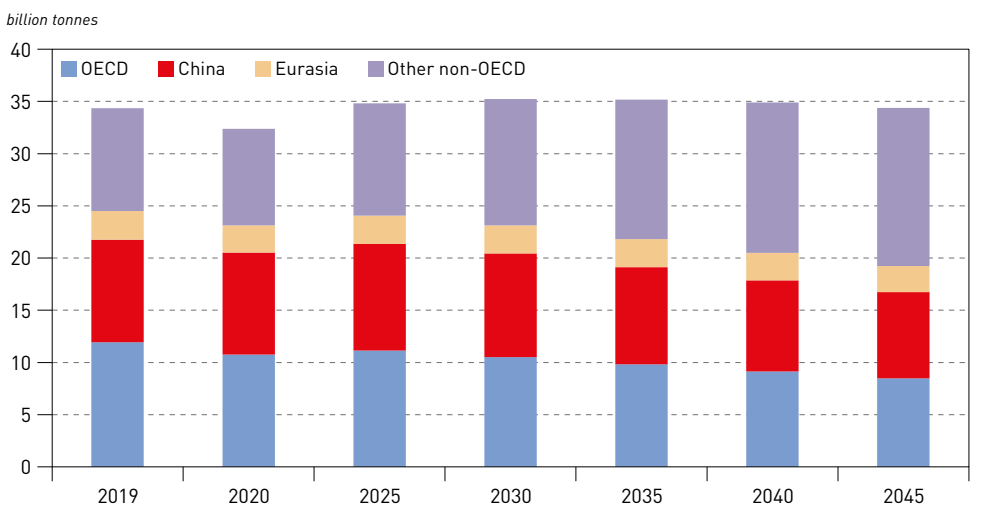
Source: OPEC.

Emissions related to the use of oil are projected to reach a level of 13.3 bt by 2045, around 2 bt higher than in 2020. It needs to be emphasized, however, that oil demand was depressed significantly during 2020, thus, pushing down the basis for the comparison. This is also reflected in the projection that 1.6 bt, or almost 75%, of this increase will take place before 2025 as part of the recovery process. Beyond 2025, some growth is still projected until around 2035, before emissions stabilize within a narrow range of 13.2–13.5 bt. There is then expected to be a marginal decline towards the end of the forecast period.

CO_2 emissions related to gas demand are anticipated to be on a rising trajectory over the forecast period, increasing from almost 7 bt in 2020 to more than 9 bt in 2045. This is a reflection of the expected strong demand growth for this energy which, after other renewables, is forecast to be the second largest contributor to incremental demand in the period to 2045.

Looking at emissions from the regional perspective, annual CO_2 emissions for major regions are provided in Figure 2.14. Emissions in most developing countries will continue growing throughout the forecast period on the back of expanding energy needs. Correspondingly, emissions in the group of 'Other non-OECD' countries (non-OECD countries without China and Eurasian countries) are expected to grow from 9.2 bt in 2020 to 15.1 bt in 2045. However, part of this growth will be offset by emissions reduction in China, Eurasia and the OECD.

Figure 2.14
Energy-related annual CO_2 emissions by region, 2020–2045

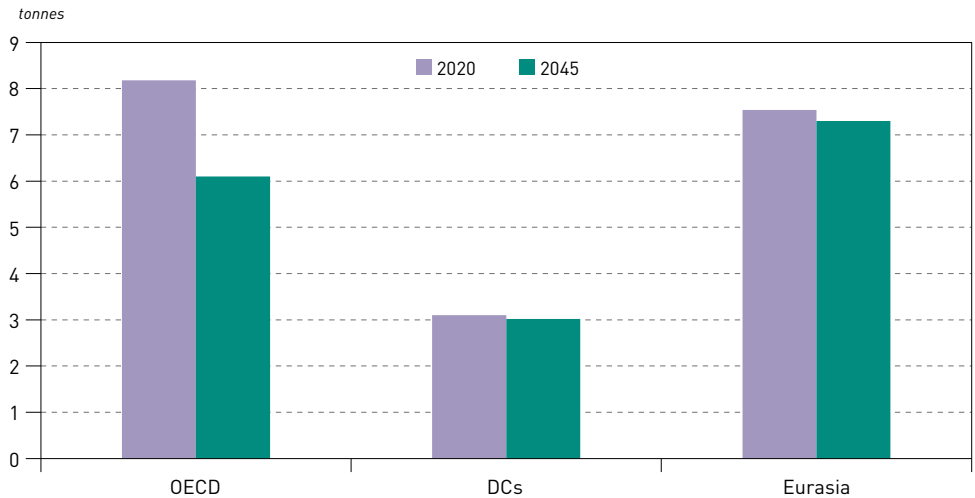


Source: OPEC.

Emissions reductions in all three of these regions is mainly driven by the strong demand decline for coal which, in the case of OECD countries, is supplemented by declining oil demand. The largest emissions reduction is projected for the OECD, at –2.3 bt between 2020 and 2045, followed by China (–1.5 bt) and Eurasia (–0.1 bt). In fact, total energy related emissions in Eurasia are expected to remain in a very narrow range of 2.6–2.7 bt throughout the forecast period, hence, it has little impact on the overall pattern.

It has to be emphasized, however, that comparing emission trends on an absolute weight basis only provides one-half of the picture. It is equally important to look at these trends on a per capita basis as presented in Figure 2.15. From this perspective, the pattern for Developing countries

Figure 2.15
Per capita CO_2 emissions by region, 2020 and 2045

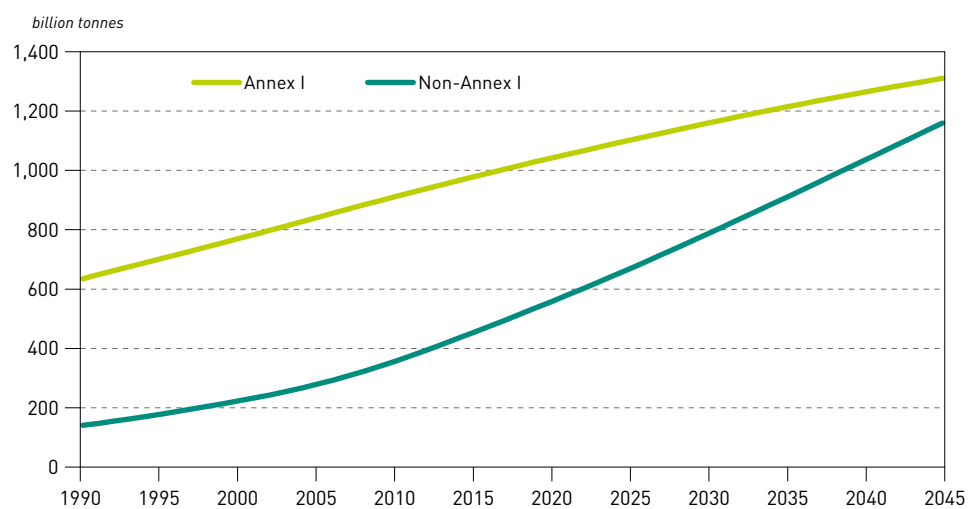


Source: OPEC.

changes from growing emissions on an absolute weight basis to a very stable, even a slight decline, on a per capita basis. Moreover, per capita emissions in OECD countries were almost three times higher than those for Developing countries in 2020 and, despite a significant decline in OECD countries, they are still forecast to be more than twice as high in 2045. A similar disparity exists when comparing Eurasia and Developing countries.

Another important aspect of the emissions discussion relates to historical cumulative CO_2 emissions. These are presented in Figure 2.16 from the perspective of Annex I and Non-Annex I countries. This figure clearly demonstrates that there is a substantial gap in cumulative emissions

Figure 2.16
Cumulative CO_2 emissions since 1900, 1990–2045



Source: OPEC.

between these two groups of countries that has evolved throughout the past century. In 2000, cumulative emissions from Annex I countries were at around 770 bt, 3.5 times higher than those from Non-Annex I that stood at around 220 bt.

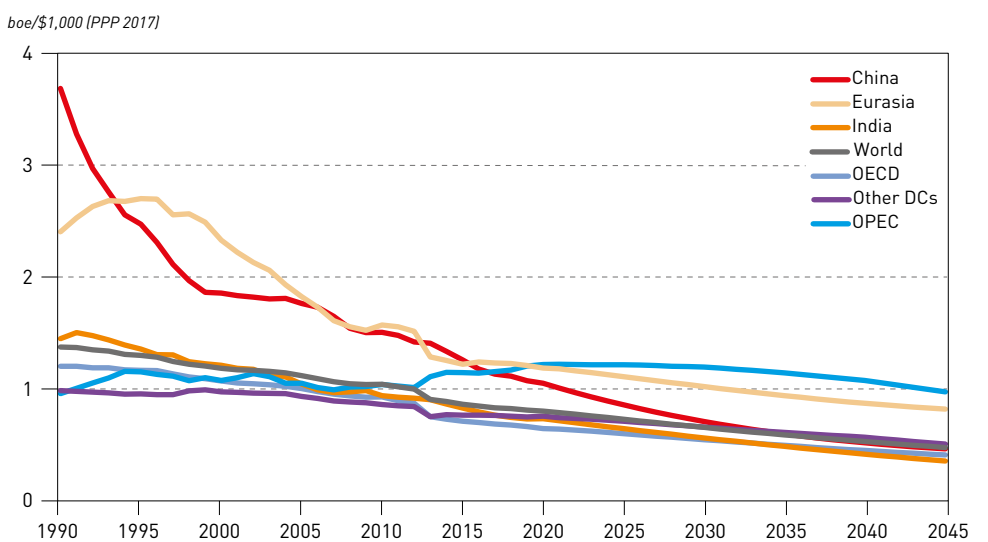
Over the past 20 years, the gap has started to narrow on the back of rapid energy demand growth in many developing countries and this trend is expected to continue over the forecast period. Despite this, even by the end of the forecast period, historical cumulative emissions by Non-Annex I countries will be more than 150 billion tonnes of CO_2 lower than those generated by Annex I countries since 1900.

2.5 Energy intensity and consumption per capita

Lockdown measures implemented across most the world in 2020, with some also in 2021, have reduced global energy consumption and GHG emissions significantly. Some observed facts during the pandemic are worth highlighting: residential demand increased compared to commercial and industrial; the energy consumption from private cars declined during lockdowns, and then witnessed a sharp increase as these were eased; and, electricity consumption in buildings at the district level increased, whereas thermal energy fell. Additionally, the COVID-19 pandemic has also established new work and living practices, which some suggest may become the new normal and outlast the pandemic. It is not all one way either, with some developments potentially seeing a rise in energy use, for example, an increasing preference for cars over public transport in a post-lockdown and post-pandemic world.

Figure 2.17 highlights the outlook foreseen for energy intensity in specific developing countries and regions. A general assertion that can be made in analyzing energy intensity patterns is that in most regions the amount of energy required to produce one unit of GDP continues to drop, despite the economic shock resulting from the pandemic. The world is moving toward a more social, and environmental conscious paradigm that is contributing to the rendering of products and services in a more sustainable and efficient manner. In most regions, energy efficiency advances are expected to accompany technological developments, with steady progress, if not acceleration, envisaged.

Figure 2.17
Evolution and projections of energy intensity in major world regions, 1990–2045



Source: OPEC.

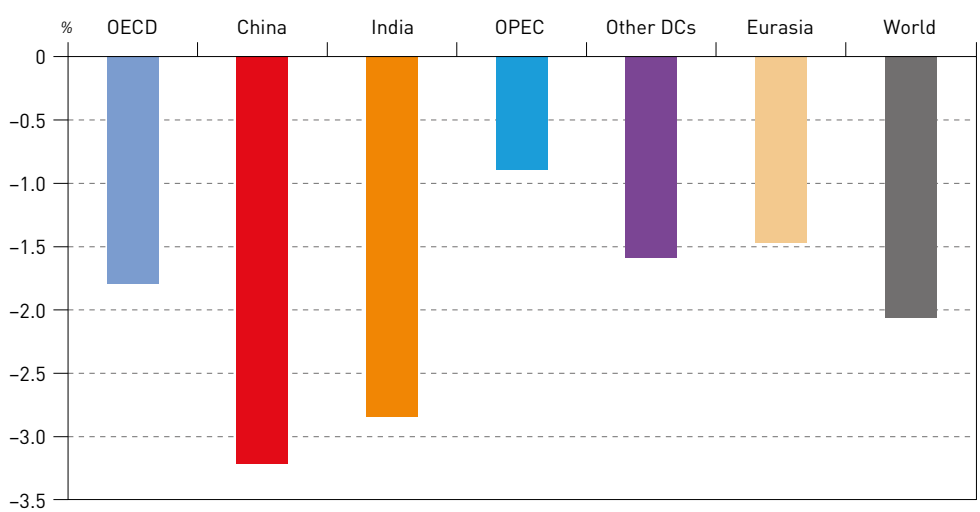
India and China are forecast to continue to see further improvements in their energy intensity over the projected period. In developed regions, technological progress and the increasing number of energy-efficiency policies in all economic sectors support a decoupling between energy use and economic growth, and this is expected to persist in these regions. This year's WOO sees a more pronounced and steep downward pattern in many regions due to the change made in the GDP (PPP) base year. This is now 2017 for this Outlook, instead of 2011 that was used last year, which offsets the forecasted energy demand reduction.

Other Eurasia and Russia have followed a similar downward energy intensity pattern since 1990. The OPEC region is not expected to start seeing a relative energy consumption decline before the early 2040s. Energy intensities across developing regions are expected to move towards convergence, as previously wide gaps in energy intensities are gradually eliminated. The world is experiencing a slowdown in obtaining energy efficiency performances and may not see a doubling of the rate of improvement – as targeted by SDG 7.3 – before the early 2040s.

The forecast for energy efficiency performance across the major regions is summarized in Figure 2.18. This year's Outlook shows an increased energy intensity rate in many regions. This is explained by the change made in the GDP (PPP) base year to 2017 and regional efforts in energy savings. Energy efficiency for most sectors, in both the OECD and non-OECD regions, will continue to advance, outpacing improvements achieved in the past 25 years, despite the economic shock related to COVID-19. China and India are expected to realize the fastest and largest reductions in energy intensity, on average 3.21% p.a. and 2.85% p.a., respectively, between 2020 and 2045. The OECD is likely to achieve an estimated reduction of 1.85% p.a. Other regions will experience an estimated reduction in the range of 0.89% to 1.59% p.a., whereas the global average reduction is projected to be at a level of 2.06% p.a.

Another vitally important global issue to highlight is energy poverty. Although the COVID-19 pandemic has hit the drive from global policymakers to reduce energy poverty, the general trend in recent years has been that the number of people suffering from energy poverty has been in decline.

Figure 2.18
Average annual rate of improvement in global and regional energy intensity, 2020–2045



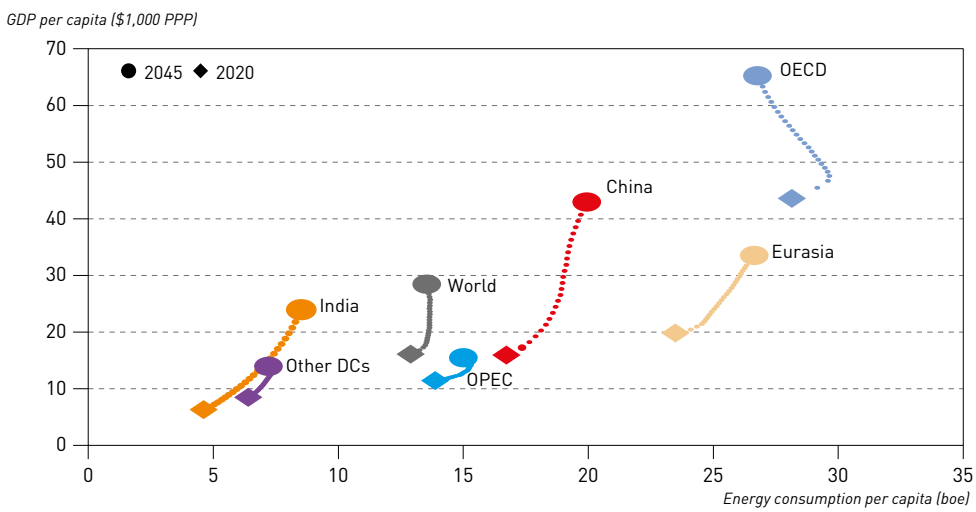
Source: OPEC.

The gap between energy consumption per capita in the OECD and non-OECD regions is forecast to narrow slightly. However, besides all the efforts made to bridge the gap, the average consumption in the OECD region is still many times higher than that in developing countries.

Since then, however, rapid economic expansion in the developing world, particularly in developing Asia, has helped lift millions of people out of poverty, expand the middle class, and enable an increase in energy access. In 2015, average energy consumption in non-OECD countries had almost tripled compared to 1970 levels and the gap with the OECD had lessened. Nevertheless, the gap is still wide and energy poverty remains an extremely important and urgent global issue for policymakers to resolve.

From the energy demand perspective, Figure 2.19 shows that variances in average per capita energy consumption (in a very broad sense, a proxy to energy poverty/wealth) can be linked to differences in the level of development and, therefore, to average income levels.

Figure 2.19
Energy consumption per capita *versus* GDP at PPP per capita, 2020–2045



Source: OPEC.

This Outlook anticipates that energy consumption in the non-OECD region will remain broadly linked with rapid economic growth. This will help bring an increase in electrification, a rise in urbanization levels, an expansion in the middle class and enable rising income levels. This is clearly apparent for the two most populous Asian economies: China and India.

In the former, average per capita energy consumption is expected to rise, increasing from around 16.7 boe in 2020 to 20 boe in 2045. In the latter, average consumption is anticipated to move from a level of 4.6 boe in 2020 to around 8.5 boe by 2045. During the medium-term (2020–2025), India is set to have the highest energy growth rate followed by China, at 3.4% and 1.8%, respectively. For other developing countries, in general, both per capita income and consumption is expected to remain at low levels, despite the significant increase in energy demand in absolute terms.

Despite anticipated modest economic growth, the OECD region – where economies are more service-oriented – are set to see energy consumption per capita continue to decline, a trend that began in 2004. The level of 28.1 boe observed in 2020 is forecast drop to 26.8 boe by 2045. The projected outlook for the OECD region continues to envision a decoupling of GDP growth and energy demand, driven by technological advances and policy-driven energy efficiency improvements.

Box 2.1

Focus on Africa

The continent of Africa is home to an abundance of energy resources, including about 10% of the world's oil reserves, however, it still has difficulty in harnessing these precious resources to meet its energy demand. This, in turn, hinders efforts to provide affordable and reliable energy required for economic growth and development.

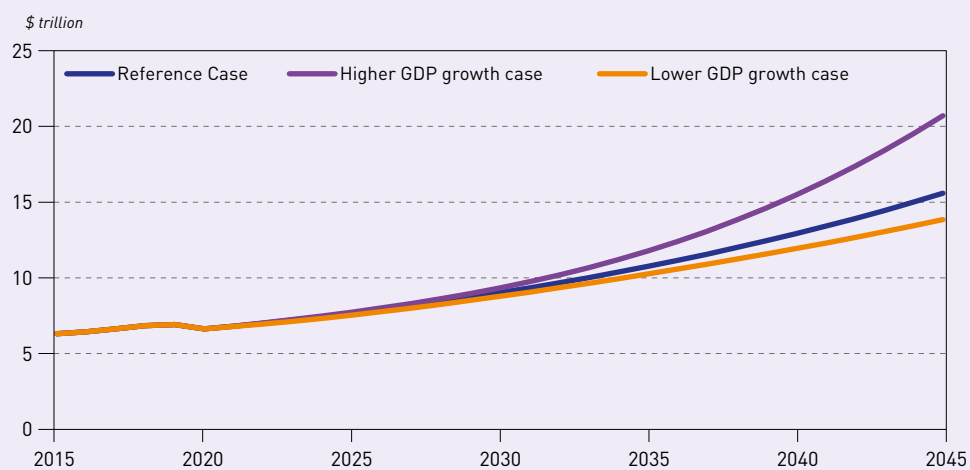
This challenging dynamic has meant that energy use per capita across the continent is below the global average. In fact, to date, there remains a huge gap in energy per capita consumption between Africa's rural and urban areas.

Africa has yet to unlock its huge potential in the energy sector, although its ever-increasing population growth and economic prospects require more energy. This drawback is mostly due to regional uncertainties, as well as government policies and regulatory frameworks guiding the energy sector, and more recently the efficiencies required to reduce CO_2 emissions in exploration and production (E&P) activities. These challenges have made it increasingly difficult to secure much-needed financing for E&P from foreign investors.

The impacts of the COVID-19 pandemic have also been a major setback, especially for those countries that depend heavily on revenue from fossil fuels for their economic growth and development. The continent was severely hit by the drop in export revenues and declines in economic activity, which invariably impacted fiscal reserves.

In a recent study conducted by OPEC on the medium- and long-term energy demand outlook for Africa, the Reference Case from the WOO was utilized and from this, two sensitivity cases were developed for higher GDP growth and lower GDP growth. The Reference Case was based on the assumption that the continent's average annual GDP will expand from 0.7 % between 2016–2020 to over 3.5% between 2025 and 2045. Figure 1 illustrates the GDP path for the three cases over the forecast period.

Figure 1
Africa GDP levels in the long-term, 2020–2045

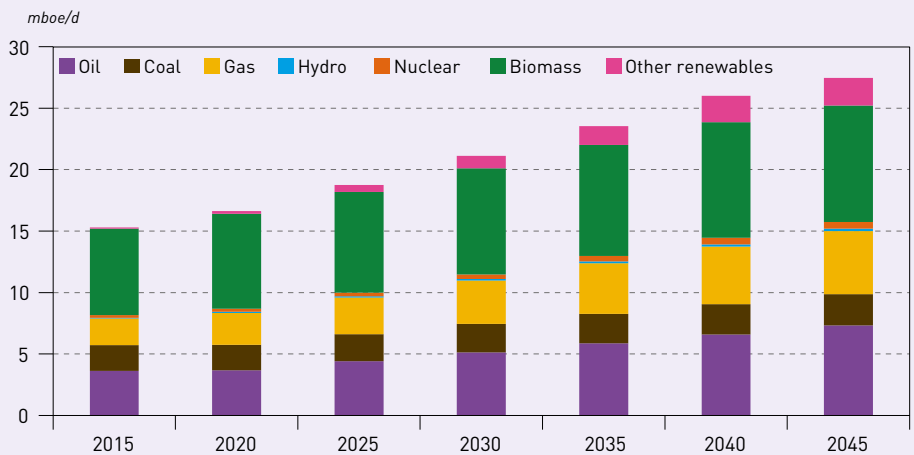


Source: OPEC.

The Reference Case shows that Africa's energy demand is expected to grow significantly, with an addition of 10.8 mboe/d in the long-term compared to 2020 levels of 16.6 mboe/d. Total energy demand is anticipated to increase to about 18.8 mboe/d by 2025 and continue rising to reach over 21 mboe/d by 2030 and 27.5 mboe/d by the end of the forecast period.

The Reference Case also sees the share of biomass in primary energy demand drop from 46.5% in 2020 to around 34.5% in 2045. This is due to more people moving from rural to urban settlements, and as they embrace a new preference towards modern cooking fuels. Figure 2 illustrates the Reference Case primary energy demand outlook in Africa.

Figure 2
Africa primary energy demand in the Reference Case



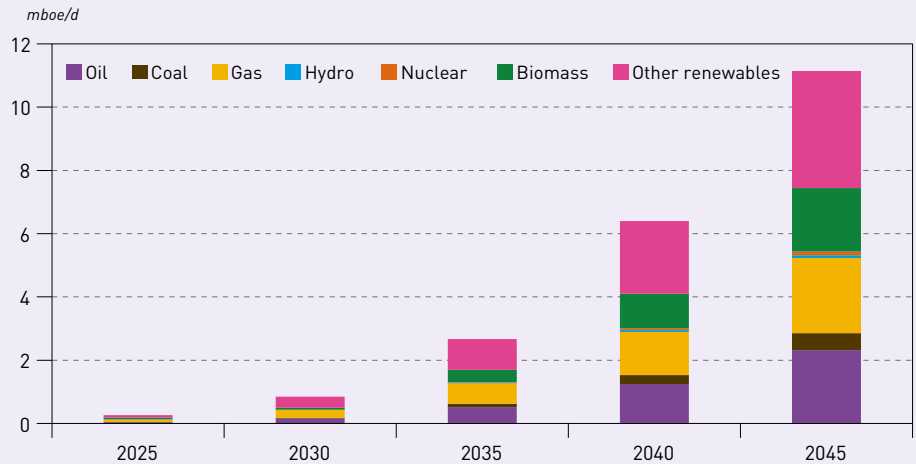
Source: OPEC.

The demand for oil is anticipated to grow from 2020 levels of 3.7 mboe/d to about 4.4 mboe/d in 2025, and 7.3 mboe/d in 2045. Hence, the share of oil in Africa's energy mix is forecast to increase from 22% in 2020 to 27% by 2045. Gas demand is anticipated to rise from 2.6 mboe/d in 2020 to 3 mboe/d in 2025 and then reach 5.1 mboe/d by 2045. The share of gas is forecast to increase from 16% in 2020 to 19% by 2045, which is about 8% lower than the share of oil by the end of the forecast period.

The higher GDP growth case assumes that the continent's average annual GDP will expand to reach 6.1% during the last five years of the forecast period. Comparing the higher GDP growth case to the Reference Cases shows that the difference in demand for oil is about 0.2 mboe/d by 2030, before increasing to reach 2.3 mboe/d by 2045. It is a similar story for gas, where the results show an increase in demand from 0.1 mboe/d in 2025 to 2.4 mboe/d by 2045. Figure 3 illustrates the increment in energy demand between the higher GDP growth case and the Reference Case.

The lower GDP growth case assumes that the continent's average annual GDP growth rate will increase steadily from 2.7% in the medium-term to reach 3.1% between 2031 and 2040, before then seeing a 0.1 pp decline by 2045. The lower GDP growth case shows that all sources in Africa's energy mix are expected to decline compared to the Reference Case, with total energy at 24.3 mboe/d by 2045, which is 3.2 mboe/d less than Reference Case

Figure 3
Incremental energy demand between Higher GDP growth and Reference Cases



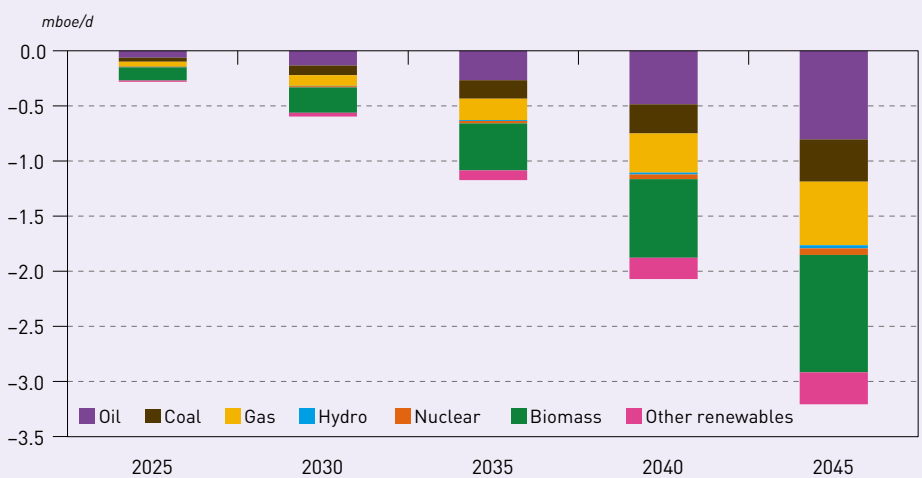
Source: OPEC.

levels. Figure 4 illustrates the decrease between the lower GDP growth sensitivity and the Reference Case.

As demand for energy is forecast to surge over the medium- and long-term, Africa is expected to restructure the way energy is produced and consumed in order to address the challenges of energy sustainability and impending climate concerns.

To meet increasing energy demand in the medium- to long-term, African countries are focusing on achieving advancements in modern energy in the transportation, electricity, cooking and other household sectors. However, this evidently requires modern infrastructure.

Figure 4
Incremental energy demand between Lower GDP growth and Reference Cases



Source: OPEC.

Africa currently exports over a third of its extracted fuels, however, in the long-term, due to the projected rise in the continent's population and the increased desire for urbanization, it will be necessary for the continent to consume these fuels locally, and in a manner that meets global emissions standards.

There is also a need for investments in the downstream sector, particularly refining, either by upgrading existing facilities or through building new ones. One of the ways to finance these projects could be for governments to seek financial partnerships with the private sector for the expansion of their refining and petrochemical industries. The petrochemical industry, in particular, will continue to require a steady supply of fossil fuels to manufacture household products, including those products that are necessary for meeting the requirements of daily life.

Investing in technologies such as blue hydrogen and CCUS while harnessing the 'reduce, reuse, recycle and remove' carbon principles are all critical paths towards a sustainable society in Africa. These principles not only minimize the environmental impacts of GHG emissions, but also contribute to achieving socio-economic development and prosperity. Additionally, hydrogen production development could make Africa a net exporter in the global market.

It should also be highlighted that the small sizes of individual markets could be addressed through increased intra-Africa trade. This enhanced continental cooperation could help promote technical partnerships, reduce the costs of buying and selling fossil fuels and other minerals, and, consequently, make energy more accessible and affordable for citizens of individual countries.

In June 2021, OPEC, in collaboration with the African Energy Commission (AFREC), the African Petroleum Producers' Organization (APPO) and African Refiners and Distributors Association (ARDA), hosted the inaugural OPEC-Africa Energy Dialogue to promote continent-wide energy cooperation initiatives. The dialogue is focused on providing critical input to identify enablers for investment in the African energy sector, improve accessibility and affordability of energy to eradicate energy poverty, and discuss the future of oil and energy in the post-COVID-19 recovery and energy transition for Africa.

Oil demand

- Oil demand is expected to recover over the medium-term and reach 104.4 mb/d by 2026.
- The global demand increase over the medium-term period (2020–2026) is estimated at 13.8 mb/d. However, almost 80% of this incremental demand is expected to materialize within the first three years (2021–2023), primarily as part of the COVID-19 recovery process.
- Using 2019 as the base year for comparison would result in incremental demand of 4.4 mb/d.
- OECD oil demand is expected to rise by almost 4 mb/d in the period to 2026. However, this increase will not be sufficient to return to pre-COVID-19 demand levels.
- Non-OECD demand is anticipated to increase by almost 10 mb/d over the medium-term; around half of this will be needed to cover the 2020 demand decline.
- Global oil demand is expected to increase by 17.6 mb/d between 2020 and 2045, rising from 90.6 mb/d in 2020 to 108.2 mb/d in 2045.
- Long-term projections highlight a contrasting demand picture, with ongoing demand growth in non-OECD regions and declining demand in the OECD.
- Demand growth will be at 2.6 mb/d on average during the first five years of the forecast period. Growth will then slow significantly during the second five-year period to 0.6 mb/d and further to 0.3 mb/d during the period 2030–2035. After that, projections indicate virtually no growth, hinting at a relatively long period of plateauing oil demand.
- The transportation sector is set to be the major contributor to future incremental global oil demand, adding around 13 mb/d between 2020 and 2045.
- More than 90% of this massive demand increase is projected to come from the road transportation and aviation sectors, each contributing around 6 mb/d, though a large part of these increases is due to a sharp demand decline in both sectors in 2020.
- The total vehicle fleet is expected to reach 2.6 billion by 2045, increasing by around 1.1 billion from 2020 levels. The EV fleet approaches 500 million vehicles by 2045, representing almost 20% of the global fleet.
- Adjusting long-term projections to the demand decline in 2020, the petrochemical sector remains the largest source of incremental demand to 2045, similar to last year's Outlook.
- With respect to refined products, major demand growth over the long-term is expected for jet/kerosene (+5.5 mb/d), diesel/gasoil (+3.3 mb/d), gasoline (+3.3 mb/d) and ethane/LPG (+3.0 mb/d).

The year 2020 was both turbulent and challenging, marked with a COVID-19-related economic downturn, public health measures restricting mobility and slower construction and manufacturing activity across the globe. This resulted in a sharp oil demand drop of almost 10 mb/d, though market conditions started improving towards the end of 2020. Oil prices were mostly on a rising trajectory in the last quarter of 2020, supported by an expectation of demand recovery and still-constrained prospects for a stronger supply recovery.

Indeed, demand started its recovery path in 2021, although this will likely remain far from a full recovery, especially in the road transportation and aviation sectors. On the one hand, progress in vaccination rollouts and the introduction of stimulus packages, especially in developed countries, led to easing lockdown measures and supported economic activity and travelling. This, in turn, resulted in a partial oil demand recovery. On the other, however, the appearance of new COVID-19 variants and slower vaccination progress in many developing countries hindered full demand recovery at the global level.

Despite the omnipresent COVID-19 pandemic, 2021 was not just about fighting the virus. On the contrary, it was a critical year during which policymakers and the entire energy and oil industries reached a crossroads, seeking direction for future developments. Many see the recent decline in energy and oil demand as an opportunity to expedite investment into renewable energy, both to support the economic recovery and accelerate the transition to cleaner fuels. This is clearly demonstrated by the number of countries that announced their intention to achieve net-zero emissions sometime around 2050.

This sentiment did not stop at the policymaking level. There is a clear visible shift in the strategy of several international oil companies (IOCs), especially in Europe, where they is a tendency to diversify portfolios by adding other energy sources as part of their regular activities. Car manufacturers are yet another example of companies seeking new direction. The investment structure of these companies provides a strong signal on the introduction of new models and expanding capacity to produce EVs.

Finally, a shift in consumer behaviour is also emerging. Tele/homeworking is becoming a norm for many companies as a result of the pandemic. Tourism started to recover slowly in 2021, but is still significantly restricted to home and neighbouring countries rather than long-distance travel. Public acceptance of more energy-efficient technologies and lower-emission solutions is also progressing.

Despite all these signals, many uncertainties and questions related to future oil demand remain unanswered. The primary one relates to the pace of these changes. Clearly, transforming the entire energy system is an extremely challenging task that will take some time. Similarly, achieving significant penetration of EVs in a global fleet of almost 1.5 billion vehicles (and growing) will not happen overnight. Moreover, will stimulus packages outlined by almost all governments be effective, leading to higher growth with the intended investment structure? How long will the change in consumer behaviour last, and what will remain permanent? Will people use cars the same way as before the crisis? How long will tourists refrain from travelling? Will the aviation industry return to past growth rates?

The list of questions is not exhaustive, but even for those highlighted there are few clear answers readily available. This chapter tries to shed light on some of the possibilities and analyze key factors affecting the future demand path, and provide insights into the evolving outlook for oil demand in the medium- and long-term.

3.1 Oil demand outlook by region

Global oil demand experienced an unprecedented decline of 9.3 mb/d in 2020, primarily due to COVID-19-related lockdowns and a reduction in economic activity of 3.4% compared with 2019.

Last year's Outlook expectation was that oil demand would recover relatively swiftly, with most of this taking place in 2021, and then some continuation of the recovery process in 2022 and possibly 2023.

However, oil demand growth in 2021 has been slower than previously anticipated. The assessment provided in the July 2021 edition of the OPEC MOMR projected a demand increase of 6 mb/d in 2021. This means that 2021 demand would still be around 3.4 mb/d lower than in 2019 and almost 1.1 mb/d lower than projected a year ago. It is important to note that a slower-than-expected recovery took place primarily in the OECD region, where the rebound in 2021 represented less than 50% of the decline in 2020. Needless to say, this lower demand base also has some implications for medium- and long-term demand levels.

Similar patterns also apply to the recovery process of most non-OECD countries, except for China. However, the differences between last year's projections and this Outlook are much smaller when examining the OECD, generally in the range of just 0.1 mb/d for most regions. The unique exception is China, for which current 2021 oil demand expectations are more than 1 mb/d higher than in the previous Outlook. Part of this difference (around 0.4 mb/d) is attributable to upward revisions in historic oil demand in China. The rest is mostly related to 2020 developments when, surprisingly, China's oil demand was much less affected by the COVID-19 pandemic than anticipated in mid-2020 analysis. The projection at that time was for a decline of 1 mb/d. However, strong demand growth in the second half of the year resulted in an annual decline of only 0.3 mb/d. The combined effect of these factors is that non-OECD demand for 2021 has been revised upward by 0.6 mb/d in this year's Outlook.

The overall downward demand revision for 2021, which now sees growth of 6 mb/d (Table 3.1), combined with assumed GDP growth of 4.1% in 2022 and prospects for containment of the COVID-19 pandemic, provide the basis for a stronger recovery process extending to 2022, and possibly

Table 3.1
Medium-term oil demand in the Reference Case

mb/d

	2019	2020	2021	2022	2023	2024	2025	2026	Growth 2020–2026
OECD Americas	25.7	22.6	24.4	25.3	25.5	25.6	25.5	25.4	2.8
OECD Europe	14.3	12.4	13.0	13.4	13.5	13.4	13.3	13.2	0.8
OECD Asia Oceania	7.8	7.1	7.4	7.5	7.6	7.5	7.4	7.4	0.3
OECD	**47.7**	**42.1**	**44.7**	**46.3**	**46.6**	**46.5**	**46.3**	**45.9**	**3.9**
Latin America	6.2	5.7	6.0	6.2	6.3	6.4	6.5	6.6	0.9
Middle East & Africa	4.2	3.9	4.0	4.2	4.3	4.5	4.6	4.8	0.9
India	4.9	4.5	5.0	5.3	5.5	5.7	5.9	6.1	1.6
China	13.5	13.2	14.3	14.8	15.0	15.2	15.4	15.6	2.4
Other Asia	9.0	8.1	8.6	8.9	9.2	9.4	9.6	9.8	1.6
OPEC	8.8	8.1	8.5	8.8	9.0	9.2	9.4	9.6	1.6
Russia	3.6	3.4	3.6	3.6	3.7	3.7	3.8	3.8	0.4
Other Eurasia	2.0	1.7	1.9	2.0	2.0	2.0	2.1	2.1	0.4
Non–OECD	**52.3**	**48.6**	**51.9**	**53.6**	**55.0**	**56.2**	**57.3**	**58.5**	**9.9**
World	**100.0**	**90.6**	**96.6**	**99.9**	**101.6**	**102.7**	**103.6**	**104.4**	**13.8**

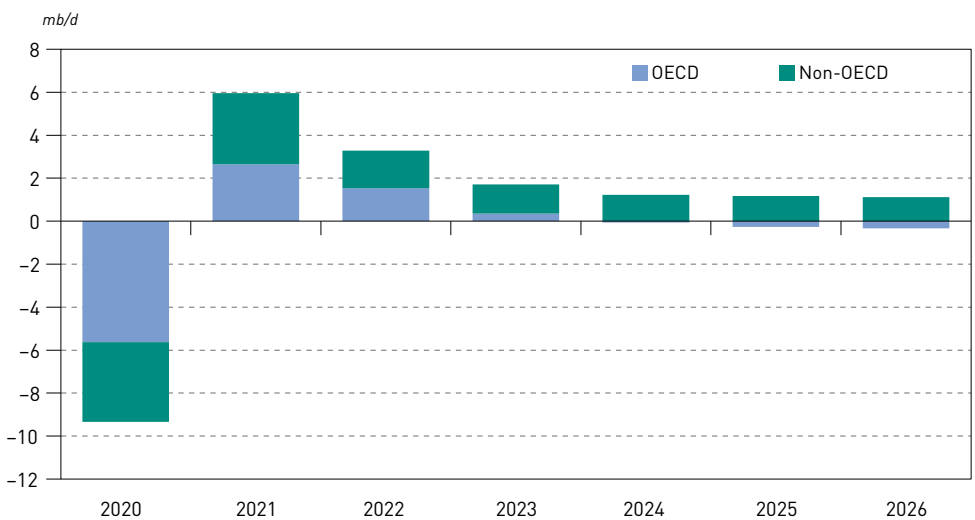
Source: OPEC.

even to 2023. Along with robust GDP growth in 2022, this view is also supported by an ongoing demand revival, especially in the sectors most affected by the COVID-19 crisis. These include road transport, aviation and industry sectors.

In the road transport and aviation sectors, an assumed improvement in the pandemic situation should result in a higher propensity to travel and fly longer distances, hence supporting demand growth beyond the standard link to economic activity. A similar effect is also expected in the industrial sector, where production declined significantly in 2020 and many investment decisions were deferred. These investments are likely to be listed once again in the coming years, especially with support from government stimulus packages, which in turn supports oil demand growth in the sector.

For these reasons, global oil demand is set to increase by 3.3 mb/d and 1.7 mb/d in 2022 and 2023, respectively, as presented in Figure 3.1. This figure also clearly illustrates that global demand growth will significantly decelerate after an initial period of strong growth from 2021–2023. Indeed, annual incremental demand is expected to drop to a range of 1 mb/d during 2024 and 2025 and then well below 1 mb/d towards the end of the medium-term, when long-term factors start prevailing that limit potential demand growth. An important element of this view is the expectation that economic growth will decelerate from a range of 3.5% to 4% p.a. in 2022 and 2023 to 3.2% to 3.3% p.a. for the rest of the medium-term.

Figure 3.1
Annual incremental oil demand by region, 2020–2026



Source: OPEC.

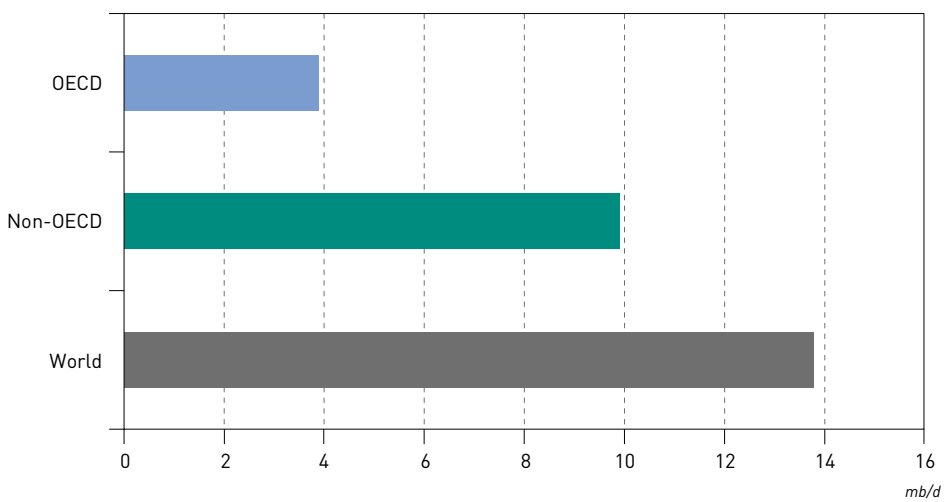
Besides lower GDP growth, a number of other factors will increasingly be at play in the second part of the medium-term period that contributes to decelerating demand growth. These include further GDP structural changes in several countries, such as China, with a higher share coming from lower energy and oil intensity sectors. This will be supplemented by ongoing efficiency improvements and changing consumer behaviour – such as increasing home office working and the use of teleconferencing instead of physical travel. Another example in this direction is an uptick in the sale of new cars, including a higher share of EVs, which affects both improved fuel efficiency and oil substitution by non-oil based energy sources.

The latter two factors – fuel efficiency and oil substitution – will also play a role outside of the road transportation sector. This is mainly due to higher electrification in residential and industrial sectors, supported by various policy measures and higher demand for natural gas, which often replaces oil products in these two sectors. Examples of such options include the City Gas Distribution initiative in India, which targets the replacement of LPG and kerosene by natural gas; the reduction of direct crude burning for electricity generation in the Middle East; growing interest in LNG-powered vessels in the shipping industry; and a ban on oil-based heating systems in the residential sector in several European countries (e.g. in Austria as of 2023 and the UK as of 2025).

The combined effect of all these factors, with varying impacts at the regional level, will likely be an overall decelerating global trend. Therefore, the global demand increase over the medium-term period (2020–2026) is estimated to be 13.8 mb/d. However, almost 80% of this incremental demand will materialize within the first three years (2021–2023), primarily as part of the COVID-19 recovery process. Using 2019 as the base year for comparison would result in incremental demand of 4.4 mb/d.

Figure 3.2 summarizes these projections from the perspective of the two major regions – OECD and non-OECD. The typical pattern for this figure for the past several years was one of declining cumulative oil demand in the OECD, which was more than offset by growing demand in the non-OECD region. Due to special circumstances in the base year (2020), this pattern changes in the current Outlook, as both regions show significant growth.

Figure 3.2
Incremental oil demand by region, 2020–2026



Source: OPEC.

In the case of the OECD, oil demand is expected to increase by almost 4 mb/d in the period to 2026. However, this increase will not be sufficient for a return to pre-COVID-19 demand levels, as the partial recovery trend until 2023 will revert to declining demand in the region for the rest of the forecast period.

The outlook for non-OECD demand is quite different. It is estimated to increase over the medium-term period in the range of 10 mb/d, with around half required to cover the demand decline of 2020. Compared with the OECD, this will be achieved relatively swiftly, sometime during 2022. As

mentioned earlier, demand growth will also decelerate in the non-OECD region over the medium-term period. Nonetheless, it will remain at more than 1 mb/d annually, thus driving global oil demand to 104.4 mb/d in 2026.

Long-term demand prospects are summarized in Table 3.2. At the global level, oil demand is expected to increase by 17.6 mb/d between 2020 and 2045, rising from 90.6 mb/d in 2020 to 108.2 mb/d in 2045.

Table 3.2
Long-term oil demand by region

mb/d

	2019	2020	2025	2030	2035	2040	2045	Growth 2020–2045
OECD Americas	25.7	22.6	25.5	24.6	22.9	21.0	19.3	–3.3
OECD Europe	14.3	12.4	13.3	12.5	11.6	10.6	9.7	–2.7
OECD Asia Oceania	7.8	7.1	7.4	6.9	6.3	5.7	5.1	–1.9
OECD	**47.7**	**42.1**	**46.3**	**44.0**	**40.8**	**37.3**	**34.2**	**–7.9**
Latin America	6.2	5.7	6.5	7.0	7.3	7.5	7.8	2.0
Middle East & Africa	4.2	3.9	4.6	5.3	6.0	6.7	7.4	3.6
India	4.9	4.5	5.9	7.2	8.5	9.8	11.0	6.5
China	13.5	13.2	15.4	16.2	16.6	16.9	17.0	3.8
Other Asia	9.0	8.1	9.6	10.5	11.4	12.2	12.9	4.8
OPEC	8.8	8.1	9.4	10.4	11.1	11.6	12.0	3.9
Russia	3.6	3.4	3.8	3.9	3.9	3.8	3.7	0.3
Other Eurasia	2.0	1.7	2.1	2.2	2.2	2.3	2.2	0.5
Non-OECD	**52.3**	**48.6**	**57.3**	**62.6**	**67.1**	**70.8**	**74.1**	**25.5**
World	**100.0**	**90.6**	**103.6**	**106.6**	**107.9**	**108.1**	**108.2**	**17.6**

Source: OPEC.

Table 3.2 also underscores several observations worth mentioning. First, long-term projections highlight a contrasting demand picture between ongoing demand growth in the non-OECD region and declining demand in the OECD. This trend will begin during the medium-term period and then intensify over the longer-term. Indeed, OECD demand is projected to peak at levels of around 46.6 mb/d as soon as 2023, before starting a longer-term decline towards 34 mb/d by 2045.

The main reasons for this trend are efficiency improvements across all sectors of consumption and the substitution of oil by gas and renewable energy. This includes the significant penetration of EVs in the road transportation sector, ongoing electrification of residential and industrial sectors and the penetration of alternative fuels in the marine and aviation sectors, among others. Part of this picture includes a static (and aging) population and low economic growth, with less oil-intensive industry, especially in the second part of the forecast period.

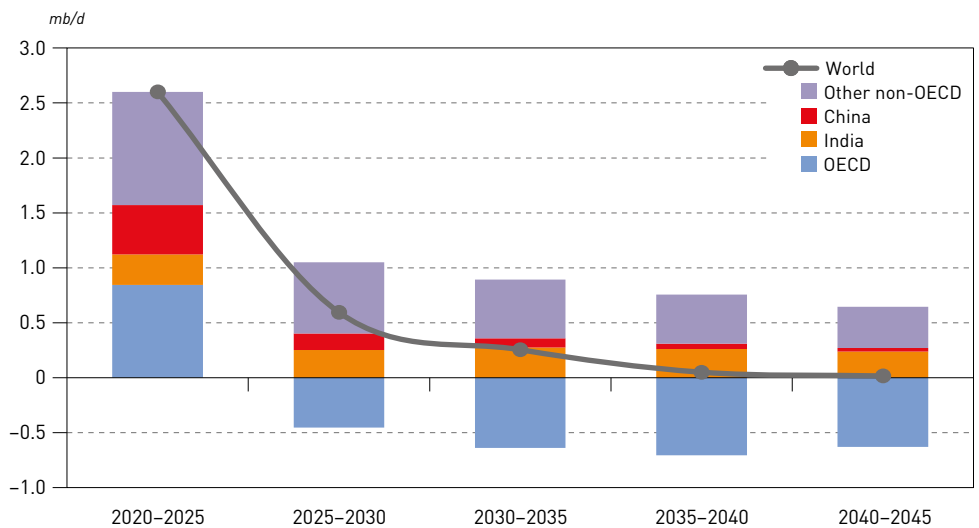
In contrast, demand will continue to grow in the non-OECD region, driven by an expanding middle class, high population growth rates and stronger economic growth potential. Oil demand in this group of countries is expected to increase by 25.5 mb/d between 2020 and 2045, to reach

74.1 mb/d in 2045. It should be noted, however, that almost 5 mb/d of the projected demand increase in the non-OECD region will be needed just to recover the demand loss from 2020.

The second observation relates to a front-loaded pattern of future demand growth. This is well illustrated in Figure 3.3, which presents average annual oil demand increments during five-year intervals. It clearly shows that future demand growth will be concentrated in the current decade, with quite limited growth potential thereafter.

Driven by the COVID-19 crisis recovery process, annual oil demand growth is forecast at 2.6 mb/d on average during the first five years of the forecast period. It is then expected to slow significantly during the second five-year period to 0.6 mb/d, and even more to 0.3 mb/d during the 2030–2035 period. After that, projections indicate virtually no growth, hinting to a relatively long period of plateauing oil demand at the global level. As noted earlier in this chapter, this will be a period when demand declines in the OECD will broadly offset decelerating growth in the non-OECD. This will be driven by both energy policies and technology development, which will play an increasing role in diversifying the future energy mix.

Figure 3.3
Average annual oil demand increments by region, 2020–2045



Source: OPEC.

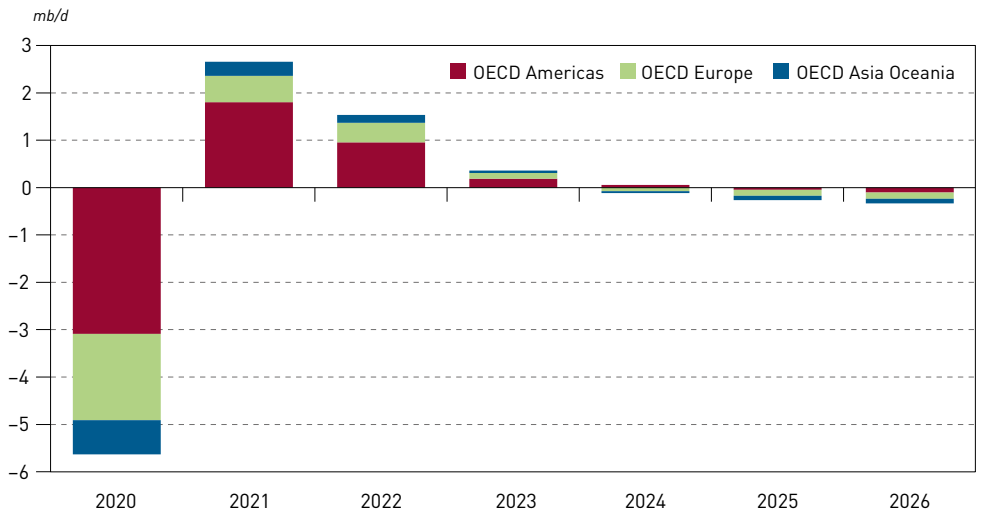
The third observation is linked to the fact that current projections represent yet another downward revision to long-term global oil demand, primarily as a reflection of tightening policy measures aimed at reducing energy-related emissions.

Compared with the WOO 2020, current demand projections are broadly similar at the end of the medium-term. However, the gap starts widening thereafter, leading to a downward revision of around 1 mb/d by 2045. Some contributing factors to this revision are slightly lower long-term GDP growth rates and lower base demand levels, though the main reasons are assumed to be greater efficiency improvements, the higher penetration of EVs and the extended substitution of refined products by other energy sources, such as marine bunker fuel by LNG in the shipping sector. The overall downward revision for this year is not large, but the cumulative effect of consecutive revisions over the last three years is significant.

3.1.1 OECD

Figure 3.4 details annual demand increments in major OECD regions over the medium-term. Oil demand in this region in 2020 declined sharply by 5.6 mb/d (Figure 3.4). As shown in Figure 3.2, incremental oil demand over the medium-term is projected at just 3.9 mb/d. This means that OECD oil demand is no longer expected to reach 2019 levels. On the contrary, after just three years of positive growth over the 2021–2023 period, OECD oil demand will start declining.

Figure 3.4
Annual oil demand growth in the OECD, 2020–2026



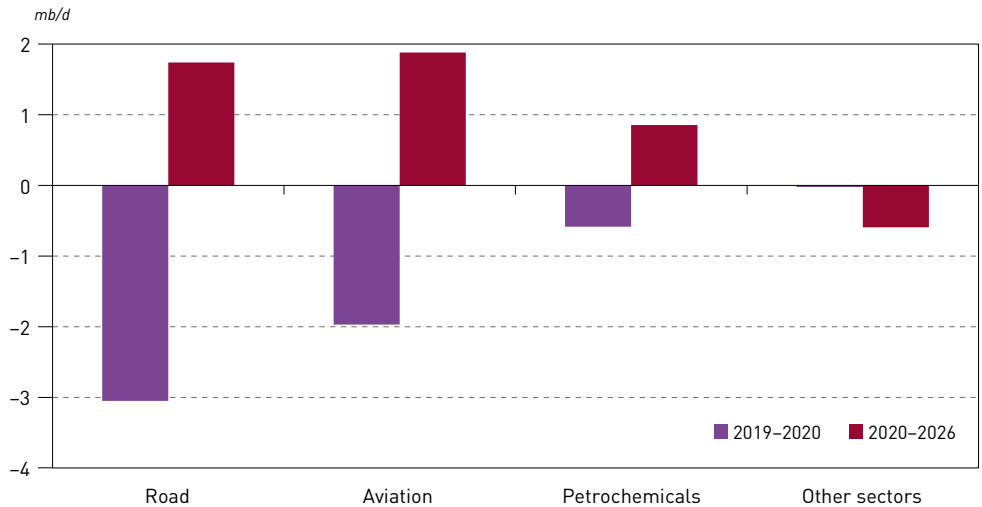
Source: OPEC.

There are several reasons supporting this view. OECD oil demand started to recover in 2021, albeit at a relatively slow rate. The demand increase in 2021 represents less than half of the 2020 decline. A large part of this is due to the sluggish recovery in road transport. Many parts of the OECD experienced local (partial) shutdowns in 2021 with strong mobility restrictions, especially at the beginning of the year. The situation has improved somewhat in the second half of the year, but cross-border travelling has remained challenging.

This is assumed to improve in the coming years on the back of progressing vaccination programmes, but consumer confidence and the propensity to travel will likely remain subdued for some time. This is also reflected in weak new car registration data in all major OECD countries. Despite some revival of new registrations in 2021 from the very low levels of 2020, they are still well below pre-COVID-19 levels. At the same time, both the total number of new EVs and their share in new registrations is expanding, especially in Europe, where the share of EVs passed the 10% mark in 2020. Adding to this, stringent fuel efficiency standards are being implemented for new vehicles in OECD countries and road transport demand in OECD Asia Oceania and OECD Europe was already on the decline before the pandemic crisis. Together, this results in an expectation that OECD oil demand in the road transport sector will not fully recover to 2019 levels (Figure 3.5).

The situation is even more challenging in the aviation sector, which was hardest hit in 2020, though the longer-term expectation is that oil demand will fully recover and continue growing in this sector. OECD Europe was among the regions with the sharpest demand drop in 2020, as the vast majority of aircraft were grounded for several months. Some traffic recovery started in the

Figure 3.5
Oil demand growth in the OECD by sector, 2020–2026



Source: OPEC.

second half of 2020 and is expected to continue over the medium-term period, though at a slow pace, as both leisure and business travel will be affected by COVID-19 measures for several years. As a result, and similar to the conclusion made in last year's WOO, OECD oil demand in this sector will remain subdued, barely returning to the 2019 levels by the end of the medium-term.

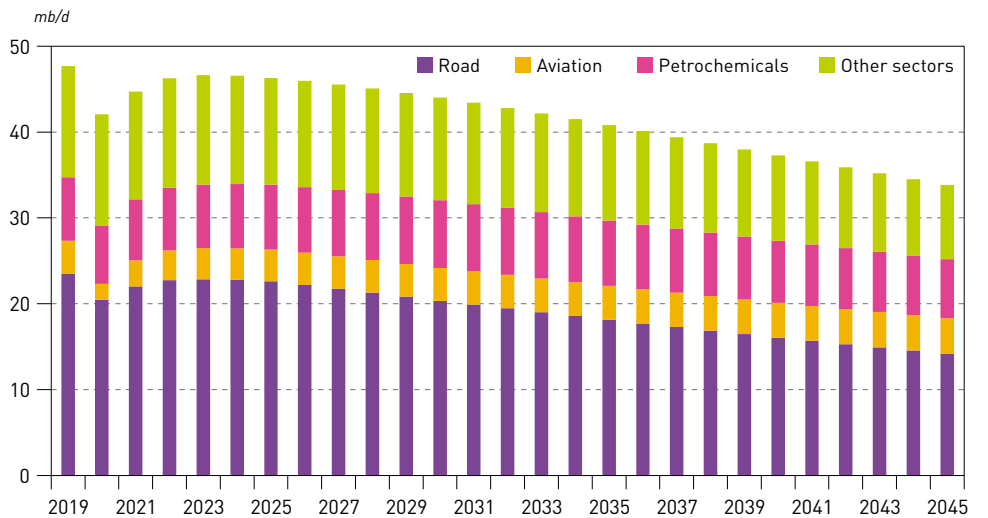
In contrast to the road transportation and aviation sectors, oil demand in the petrochemical sector is expected to recover relatively swiftly from the COVID-19 crisis, driven largely by capacity additions in OECD Americas, especially in the US. This newly built US capacity will remain competitive due to the availability of suitable domestic feedstock, which is set to push demand higher by some 0.3 mb/d over the medium-term. This will offset declines in petrochemical feedstocks in OECD Europe and OECD Asia Oceania, which struggle to remain competitive with other producers in Asia and the Middle East. Nonetheless, growth in demand for petrochemical products will not be sufficient to prevent OECD oil demand from shifting to a declining path.

Beyond the medium-term, OECD demand is set to decline as presented in Figure 3.6. The overall demand drop between 2020 and 2045 will be around 8 mb/d. By far the largest demand decline at the sectoral level is projected for road transport, where oil demand will be 6 mb/d lower by 2045, compared to 2020. Almost half of this decline (–2.8 mb/d) will materialize in OECD Americas, followed by OECD Europe (–2.2 mb/d) and OECD Asia Oceania (–1.2 mb/d). The two main factors, almost equally contributing to this demand decline, are the fast penetration of EVs into the OECD fleet and efficiency improvements for new ICE vehicles. Moreover, changes in driving habits leading to lower mileage driven per vehicle are anticipated to further exacerbate the demand decline.

Contrary to road transport, oil demand in the aviation sector is projected to increase in the long-term. As already discussed, demand in this sector will struggle to recover from the 2020 collapse in the medium-term. However, once the recovery phase is over and consumers regain confidence, demand is anticipated to continue growing. Overall incremental demand is expected at 2.3 mb/d between 2020 and 2045. However, almost 2 mb/d of this will be compensation for the 2020 demand decline and only around 0.3 mb/d will be required to provide fuels for additional aviation activity compared with 2019.

The long-term path for OECD oil demand in the petrochemical sector will be somewhere between the road transport and aviation sectors. OECD demand in this sector rebounded fairly quickly after dropping in 2020 and is projected to grow until around 2030. This growth will primarily be driven by favourable conditions in the US on the back of growing tight oil production and available steam-cracking capacity. This, however, will change after tight oil production peaks towards the end of the current decade and starts to decline for the rest of the forecast period.

Figure 3.6
OECD oil demand by sector, 2019–2045



Source: OPEC.

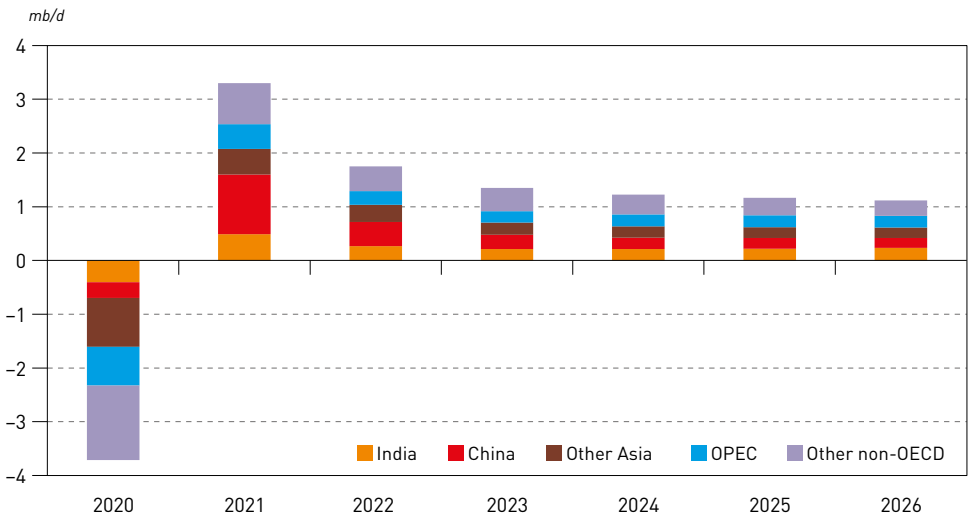
In the other two OECD regions, oil demand in the petrochemical sector is set to start declining much earlier than in OECD Americas. The main reason is a competitive disadvantage against fast-growing capacity in Asia and the Middle East, which will already play a role in the medium-term and then more over the longer-term. The net effect of these trends is that OECD oil demand in the petrochemical sector will be broadly at 2020 levels by 2045.

From the oil demand perspective, developments in other sectors (including industrial, residential, commercial and electricity generation) will be marked by oil replacement through natural gas and electricity as a result of various policy measures. Tighter building codes, the partial exclusion of oil-based heating systems from the residential and commercial sectors, emissions-trading systems in the industrial sector and oil substitution in electricity generation are just a few examples of mechanisms steering the demand decline. Moreover, the implementation of more efficient technology will play a role in further reducing OECD oil demand.

3.1.2 Non-OECD

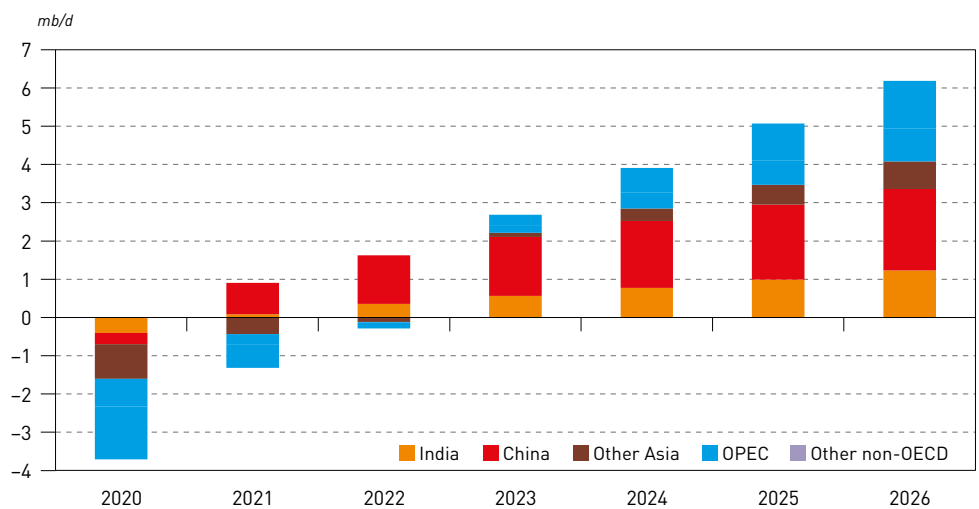
Similar to the OECD trend, oil demand sharply declined in non-OECD regions during 2020, although the extent of the decline was lower in both absolute and relative terms. Non-OECD demand declined by 3.7 mb/d in 2020, though a large part of this is projected to recover in 2021, when demand is set to increase by 3.3 mb/d, suggesting that the impact of the COVID-19 pandemic on oil demand in this region will be short-lived. However, a closer look at Figures 3.7 and 3.8 highlight some interesting perspectives.

Figure 3.7
Annual oil demand growth in non-OECD countries, 2020–2026



Source: OPEC.

Figure 3.8
Oil demand change compared to 2019, 2020–2026



Source: OPEC.

It is evident that exceptionally high demand growth in China in 2021 and 2022 will compensate for weak demand performance in other regions. Indeed, according to the July 2021 edition of the OPEC MOMR, demand in China declined by 0.3 mb/d in 2020 and is set to increase by 1.1 mb/d in 2021, representing one-third of overall non-OECD demand growth. Strong demand growth in China will also continue in 2022, before decelerating to much smaller annual increments towards the end of the medium-term.

A different demand pattern is projected for India, where demand growth in 2021 will just broadly compensate for losses in 2020. This is mainly because of the challenging pandemic situation in

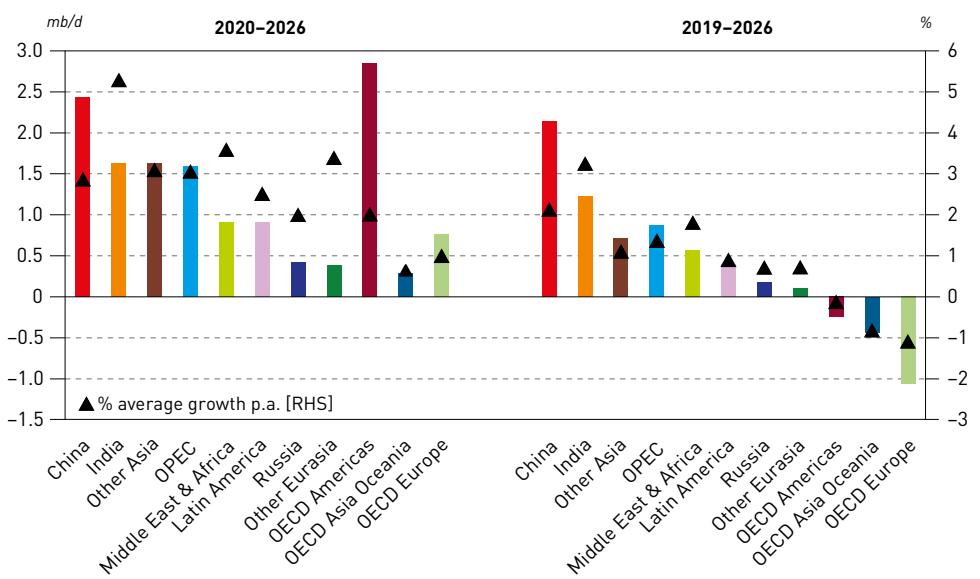
India, with the country struggling to contain the COVID-19 virus in the first half of 2021. As seen in Figure 3.8, it means that China and India will be the only two countries/regions (in the Outlook's regional breakdown) with higher demand in 2021 than 2020.

This stands in stark contrast to other non-OECD regions, where the oil demand recovery in 2021 will only be in the range of 40%–60% of the 2020 decline. Moreover, demand in these regions will likely be below 2019 levels even during 2022 and will only move into positive territory in 2023. After that, demand growth is expected to continue for the rest of the medium-term on the back of robust and relatively stable GDP growth in the region. This will be in the range of 4.6% to 4.7% p.a. on average for developing countries and around 2% p.a. for the Eurasian region. Therefore, non-OECD demand growth will remain in the range of 1.1 mb/d to 1.2 mb/d p.a., with a marginally decelerating trend.

The overall effect of these regional trends is that non-OECD demand is set to increase by almost 10 mb/d between 2020 and 2026. Figure 3.9 shows how this growth is distributed between regions (including OECD regions for ease of comparison), together with the corresponding average annual demand growth rate. In the first case, where 2020 serves as a basis for comparison, all regions – including within the OECD – are projected to record positive and in most cases significant demand growth. In fact, the largest growth would come from OECD Americas, where demand declined most in 2020. This is followed by China, India, Other Asia and OPEC, with each contributing between 1.5 mb/d to 2.5 mb/d to incremental medium-term demand.

This picture changes substantially, however, if the basis for comparison is 2019. In this case, China becomes the major contributor to incremental demand, followed by India, OPEC and Other Asia. What also changes is the order of magnitude of these components. Only the demand contribution of China remains relatively stable by shifting the base year. All other regions decline quite significantly, including OECD regions, which revert to negative growth if pre-pandemic levels are considered as a base for comparison.

Figure 3.9
Regional oil demand growth



Source: OPEC.

Another important observation relates to relative demand growth. In this respect, Figure 3.9 shows that the fastest demand growth is projected for India, which is around 1 pp higher than in other fast-growing regions. Moreover, although not presented in the figure, demand growth in China is set to rapidly decelerate, while growth in India, Other Asia, OPEC and the Middle East and Africa remains robust for a longer period.

Therefore, incremental demand in these regions will be higher (except for the Middle East & Africa because of the low demand base) than that of China in the long-term (see Table 3.2). The largest demand increase over the forecast period (2020–2045) is projected to come from India at 6.5 mb/d, followed by Other Asia (4.8 mb/d), OPEC (3.9 mb/d) and China (3.8 mb/d). This also shows that the future centre of gravity of global oil demand will shift significantly towards non-OECD Asian countries.

India

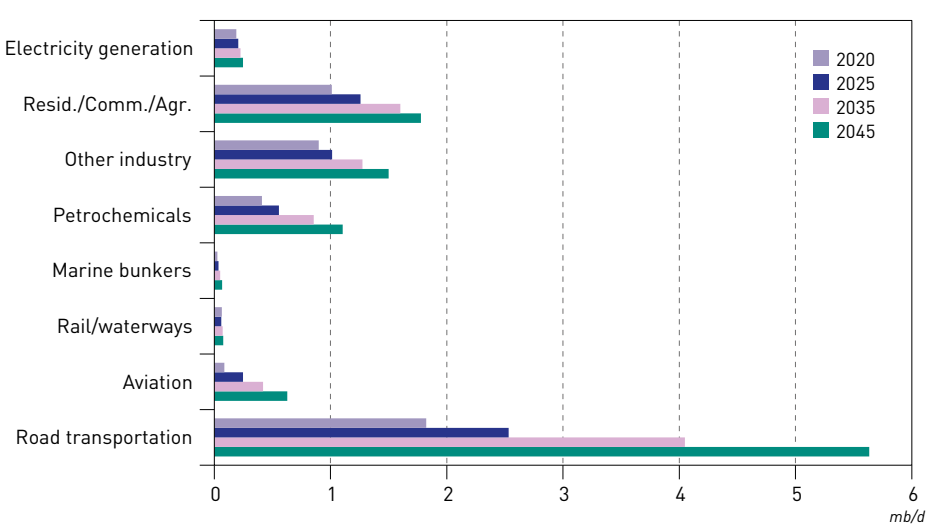
A detailed discussion of major trends and key factors driving future oil demand in India is provided in Chapter 9. Thus, analysis in this section is limited to high-level observations.

As presented in Table 3.2, India is projected to be the country with the highest oil demand growth and largest incremental demand over the forecast period. The primary reason for this is projected demand expansion in the road transportation sector, and supported by a demand rise in the residential, industrial and aviation sectors (Figure 3.10).

Demand growth in road transportation will by driven by a rising middle class segment of the population leading to a rapid expansion of the vehicle fleet and infrastructure. The total number of vehicles in India is set to increase by more than 200 million between 2020 and 2045 from less than 50 million (except two-wheelers) in 2020 to almost 250 million in 2045. As a result, oil demand in road transportation alone is forecast to increase by 3.8 mb/d during the forecast period.

Demand additions in other sectors are set to be in a significantly lower range. Combined demand in the residential, commercial and agricultural sectors is anticipated to grow by around 0.8 mb/d

Figure 3.10
Oil demand by sector in India, 2020–2045



Source: OPEC.

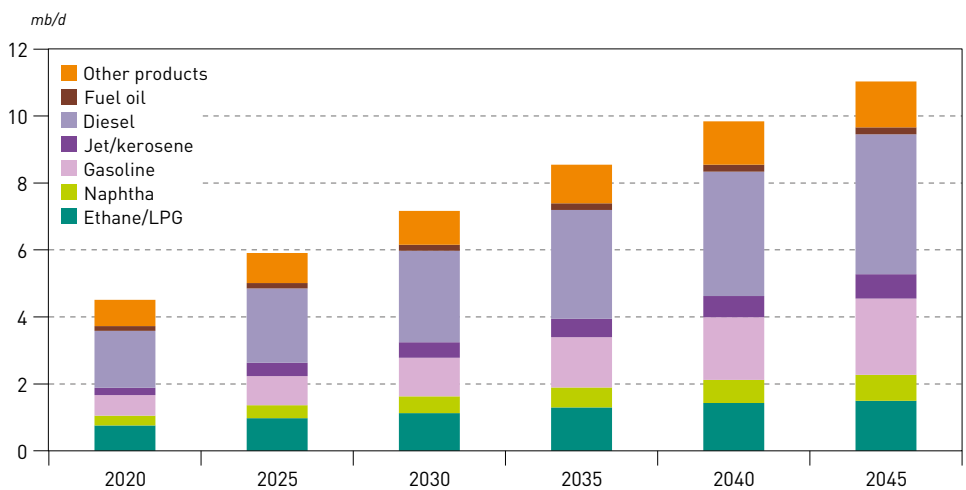
between 2020 and 2045. The next largest increase is projected for the petrochemical sector at 0.7 mb/d, followed by 'other industry' at 0.6 mb/d and the aviation sector at 0.5 mb/d.

Demand trends at the sectoral level also determine the future breakdown of specific refined products. These are presented in Figure 3.11. The largest demand increase during the entire forecast period is projected for diesel at 2.5 mb/d, on the back of the robust growth of commercial vehicles, industry and the agricultural sector. Since gasoline is the preferred fuel for passenger cars, its demand in India is projected to increase by around 1.7 mb/d until 2045. A large part of the residential sector growth will be linked to the use of LPG. Its total demand in India is set to increase by 0.7 mb/d. Growth in the aviation and petrochemical sectors will result in increased demand for jet kerosene (0.5 mb/d) and naphtha (0.5 mb/d).

Demand growth in the same range is also projected for the group of 'other products' (0.6 mb/d) such as bitumen, pet coke, lubes/greases and waxes. Most of these products are used to expand the road network, as refinery fuels and to produce energy-intensive goods such as cement, aluminium and steel. Finally, demand for residual fuel oil is set to remain in a narrow range of 0.1 mb/d to 0.2 mb/d during the entire forecast period, since there are no major international bunkering hubs in India and the electricity sector is dominated by the use of coal, renewables and natural gas.

China

Figure 3.11
Oil demand by product in India, 2020–2045

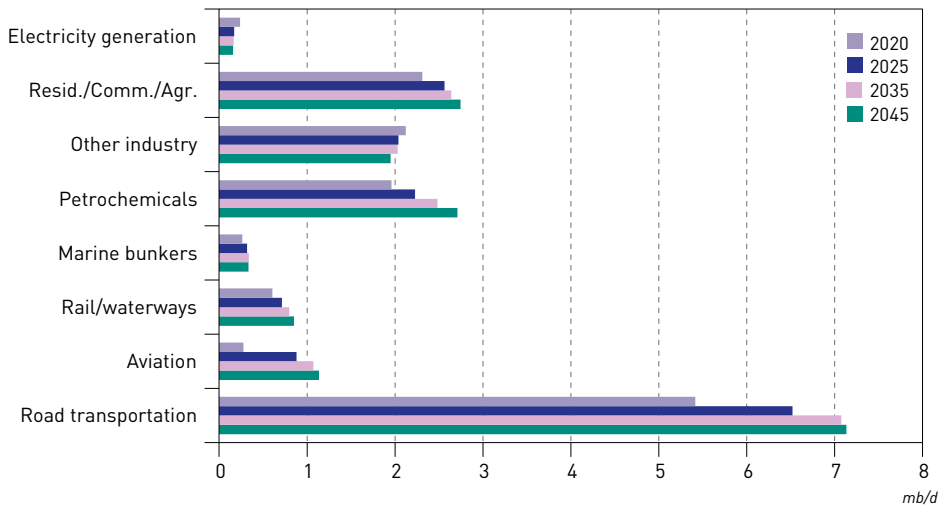


Source: OPEC.

As mentioned in earlier parts of this chapter, China's oil demand is set for exceptionally high growth of 1.1 mb/d in 2021 after declining by 0.3 mb/d in 2020. However, this high growth – supported by massive governmental investment – is not expected to be sustained. On the contrary, demand growth in China is expected to decline below 0.5 mb/d by 2022, with sustained annual increments of between 0.2 mb/d and 0.3 mb/d for the rest of the medium-term.

This trend is projected to continue in the long-term, with annual increments falling below 0.1 mb/d sometime after 2030 and virtually reaching no growth towards the end of the forecast period. This is clearly presented in Figure 3.12, which provides a breakdown of China's oil demand in major consumption sectors. It shows that future demand growth in China will be driven mainly by the

Figure 3.12
Oil demand in China by sector, 2020–2045



Source: OPEC.

road transportation, petrochemical and aviation sectors. Some growth is also projected for the residential and agricultural sectors, as well as in rail and domestic waterway transport modes.

Overall demand changes in China will largely depend on what happens in its road transport sector. The car market in China is among the most dynamic markets in the world and currently also the largest in terms of new sales. The size of the passenger vehicle fleet in China is projected to more than double, rising from about 185 million cars in 2020 to around 464 million in 2045. However, a significant part of the potential demand growth resulting from this impressive increase in fleet size will be offset by improved average efficiencies, as well as fuel substitution through electrification and natural gas. Combined, there is set to be around 150 million alternative vehicles on Chinese roads by 2045, leading to much slower growth in oil demand by then. Despite this, road transportation in China will account for around 45% of overall demand growth – 1.7 mb/d of a total 3.8 mb/d of incremental demand – between 2020 and 2045.

Using 2020 as the base year, the aviation sector is the second-largest contributor to long-term demand growth in China, adding 0.9 mb/d between 2020 and 2045. However, almost 0.4 mb/d of this incremental demand relates to the demand decline of 2020, which will be recovered over the medium-term. Demand growth in this sector will continue in the long-term, however, similar to road transport, growth will gradually slow.

The petrochemical industry in China is expected to contribute to future demand growth at levels comparable to the aviation sector – around 0.8 mb/d over the forecast period. A large part of this expansion will be naphtha-based (+0.6 mb/d), supplemented by ethane and LPG. In comparison to the previous two highlighted sectors, however, the petrochemical industry is likely to be on a growth trajectory, even at the end of the forecast period.

At the other end of the spectrum are electricity generation and the industrial sector. Oil plays a minor role in China's power sector, mostly fuelling diesel aggregates for special purposes, and this will not change significantly in the years to come. In the industrial sector (other than petrochemicals), China's gradual departure from energy-intensive industries is also set to result in a slow decline in oil demand over the long-term.

Other non-OECD regions

Other Asia is the second-largest contributor to future oil demand. Consisting of several countries with high population growth, such as Indonesia, Philippines and Vietnam, rising urbanization and a growing middle class, this region is projected to experience robust economic growth in the period to 2045. This, in turn, provides strong support for oil demand growth, especially in the first half of the forecast period, as the road transportation, petrochemical and aviation sectors expand. The largest incremental demand is projected in road transportation (2.3 mb/d) on the back of growing numbers of both passenger cars and commercial vehicles. The petrochemical and aviation sectors are set to add another 0.9 mb/d and 0.8 mb/d, respectively.

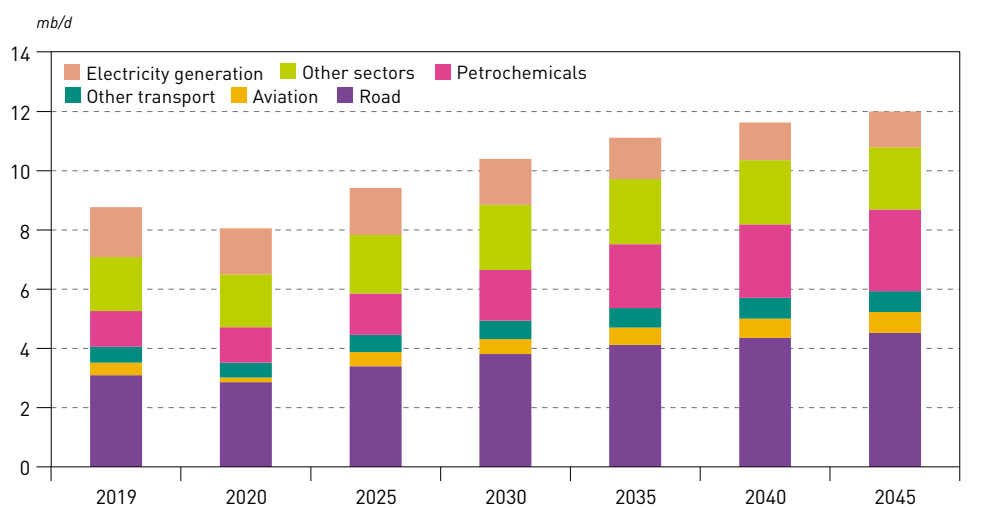
The specifics of Other Asia include a high share of marine bunkers in total demand due to the presence of large bunkering ports in the region. Projected growth in marine shipping in this region will likely offset expected efficiency improvements and some shift to LNG, so that demand for marine bunkers increases by 0.5 mb/d.

OPEC countries are also expected to play an important role in shaping future oil demand. Cumulative oil demand in these countries is set to increase by around 4 mb/d between 2020 and 2045, of which 0.7 mb/d will relate to demand recovery after 2020. Similar to other developing countries, road transportation will be the main source of this increase, contributing 1.7 mb/d to future growth (Figure 3.13).

Specific to OPEC, particularly in the Middle East, is large incremental demand growth in the petrochemical industry, which is projected to be almost at parity with road transportation. Strong growth in this sector is expected in the medium-term, as several large petrochemical projects come on stream in Saudi Arabia, IR Iran and the UAE. Finally, some demand growth is also set to take place in the aviation and marine bunkers sectors. However, overall demand increases in these sectors is forecast to be limited to a range of 0.2 mb/d for marine bunkers and 0.5 mb/d for the aviation sector.

The range of projected demand growth in the **Middle East & Africa** is comparable to that of China and OPEC, standing at 3.6 mb/d during the entire forecast period. However, considering the relatively low demand base in 2020, the Middle East & Africa (excluding OPEC Member Countries) is the second-fastest growing region in relative terms (2.6% p.a. on average), just behind India. However, given the very dynamic demographic developments in Africa, its rich endowment of

Figure 3.13
Oil demand in OPEC by sector



Source: OPEC.

natural resources, still relatively low urbanization and high potential for improvements in labour productivity, growth is still below the continent's potential.

Around half of the region's incremental demand is projected to take place in road transportation, 1.8 mb/d over the entire forecast period, followed by the residential/commercial sector (0.5 mb/d) and aviation (0.4 mb/d). Contrary to other regions, oil use for electricity generation is set to continue expanding in the Middle East & Africa, adding almost 0.4 mb/d to incremental demand. A clear indication of higher potential demand growth in this region is the petrochemical industry, where oil demand is currently less than 0.1 mb/d. It is expected to more than double over the forecast period, but due to a low base, even by 2045 it will only be slightly above 0.1 mb/d.

Average GDP growth in **Latin America** is projected to stay in the range of 2–2.5% p.a. for most of the forecast period, although it declines to below 2% towards the end. This will likely put a cap on oil demand growth. Overall demand is projected to increase by 2 mb/d between 2020 and 2045, out of which around 0.5 mb/d is due to a demand drop in 2020.

From the sectoral perspective, growth is mainly driven by road transportation at 0.7 mb/d. Relatively high increments are projected for the residential and agricultural sectors which, combined, will add another 0.4 mb/d to future demand. Demand in the aviation and industrial sectors is set to grow by around 0.3 mb/d each.

Demand growth in the remaining two regions – **Russia and Other Eurasia** – is projected at significantly lower levels. The combined demand change for these two regions is around 0.8 mb/d between 2020 and 2045. Out of this, however, more than 0.5 mb/d will be needed just to reach pre-pandemic levels, which leaves 0.3 mb/d for future growth. Moreover, oil demand in these regions will only slightly expand till around 2035, before it plateaus ins in Other Eurasia and marginally declines in Russia.

3.2 Oil demand outlook by sector

This section highlights major trends in sectoral oil demand in the Reference Case. It starts with issues regarding the key transportation sector, including road transportation, aviation, rail and domestic waterways, as well as marine bunkers. This is followed by a review of key trends in the industrial sector, which comprises petrochemicals and other industry. Finally, the evolving oil demand pattern in the remaining sectors – including residential, commercial, agricultural and electricity generation – is highlighted.

Table 3.3 and Figure 3.14 summarize oil demand trends at the global level in these sectors. Currently, around 56% of global oil demand, or more than 54 mb/d, comes from various forms of transportation. This is still slightly below the pre-pandemic years, as road and aviation transport were severely affected by COVID-19. Nevertheless, demand is expected to be restored in these two sectors over the medium-term, pushing the share back to almost 58% in 2025. It is expected to remain in a very narrow range of 57–58% for the rest of the forecast period.

This does not mean, however, that all transportation modes will retain their share over the long-term. On the contrary, a fairly stable share of oil demand in the transportation sector is set to result from the offsetting effect of growing demand in the aviation and marine bunker sectors and an inverted cup shape demand in the road transportation sector.

The transportation sector is forecast to be the major contributor to future incremental demand, adding around 13 mb/d to global oil demand between 2020 and 2045. More than 90% of this massive demand increase is projected to come from the road transportation and aviation sectors, with each contributing around 6 mb/d, although a large part of these increases will be due to the recovery from the sharp demand declines experienced in these two sectors in 2020.

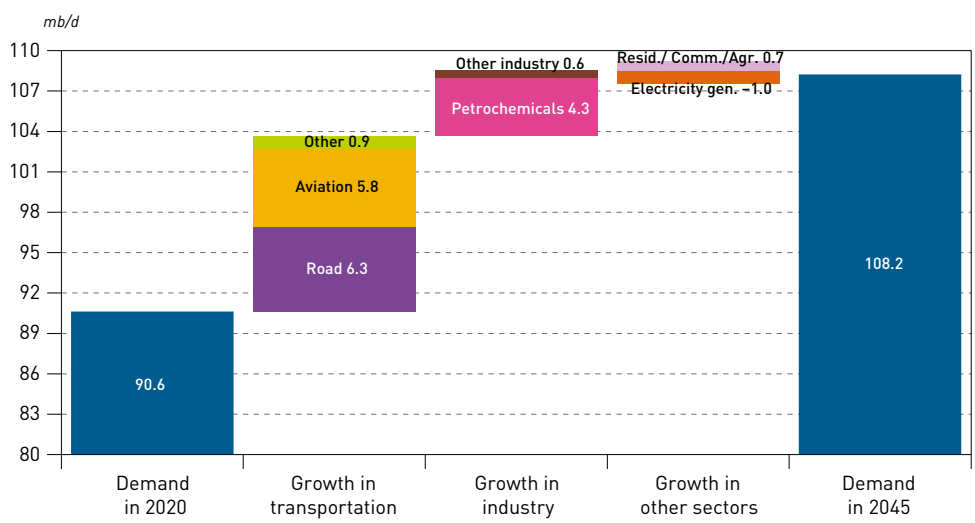
Table 3.3
Sectoral oil demand, 2019–2045

mb/d

	2019	2020	2025	2030	2035	2040	2045	Growth 2020–2045
Road	44.6	40.0	46.3	46.5	46.4	46.2	46.2	6.3
Aviation	6.7	3.5	7.1	7.6	8.3	8.8	9.3	5.8
Rail/waterways	1.9	1.8	2.0	2.0	2.1	2.1	2.0	0.2
Marine bunkers	4.2	3.9	4.3	4.5	4.6	4.6	4.6	0.7
Transportation	**57.3**	**49.2**	**59.6**	**60.7**	**61.4**	**61.8**	**62.2**	**13.0**
Petrochemicals	13.7	13.0	14.8	15.9	16.5	16.9	17.3	4.3
Other industry	12.9	12.7	13.1	13.5	13.7	13.4	13.3	0.6
Industry	**26.6**	**25.7**	**27.8**	**29.4**	**30.2**	**30.3**	**30.5**	**4.9**
Resid./Comm./Agr.	11.1	10.9	11.4	12.0	12.0	12.0	11.6	0.7
Electricity generation	4.9	4.9	4.7	4.5	4.3	4.0	3.9	–1.0
Other uses	**16.1**	**15.8**	**16.2**	**16.5**	**16.3**	**16.0**	**15.5**	**–0.3**
World	**100.0**	**90.6**	**103.6**	**106.6**	**107.9**	**108.1**	**108.2**	**17.6**

Source: OPEC.

Figure 3.14
Oil demand growth by sector, 2020–2045



Source: OPEC.

Some demand growth is also projected in the industrial sector, driven by strong demand for petrochemical products, though the magnitude of this increase is much lower compared with the transportation sector. The overall demand change in the industrial sector is forecast to be 4.9 mb/d, of which 4.3 mb/d relates to petrochemical feedstock. Demand growth in the petrochemical industry represented the single-largest contributor to incremental oil demand in the past few Outlooks. Technically, this is not the case in this year's Outlook, as both the road transportation

and aviation sectors are projected to grow by larger volumes. This change, however, is only due to specific developments related to COVID-19 in 2020, which is the base year for comparison in this WOO. Adjusting these figures for the demand decline in 2020, the petrochemical sector actually remains the largest source of incremental demand to 2045.

The other part of industrial demand – covering mainly iron, steel and cement production, along with mining and construction – is projected to grow during the current decade before a plateau is reached sometime around 2035. Moreover, growth rates during the first half of the projection period are forecast to be much lower than for petrochemicals. This is mainly due to a number of fuel substitution options, primarily by natural gas and electricity. This is particularly the case in the OECD regions, where oil demand in this sector will generally be on a declining trajectory, except for the initial years after 2020, when revived economic activity will push the industrial use of oil slightly higher.

In the case of non-OECD countries, oil demand in 'other industry' will result from an interplay of several factors. Robust GDP growth in these countries is often tightly linked to industrialization. However, competition between oil, gas and electricity will also play a role by partly offsetting the potential demand growth linked to economic activity. This will be further affected by efficiency improvements and gradual structural changes in the economies of these countries as the service sector share rises, especially towards the end of the forecast period. In some countries, such as China, this is already clearly present and will be fostered further in the years to come. The net effect of these counter-balancing trends is that the global demand increase in the 'other industry' sector is only forecast to be 0.6 mb/d between 2020 and 2045. The demand decline over the year 2020 also plays a role.

Combined, the residential, commercial and agricultural sectors account for around 12% of total oil demand. At the global level, similar to 'other industry', demand in this sector is projected to grow by around 1 mb/d during the next 10–15 years and then decline by around 0.5 mb/d by the end of the forecast period. This overall pattern results from varying trends between the major regions.

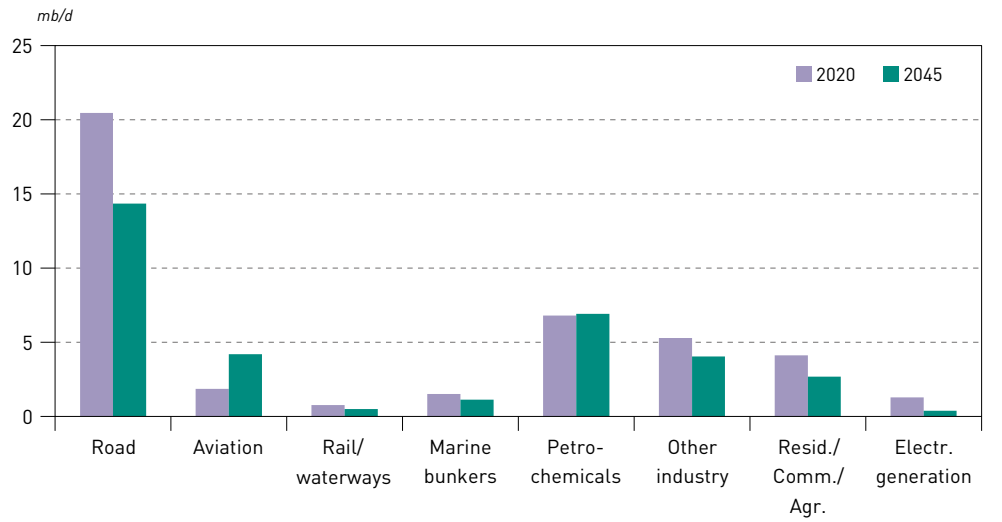
Strict policy measures, especially for building codes and heating systems, combined with electrification and fuel substitution, is expected to cause OECD demand in this sector to slowly, albeit steadily, decline during the current decade. This trend will accelerate over the second part of the forecast period as even tighter policy measures push demand lower. The demand difference between 2020 and 2045 is projected to be 1.4 mb/d. However, strong growth in the non-OECD region, especially India, China and Africa, is anticipated to offset demand losses in the OECD and result in net growth of 1.3 mb/d in the period to 2035. Demand growth in the non-OECD region will decelerate during the remaining part of the forecast period, which, combined with declining demand in the OECD, is set to lead to an overall demand increase of around 0.7 mb/d by 2045.

Finally, electricity generation is the only sector in which demand is forecast to decline, a result of increasing competition from natural gas and renewables. The overall loss is projected at 1 mb/d between 2020 and 2045.

Figures 3.15 and 3.16 provide a summary of sectoral demand changes from the perspective of major regions. Shifting the base year for comparison to 2020, with its exceptionally low oil demand, alters the magnitude of demand changes compared with last year's Outlook. In the case of the OECD, oil demand is projected to decline for the period 2020–2045 in all major sectors except for aviation and petrochemicals. The largest demand drop is projected for road transportation at –6.1 mb/d, followed by residential (–1.4 mb/d) and 'other industry' (–1.2 mb/d). Oil demand in the aviation sector is set to expand by 2.3 mb/d, while demand in the petrochemical sector by 2045 is forecast to be at levels comparable with 2020.

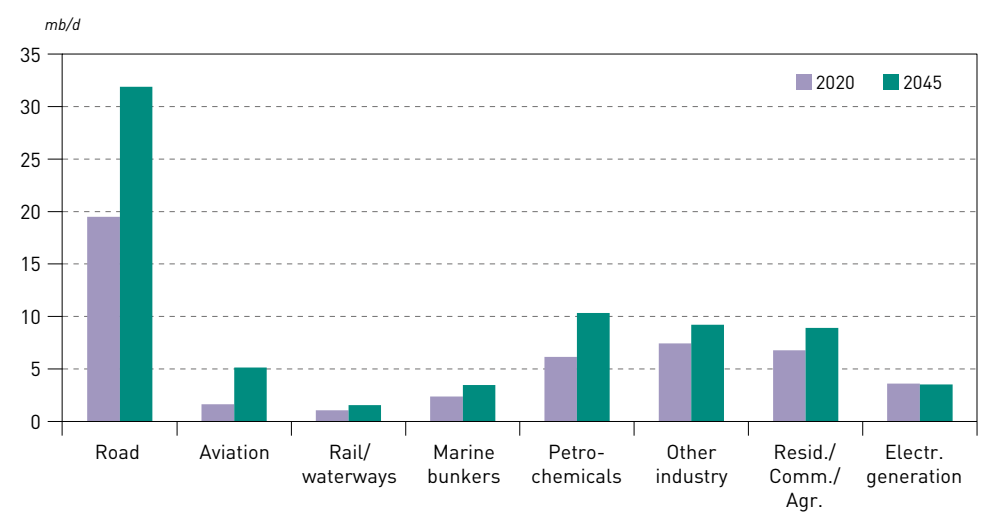
For the non-OECD region, demand in all sectors is projected to grow, except in electricity generation. The largest demand increase is seen in the road transportation (+12.4 mb/d) and petrochemical (+4.2 mb/d) sectors. Significant growth is also expected in the aviation (+3.5 mb/d), residential (+2.1 mb/d) and 'other industry' (+1.8 mb/d) sectors.

Figure 3.15
Sectoral oil demand in the OECD region, 2020 and 2045



Source: OPEC.

Figure 3.16
Sectoral oil demand in non-OECD countries, 2020 and 2045



Source: OPEC.

3.2.1 Road transportation

The pandemic and subsequent recovery plans introduced new dimensions and opportunities to the mobility sector. The restrictions in place during lockdown periods exerted downward pressure on all transport modes, with road and aviation sub-sectors affected the most. Demand in the road transport sector contracted most in Europe and North America, especially during the first and second waves of the pandemic. At its peak, road transport activities declined by over 80% in all major OECD economic centres. The contraction during the second wave, which spread to early 2021, was invariably lower due to the vaccination rollout, and less restrictive lockdowns.

The underlying effects on road transport development, however, varied from region-to-region, and affected powertrains differently. The growth of ICE vehicles was hindered during the pandemic and will likely remain subdued during the rebound period. However, growth in the electric mobility segment was resilient and continued to rise unabated.

Economic activity in China was quick to return in 2020, leading to an earlier pickup in new vehicle registrations in the region, including rising new energy vehicle (NEV) sales. In the early stages of the pandemic, passenger vehicle sales in the OECD contracted due in part to the shutdown of manufacturing facilities. US new vehicle registrations declined by about 15% in 2020, but rebounded in the last quarter of the year and into much of 2021 due to the availability of low-interest financing and some changes in consumer behaviour, including the avoidance of public transport and air travel.

At the global level, new vehicle registrations plummeted by about 25% in 1H20. Full year new vehicle registrations over the year crawled forward, reaching about 80 million vehicles – a clear 15–16% decline from average sales during the pre-COVID-19 period. New vehicle registrations are expected to increase over 2021, but the rate of growth will likely remain tapered.

At the same time, many countries embedded accelerated energy system decarbonization in their post-COVID-19 recovery stimulus plans, including emissions reductions in the transport sector. The new strategic drive includes a reset of target dates for the phase-out of ICEs, especially in Europe, with electrification of the transport sector regarded as a primary way to reduce emissions.

The short-term influence of COVID-19 on the total vehicle fleet will ultimately also impact future prospects. This effect also presents itself unevenly in different transport segments, with the tapering pattern varying from region-to-region. Principally though, the transport sector will continue expanding and will be guided by demographic factors, including economic prosperity, developing trade relations, technology and evolving policies.

These growth drivers now face uncertainties that inadvertently make any projections somewhat complicated. Uncertainties in economic prospects, capital investment and technology deployment are among the factors with the potential to shape pathways for vehicle fleet development. In addition, policies and regulatory frameworks are currently playing a greater role in the further evolution of fossil fuel-driven vehicles, especially in developed economies.

Despite this, there is still huge potential to continue the future expansion of the vehicle fleet, especially in developing regions with lower motorization rates and promising economic prospects. Developed country stock expansion is projected to progress at a very slow rate due to the attainment of saturation and a well-established public transport system.

Vehicle stock

In principle, vehicle stock growth is closely linked to economic growth, demographics, the motorization rate, policy measures and technology deployment. At the regional level, demographic changes, socio-economic conditions and consumer preferences are among the major drivers for

vehicle demand and ownership. Low car ownership plays a significant role in driving the vehicle fleet in developing nations. Hence, the vehicle fleet is set to continue to increase in non-OECD regions due to this 'spare' motorization capacity. However, the growth of ICEs in China and Other Asia regions with congested cities may be partly hindered by regulators that enact policies and measures restricting vehicle growth to abate pollution in mega-cities.

Vehicle demand in other non-OECD regions and emerging economies will continue to be driven by per capita GDP and demographic structures. India, Other Asia, and the Middle East and Africa are set to drive vehicle growth. Unlike OECD regions, where the effects of a decoupling with GDP are visible due to saturation, non-OECD regions will continue to demand more vehicles with increasing disposable middle class incomes.

On the other hand, passenger car fleet development in the OECD, especially in Europe, is already being curtailed. Growth-impeding factors include a well-structured public transport system, policies, shared mobility and an already high motorization rate. Concerns over transport sector emissions and additional policy-related decarbonization thrusts, led by Europe, stagnated passenger vehicle stock development, especially for those with an oil-based powertrain. Many large European cities are introducing measures that depress the use of vehicles with lower efficiency standards to safeguard the environment and abate pollution. Despite this, private vehicles still remain the most popular mode of transport in the OECD.

The COVID-19 pandemic and the ensuing recovery period altered the previously established long-term outlook trajectory for vehicle stock development. This is particularly noticeable in OECD Europe, where additional policy impetus and support for further electrification and efficiency enhancements are dwarfing the stock growth of ICE powertrains. Conversely, consumer preferences during the pandemic and rising vaccination rates have in 2021 influenced the demand rebound. This is particularly apparent in waning public transport use in preference to private cars among the middle class, as well as diminishing mobility-as-service habits, especially car pooling and sharing. Other regions outside of the OECD that were more vulnerable to the knock-on effects of the pandemic, such as the Middle East & Africa, have suffered from a slower economic recovery. Therefore, vehicle stock growth has decelerated even further.

New passenger car sales in China declined by only 6% in 2020. This is mainly due to China's handling of the crisis and its easing of lockdowns earlier than other countries. In addition, local authorities assisted in strengthening the rebound by offering new incentives and relaxing sales restrictions. NEVs especially benefited from policy and regulatory preferences. Additionally, vehicle sales in China received more impetus via the introduction of digital innovation, in which customers have direct access to original equipment manufacturers (OEMs) via virtual showrooms. It is important to note that, despite a setback in passenger car sales, NEVs continued to grow, adding about 1.4 million vehicles in 2020. Moreover, the expansion of charging infrastructure and the reinforcement of battery-as-a-service (BaaS) continued.

In OECD Americas, new vehicle registrations fell in 2020, dropping below the usual 17 million vehicles p.a. With only about 14 million new vehicles sold, the year recorded an average 15% decline compared with the pre-crisis period. It marks 2020 as the single year with the highest contraction since the 2008/2009 recession. Sales destruction was especially prominent in the 1H20, when manufacturers were obliged to shut facilities and dealers were forced to close showrooms. However, sales quickly picked up in the last quarter of the year and into 2021 with the vaccination rollout and economic activity on the rise.

A large majority of US sales were in the ICEs segment. Sports Utility Vehicle (SUV) new registrations continued to increase, maintaining the trend of previous years, and the sale of these high-capacity vehicles continues to impact overall efficiency gains, which are improving at a slow pace. EV sales growth in the US suffered a setback due to the pandemic and given the fallout from

eroding federal tax credits, among other reasons. EV sales in the US did increase by around 4% in 2020, but this was much less than that witnessed in Europe and China.

The European ICE market contracted significantly in 2020. The pandemic impacted European new passenger car registrations, causing a decline of about 24% compared with 2019. This resulted in sales of only 10 million passenger cars due to containment measures that were implemented across the entire region. Four of the five largest passenger vehicle markets (France, Italy, the UK and Spain) recorded declines of more than 20%. Germany's new passenger car registrations plummeted by 19.1%. With only 2.9 million passenger cars sold in the country, it is the lowest recorded level since 2013. Equally affected were European new registrations of commercial vehicles, which dropped 19%.

Nevertheless, EV stocks increased in Europe due to improved sales in 2020. In fact, new EV sales growth in Europe surpassed that of China for the first time. New registration of European EVs surged by about 136%, adding approximately 1.3 million units to the inventory and making it the new EV-growth centre. With the pandemic-induced decline of ICE sales in Europe, the share of EVs in total new vehicle registrations reached 10.5% in 2020.

The EU's 'green' recovery plans and stimulus, specifically, the NGEU and European Green Deal, all included enhanced ambitions and strategies for 'greening' the transport sector. Major car manufacturers and high-end technology groups are increasing investment in electric mobility. Other drivers for EV growth include additional investment in charging infrastructure, closing price parity with ICEs through subsidies in several countries and further developments in battery technology to address range anxiety.

Turning to the Outlook, the global passenger car stock is projected to have surpassed two billion vehicles by 2045, as depicted in Table 3.4. Most of this growth will come from the developing regions. China and India alone are forecast to be responsible for the largest growth percentage, as these countries will have the highest urbanization rates, with teeming populations and significant

Table 3.4
Number of passenger cars, 2020–2045

millions

	2020	2025	2030	2035	2040	2045	Growth 2020–2045
OECD Americas	282.2	286.4	300.5	314.4	324.4	331.8	49.6
OECD Europe	258.5	260.3	261.5	263.6	264.7	264.8	6.3
OECD Asia Oceania	93.4	94.6	94.5	94.1	93.3	92.3	–1.2
OECD	**634.1**	**641.3**	**656.5**	**672.0**	**682.4**	**688.8**	**54.7**
Latin America	83.0	88.7	95.6	102.1	108.4	115.4	32.5
Middle East & Africa	38.2	47.4	61.0	78.1	99.6	122.9	84.7
India	30.9	48.9	73.5	105.2	142.3	178.6	147.7
China	184.5	255.0	323.2	382.7	426.8	463.9	279.4
Other Asia	76.8	104.0	140.4	181.8	225.6	268.3	191.6
OPEC	54.2	68.7	84.4	100.6	116.8	133.1	79.0
Russia	36.1	41.3	43.2	44.6	45.4	46.3	10.2
Other Eurasia	48.2	52.5	57.2	61.3	64.7	68.4	20.2
Non-OECD	**551.8**	**706.5**	**878.5**	**1,056.4**	**1,229.8**	**1,397.0**	**845.2**
World	**1,185.9**	**1,347.8**	**1,535.0**	**1,728.4**	**1,912.2**	**2,085.9**	**899.9**

Source: OPEC.

GDP expansion. In contrast, it is projected that the OECD's passenger car stock will replenish by just 54.7 million vehicles by 2045, with most of this growth in OECD Americas.

Turning to commercial vehicles, the OECD commercial vehicle stock is projected to grow by 1.5% p.a. on average during the 2020–2045 period, which closely follows the GDP growth trajectory. Table 3.5 indicates that the OECD is expected to replenish its stocks by around 47 million vehicles by 2045. The largest increase within the group is projected for OECD Europe, which is forecast to add around 25 million commercial vehicles by 2045.

Table 3.5
Number of commercial vehicles, 2020–2045

millions

	2020	2025	2030	2035	2040	2045	Growth 2020–2045
OECD Americas	40.4	43.1	47.5	52.4	56.8	60.9	20.5
OECD Europe	42.4	46.4	51.1	56.4	62.0	67.7	25.3
OECD Asia Oceania	25.3	25.8	26.0	26.2	26.3	26.4	1.1
OECD	**108.1**	**115.3**	**124.7**	**135.0**	**145.1**	**155.0**	**46.9**
Latin America	21.6	24.9	29.1	33.6	38.7	44.0	22.4
Middle East & Africa	17.0	20.6	25.7	32.4	41.3	51.0	34.1
India	17.4	24.3	32.6	42.9	55.8	68.4	51.1
China	29.1	36.5	44.6	53.2	62.2	70.1	41.0
Other Asia	28.3	34.5	42.3	50.2	58.2	66.0	37.7
OPEC	16.4	18.7	21.6	25.0	29.1	33.1	16.7
Russia	5.8	6.4	6.4	6.4	6.4	6.5	0.6
Other Eurasia	5.0	5.6	6.4	7.2	8.2	9.1	4.1
Non-OECD	**140.5**	**171.6**	**208.6**	**251.0**	**299.8**	**348.2**	**207.7**
World	**248.6**	**286.9**	**333.3**	**385.9**	**444.9**	**503.2**	**254.6**

Totals may not add up due to rounding.
Source: OPEC.

The growth of commercial vehicle stocks in developing countries follows a different pathway to the OECD. Developing trade, urbanization and promising GDP growth play a significant role in expanding commercial vehicles. China, India and the Middle East & Africa are adding commercial vehicle fleets at a much faster rate than in the OECD region. This trend is particularly valid for minivan-delivery vehicles and freight trucks.

It is expected that non-OECD commercial vehicles will have increased by about 208 million units at the end of the forecast period. Most non-OECD growth will be driven by China and India. Large incremental stock is also projected for Other Asia and Africa, as infrastructure expansion encourages inter-regional trade and the exchange of goods and services. It is worth noting that new additions to the non-OECD region outnumber the OECD region more than four-fold. Overall, the global stock of commercial vehicles is expected to expand in the long-term by about 255 million by 2045.

Vehicle fleet composition

COVID-19 avails the opportunity for electric powertrain expansion, especially in Europe and China. Strengthening emissions regulations and additional policy thrusts supporting the clean energy transition are behind the rapid growth of electric mobility. Electric mobility developments are

dominating the decarbonization arena as a means to reduce emissions. The NGEU recovery stimulus and European Green Deal provide platforms and the required impetus for the uptake of EVs in Europe. Equally, in China, regulators revised the dual-credit policy for a stepwise increase in NEV credit ratios to reach 18% by 2023 and offered an additional extension to the subsidy. The policy also introduces a further reduction in corporate average fuel consumption for ICEs. Hence, the year 2020 witnessed increasing shares of EVs in Europe and China.

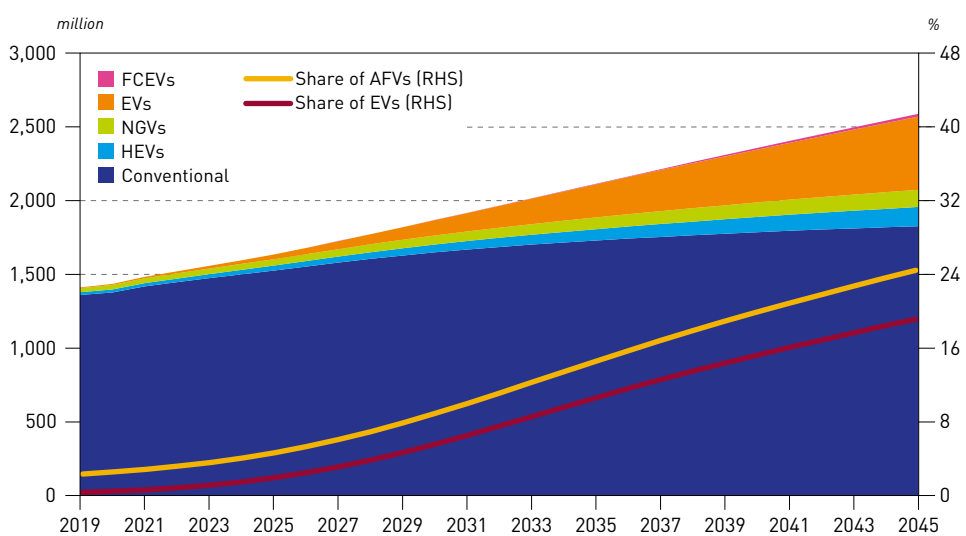
In 2020, about three million electric propelled vehicles (plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV)) were added to global EV stocks – Europe and China alone accounted for more than 85% of the new sales figures. With the sale of about 1.3 million EVs in 2020, Europe is nearly on par with China regarding sales growth. The US saw a marginal increase compared to 2019. Other OECD regions, including Japan, recorded declines in 2020.

Despite impressive growth in EVs, full year 2020 new vehicle registrations in Europe still consisted of over 75% of gasoline and diesel engine vehicles. Market forces continue to drive the growth of ICEs in developing regions. Hybrid vehicles are following a similar growth pattern to regular ICEs. While the expansion in NGVs is dwarfing the other vehicle types in the passenger car segment, it is also receiving attention in long-range freight trucks in China and India.

Turning to the projections, Figure 3.17 presents the expected long-term evolving structural composition of both passenger and commercial vehicle fleets. This figure takes into consideration the implications of current and assumed future vehicle sales based on the powertrain shift and deployment. It is noticeable that the structural change in fleet composition is proceeding rather gradually due to a large base of conventional vehicles in the global fleet. Hence, the transition to alternative powertrains will take decades to accomplish, even if new vehicle registrations in this area advance at a higher rate.

Figure 3.17 indicates that EVs are set to become the fastest-growing alternative powertrain. This trend will continue to gradually change the fleet composition in the long-term. The electric powertrain is set to overtake NGVs in terms of nominal volumes within the global fleet structure during

Figure 3.17
Global fleet composition, 2019–2045



Source: OPEC.

the current decade. Electrification of the global fleet is set to grow steeply in both the medium- and long-term, attaining a share of about 10% in around 2035 and rising further to almost 20% by 2045. It is estimated that by 2045, the on-the-road EV fleet will approach 500 million vehicles.

It is worth noting that powertrain electrification in all regions is only strongly impacting the passenger car segment. Electrification of other segments is expected to remain at lower levels. Further, apart from Japan, Europe and the US, hydrogen fuel cell vehicles are receiving less attention due to cost and technology readiness. Fuel cell vehicles remain a niche market in other regions. It should be noted, however, that China has revised its NEV policy and supports fuel cell vehicle research and the demonstration stage through the allocation of funds for that purpose. The new hydrogen infrastructure development framework in China is also starting strategic research & development (R&D) on hydrogen energy to chart a specific industrial plan.

From the perspective of Asia, India's transport sector electrification is progressing rather slowly in the passenger car segment. However, the current determination and announcements from the government indicate an intent to adopt an EV penetration roadmap. It is worth mentioning that two- and three-wheeler electrification is progressing at a faster rate than four-wheelers in India. Regarding anticipated EV growth in China, it is projected that over 40% of new passenger car registrations will be electric by 2045. This percentage will be even larger for municipal commuter buses and commercial delivery vans.

However, electric mobility in other regions of the world outside of those highlighted is set to progress rather slowly.

Some growth is also projected for NGVs, with a global increase in the range of 80 million between 2020 and 2045. Although LNG and CNG are gaining relevance in the commercial vehicle segment, their share in the global fleet is expected to remain below 5%. Natural gas in the form of LNG is penetrating heavy-duty commercial vehicles in India and China. Greater NGV penetration is anticipated in mainland China, due to additional investment in LNG infrastructure.

As a result of these trends, ICEs will continue to leverage a larger base to maintain a leading role in the composition of the global fleet. The outlook sees ICEs constituting about 76% of the world vehicle fleet by 2045, largely sustained by fleet size increases in developing regions. Transport electrification is in its infancy stage in most developing regions and it will take some time until a significant penetration of EVs is achieved. In absolute numbers, projections suggest that there will be close to 2 billion ICEs on the road by 2045.

Box 3.1

Charging EVs: is it really that cheap?

Over the past year, the world has witnessed a strong increase in EV sales, particularly in Europe. EVs are indeed much more visible on the streets of many cities, including Vienna, where the OPEC Secretariat is located. In addition, the number of public charging stations has increased significantly since 2016. There were around 91,000 charging stations in Europe in 2016. This figure increased to 360,000 stations in 2020, and there is strong policy support for further developments.

Analysis related to EVs has been focused on evolving battery costs and the related purchasing costs of EVs in recent years. This is, for good reason, relevant when comparing EVs to

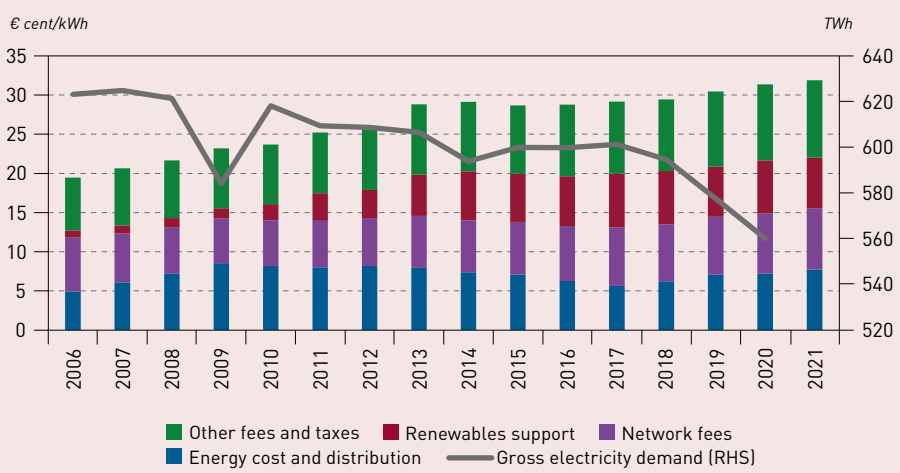
ICE vehicles and estimating the possible pathways of future EV deployment. However, the issue of running costs – such as charging costs – has been much less discussed, although it is a significant part of overall EV costs and an important aspect when comparing EV running costs to those of an ICE.

There is a general assumption that although EVs are still relatively expensive to purchase, charging is relatively cheap for final consumers and cost competitive relative to gasoline or diesel. However, costs for EV charging are not uniform and depend on various factors.

First, there are strong regional differences in electricity costs, related network fees and taxes. In the EU, the lowest household electricity price during the second half of 2020 was recorded in Bulgaria and Hungary at around 0.1 EUR/kilowatt hour (kWh) and the highest in Germany at around 0.3 EUR/kWh. This does not only include the price, but also network fees (for transmission and distribution services) and various taxes (including support for renewable power).

In fact, the energy component of household electricity prices represents only a small portion of the overall final price. In recent years, the share of taxes (including subsidy support for renewables) and network fees has increased significantly in some countries. In Germany, for instance, the share of the energy price in the average electricity bill was only around 24% in early 2021 (Figure 1). The share of network fees was calculated at 24.5%, while taxes (VAT, electricity tax, support scheme for renewables, etc.) accounted for more than 50% of household electricity bills. Of course, these shares vary in different countries, but given EU targets to increase the portion of renewables in the power generation mix, the share of taxes and network fees could increase significantly in other European countries too.

Figure 1
German electricity price for households and final electricity demand



Source: BDEW, AG Energiebilanzen, Sueddeutsche Zeitung.

Furthermore, the cost of EV charging also depends on various charging modes. Charging at home (or possibly at work) is normally more cost-competitive relative to charging at a public charging station. In addition, charging at home offers permanent access to a charging device. However, while charging through a standard outlet (up to 3.5 kW) is cheaper, the consequence is a longer charging time.

This is why most local utilities recommend installing a so-called mid-accelerated charger (Wallbox) with capacity above 7 kW and below 22 kW. While a Wallbox device and its installation may result in additional costs, many national and local governments currently offer subsidies. Due to higher network usage, Wallbox installations may also create additional network fees and will depend on regional network policies and costs. Another option is to install solar panels, and thus source less electricity from the network. This would help reduce network fees and taxes for the owner's personal consumption, including EV charging, but this option is only available to homeowners.

On the other hand, costs for public charging vary, depending on the capacity of the charging spot, charging time (peak or off-peak), possible subscriptions, etc. Some providers offer simple charging at an energy price (per kWh), while others have introduced a standing fee (fee for the time spent at the charging point). Discounts are offered to customers who pay a monthly or annual subscription fee, but not to non-subscribing customers. The capacity of charging points can vary from 3.5 kW to over 50 kW, with some providers offering charging at an even higher capacity (primarily motorway charging). A general rule is that the higher the capacity of the charging station the higher the cost. Increasingly, charging providers are also introducing penalty fees if the maximum standing time is exceeded.

Considering average consumption of around 20 kWh per 100 kilometres (km) for mid-size EVs (as per ADAC [General German Automobile Club] tests), costs when charging at home currently start at around €4.2–4.5 in countries like Austria, Italy, France or Spain (with an average household electricity price of around €0.20–0.22/kWh in the 2H20). In Germany, however, costs would be significantly greater due to a higher average household electricity price of around €0.3/kWh, reaching €6 per 100 km. However, some providers have started offering metering services at home, which would enable consumers to profit from lower off-peak, such as night or weekend, prices. As already mentioned, there are additional costs due to potential investment in a Wallbox and related network fees.

Charging at public stations varies greatly depending on the service provider, the capacity of the charging device and the time of charging. In some countries, off-peak charging is offered at levels around €0.07/kWh. This would mean that a 100 km load would cost only around €1.5. However, daily tariffs are usually higher, reaching €5–7.5 for mid-accelerated charging (up to 22 kW) . For faster charging, the cost goes up significantly, reaching levels around €6.5 or even up to €12 per 100 km. Thus, the total charging cost for EVs very much depends on how a vehicle is used and where it is charged (city driving or motorway, private or public charging point).

It begs the question: how do EV charging costs compare with the fuel costs of an ICE? First, ICE costs are much more uniform, with marginal differences between EU countries. The newest ICE models, equivalent to mid-size EVs, consume around six litres of gasoline or five litres of diesel per 100 km, as confirmed by German ADAC. At current EU prices (as of mid-July 2021), this leads to a total cost of around €9 for gasoline and €6.5 for diesel per 100 km. Consequently, costs for specific EV charging modes, such as mid-accelerated public charging, come close to or are higher than the cost of diesel. Costs for super-fast charging on motorways come close to or are even higher than equivalent gasoline costs.

Due to the wide range of costs for EV charging, it is obvious that EV drivers with access to their own Wallbox, mostly owners of single-family dwellings, possibly in combination with personal PV modules, or charging facilities at work, have a clear cost advantage. Other

drivers are disadvantaged in having to charge their EVs at public charging points, mostly at higher prices.

Looking forward, it remains to be seen how charging costs for EVs in the EU will develop going forward. Electricity prices in the EU could increase in the future given the clear tendency for electrification and potentially rising electricity demand. In mid-July 2021, the German Minister of Economy stated that Germany's gross electricity demand could increase by up to 665 terawatt hours (TWh) by 2030, which is almost a 20% increase relative to 2020 levels. This is a strong increase, given that electricity demand in most EU member states (including Germany, as shown in Figure 1) has been stable or declining since 2010.

At the same time, electricity prices for households increased significantly between 2010 and 2020, for example, Germany +28%, France +48%, Greece +42%, Belgium +43% and Spain +30%. There are many reasons for this, such as rising fuel costs and CO_2 prices, increasing network fees for transmission and distribution, and support schemes for renewables. As European countries are likely to expand their renewable capacities, costs for renewable support and network fees related to renewable expansion are expected to increase, thus raising household and EV tariffs even more in the years to come. In addition, declining state tax income related to the consumption of oil products, such as diesel and gasoline, and ownership of ICEs is likely to decline, given the expected increased share of EVs in future car sales. This could lead to the introduction of taxes on EVs and their electricity consumption.

At the same time, while it is impossible to predict the price of diesel or gasoline in the years to come, it is certain that the efficiency of ICEs will improve, reducing fuel consumption. Improvements in engine design, as well as rising hybridization of ICEs, could lead to an efficiency improvement of almost 20% by 2030, relative to current levels.

However, though these trends will be important, the further development of EU energy policies in the road transportation sector – including regulation of the EV sector and possibly stricter regulations related to gasoline and diesel – will be decisive in defining the competitive position of EVs relative to ICE vehicles in the coming decades.

Outlook for oil demand in road transportation

Vehicle fleet growth and composition changes will continue to influence global oil demand. The COVID-19 pandemic had a devastating effect on the road transport sector, with sales plummeting to the lowest level in decades. New waves of infection are also causing some governments to reimpose lockdown measures that further constrain mobility. The influence of teleworking on mobility is now a given, and offers striking opportunities for transportation cost savings. Teleworking, in addition to already declining pre-crisis vehicle miles travelled (VMT), especially in developed regions, will support the curtailing of oil demand in the road transport sector. On the flip side, the pandemic is also causing an increasing number of customers to avoid public transport in preference of personal mobility solutions. This 'mode-switching' process has the potential to increase oil use in transportation.

Furthermore, challenges arising from the energy transition and efficiency improvements in ICEs are expected to continue exerting pressure on future oil demand, as well as the rapid penetration of EVs. These, and other drivers, are impacting future regional oil demand growth in the road transport sector, as presented in Table 3.6.

Table 3.6
Oil demand in the road transportation sector by region, 2019–2045 *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Growth 2020–2045
OECD Americas	14.1	12.3	13.9	12.6	11.3	10.2	9.5	–2.8
OECD Europe	6.7	5.8	6.2	5.6	4.9	4.3	3.7	–2.2
OECD Asia Oceania	2.7	2.3	2.5	2.2	1.8	1.5	1.1	–1.2
OECD	**23.5**	**20.5**	**22.6**	**20.3**	**18.1**	**16.1**	**14.3**	**–6.1**
Latin America	3.0	2.8	3.1	3.2	3.3	3.4	3.5	0.7
Middle East & Africa	1.9	1.7	2.2	2.5	2.8	3.2	3.6	1.9
India	1.9	1.8	2.5	3.3	4.0	4.8	5.6	3.8
China	5.6	5.4	6.5	6.9	7.1	7.1	7.1	1.7
Other Asia	3.4	3.0	3.8	4.2	4.6	5.0	5.3	2.3
OPEC	3.1	2.9	3.4	3.8	4.1	4.4	4.5	1.7
Russia	1.2	1.1	1.2	1.2	1.2	1.1	1.1	0.0
Other Eurasia	0.9	0.8	1.0	1.1	1.1	1.1	1.1	0.3
Non–OECD	**21.1**	**19.5**	**23.7**	**26.2**	**28.3**	**30.2**	**31.9**	**12.4**
World	**44.6**	**40.0**	**46.3**	**46.5**	**46.4**	**46.2**	**46.2**	**6.3**

Totals may not add up due to rounding.
Source: OPEC.

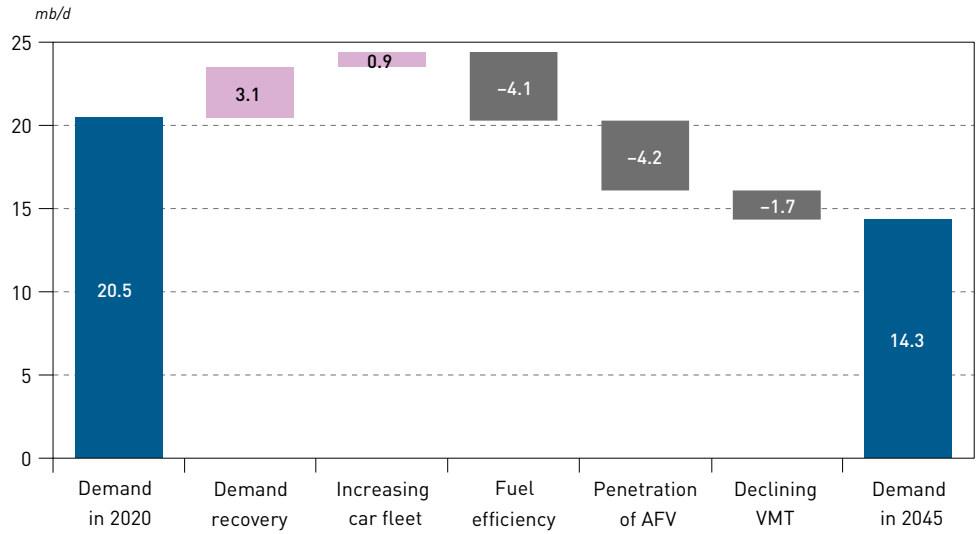
This table portrays obvious differences in road transport sector oil demand between OECD and non-OECD regions. While growth in non-OECD regions is mainly supported by a rising vehicle fleet and increasing economic activity, OECD growth is curtailed by the penetration of alternative fuel vehicles (AFVs) and improved efficiencies. Even though pandemic multiplier effects and recovery plans continue to pose uncertainties to future growth, this year's Outlook projects that transport sector demand in the non-OECD region will add up to about 12.4 mb/d and expand on average by around 2% p.a. between 2020 and 2045.

Sustained growth in the region will mainly come from India, which is forecast to contribute almost 4 mb/d to global growth. Equally, population growth and economic activity in Africa and the Middle East and in Other Asia will bolster non-OECD demand in the long-term. Strong policy footing for EV expansion and fuel-switching, especially in the long-haul trucking sector, is anticipated to stagnate China's long-term oil use in this sector.

Oil demand in the OECD region is projected to decline to 14.3 mb/d by 2045. This is more than 6 mb/d lower than in 2020. In fact, the level of oil decline in the OECD is even greater, since part of it is masked by the demand recovery in the initial years of the forecast period. As presented in Figure 3.18, the decline in OECD demand is mainly attributed to the penetration of AFVs (–4.2 mb/d) and improving efficiencies (–4.1 mb/d). Some contributions to the drop will also come from declining VMT due to teleworking and other factors. The impact of VMT is, however, much smaller, estimated at a drop of 1.7 mb/d.

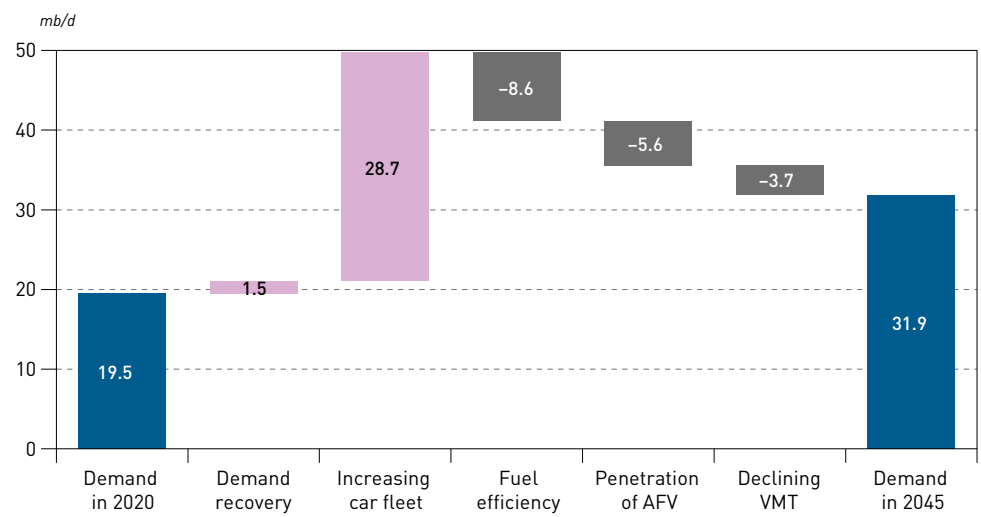
In non-OECD regions, low motorization rates continue to further support car ownership and stock development. At the beginning of the outlook period, the pandemic and its multiplier effects slowed vehicle sales. However, as economic activity rebounded and given increasing urbanization, the vehicle fleet began to surge again. Moreover, most fleets in the region are less efficient and the replacement rate is lower, translating into less efficiency gains. This leads to oil demand growth

Figure 3.18
Demand in road transportation in OECD countries, 2020 and 2045



Source: OPEC.

Figure 3.19
Demand in road transportation in the non-OECD region, 2020 and 2045



Source: OPEC.

that more than offsets the decline from the OECD region. These and other trends in the non-OECD region are shown in Figure 3.19.

It is projected that road transport oil demand in the non-OECD will grow by 12.4 mb/d to reach 31.9 mb/d by 2045. This will be driven by a projected increase of over one billion vehicles between 2020 and 2045. Accordingly, the fleet's expansion would add 28.7 mb/d to future oil demand, *ceteris paribus*. However, part of this potential demand will be offset by the penetration of AFVs (–5.6 mb/d), efficiency gains (–8.6 mb/d) and declining VMT (–3.7 mb/d).

3.2.2 Aviation

After many years of impressive growth in the aviation sector, the outbreak of the COVID-19 pandemic had a devastating effect on the industry. The worst period was the 2Q20, when large numbers of aircraft were grounded for many weeks/months and oil demand collapsed to its lowest level. The sector's recovery has taken place more slowly than expected, as new waves of the pandemic caused a re-emergence of regional travel restrictions and a number of additional obstacles arose, especially for international and long-haul flights.

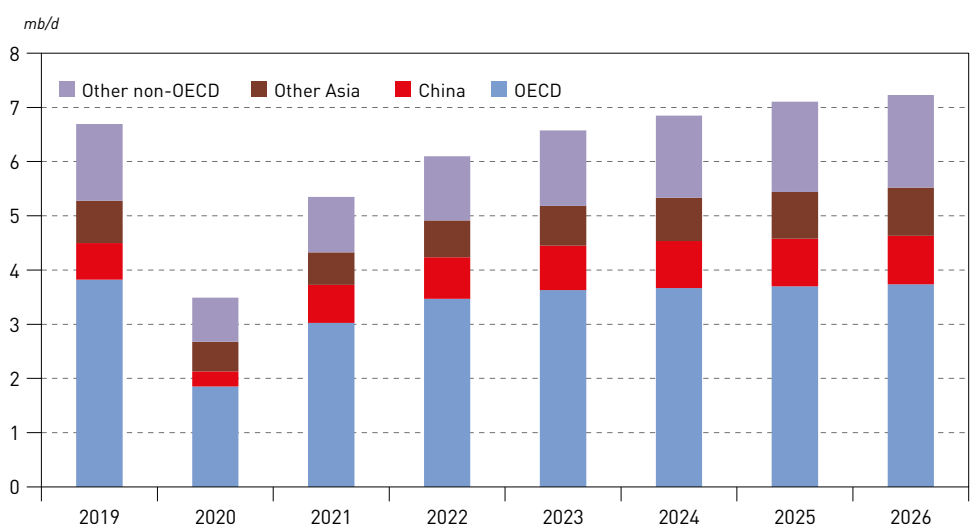
These developments will have significant implications on oil demand in global aviation in both the medium- and long-term. Demand projections included in this outlook assume only a gradual demand recovery to pre-pandemic levels, reflecting the expectation of a relatively slow increase in aviation traffic, especially in business travel.

The projections are also clouded by many uncertainties. The appearance of new COVID-19 variants makes any projection challenging. With the exception of a few countries, vaccinations are progressing slower than expected only a few months ago, especially in developing countries. Moreover, it is still unclear how, and for how long, consumer behaviour will be impacted by the pandemic.

Bearing in mind these uncertainties, oil demand in the aviation sector is projected to continue recovering in the coming years to reach pre-pandemic levels of 6.7 mb/d sometime in 2024, as presented in Figure 3.20. This level is expected to further increase to 7.2 mb/d by the end of the medium-term. From a regional perspective, the recovery process will be somewhat faster in non-OECD countries, which are expected to already reach pre-pandemic levels in 2023. In contrast, demand in the OECD regions is forecast to remain below 2019 levels during the entire medium-term period, as it was more severely affected in 2020.

Long-term demand in the sector will face further challenges. On the positive side, robust GDP growth in developing countries, a growing population and expanding middle class, an expected increase in the frequency of air travel per citizen, and increasing cargo movements between regions, will work towards supporting a rising number of flights and related oil demand. A counterbalancing effect to this potential growth will come in the form of a quest for improved efficiency

Figure 3.20
Oil demand in the aviation sector, 2019–2026



Source: OPEC.

and emissions reductions. The two leading targets for the aviation sector – set by the International Civil Aviation Organization (ICAO) and IATA – are a cap on net aviation CO_2 emissions (carbon-neutral growth) on a 2019 basis and a reduction in net aviation CO_2 emissions of 50% by 2050 (compared with 2005 levels).

Broadly, this should be achieved by a combination of measures, such as more efficient technology, optimization of scheduling, air traffic control, route optimization and emissions-offsetting programmes in other sectors. It is worth noting that the original agreement for capping emissions in the aviation sector assumed 2020 as a basis for the pilot phase, which will run from 2021–2023. However, a COVID-19-induced drop in emissions would, according to the ICAO, "create an inappropriate economic burden on aeroplane operators".

The main options to achieving better efficiency in the sector include improving the aerodynamic properties of wings, the extended use of carbon fibre-reinforced compounds and new lightweight, but resistant metal alloys that substantially reduce aircraft weight. These advances should be supplemented by higher load factors, better navigational equipment and, more importantly, improving fuel economy in future aircraft.

Besides improved efficiencies, fuel substitution could also potentially reduce future oil demand in the aviation sector. It is expected that small electric aircraft with up to 10 seats could start entering the market in the current decade and evolutionally increase in size up to 150 seats thereafter. However, according to current projections, it is unlikely that a fully electric short-range aircraft of this size will substitute a significant part of oil demand during the forecast period of this Outlook.

Taking into account the most likely impact of these factors, Table 3.7 summarizes projected regional oil demand in the aviation sector over the forecast period. At the global level, oil demand in this sector is expected to expand by 5.8 mb/d during the forecast period from 3.5 mb/d in 2020 to 9.3 mb/d in 2045. Similar to other sectors, the larger part of this incremental demand is projected for non-OECD countries (+3.5 mb/d), while total OECD is set to grow by 2.3 mb/d.

Table 3.7
Oil demand in the aviation sector by region, 2019–2045

mb/d

	2019	2020	2025	2030	2035	2040	2045	Growth 2020–2045
OECD Americas	1.9	0.9	1.9	1.9	2.0	2.0	2.1	1.2
OECD Europe	1.4	0.8	1.3	1.3	1.4	1.4	1.4	0.6
OECD Asia Oceania	0.5	0.2	0.5	0.6	0.6	0.6	0.7	0.5
OECD	**3.8**	**1.9**	**3.7**	**3.8**	**4.0**	**4.1**	**4.2**	**2.3**
Latin America	0.3	0.2	0.3	0.4	0.4	0.5	0.5	0.3
Middle East & Africa	0.3	0.2	0.3	0.3	0.4	0.5	0.5	0.4
India	0.2	0.1	0.2	0.3	0.4	0.5	0.6	0.5
China	0.7	0.3	0.9	1.0	1.1	1.1	1.1	0.9
Other Asia	0.8	0.5	0.9	1.0	1.1	1.2	1.3	0.8
OPEC	0.4	0.2	0.5	0.5	0.6	0.7	0.7	0.5
Russia	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.1
Other Eurasia	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Non-OECD	**2.9**	**1.6**	**3.4**	**3.8**	**4.3**	**4.8**	**5.1**	**3.5**
World	**6.7**	**3.5**	**7.1**	**7.6**	**8.3**	**8.8**	**9.3**	**5.8**

Source: OPEC.

However, these figures change significantly compared with pre-pandemic levels in 2019. In this case, demand growth in the OECD would be in the range of only 0.3 mb/d as, after recovering from the current crisis, it will represent a mature market where growth is constrained by infrastructure capacity and only a minor population increase. In the non-OECD, the adjustment would be much less pronounced. Growth in this region would be at 2.3 mb/d, amplifying its importance.

3.2.3 Marine bunkers

As with all other sectors, maritime trade was also significantly affected by the COVID-19 pandemic. Broadly mirroring the decline in global GDP, according to UNCTAD , the volume of international maritime trade declined by 4.1% in 2020. This, however, has already shifted the other way in 2021, with trade expected to recover by 4.8% on the back of a strong recovery in economic activity.

Besides the immediate impact of shifting trade volumes, the pandemic also raises a number of issues that could potentially have implications on sector developments. It primarily highlights the importance of trade in the production chain of various products, potentially leading to a shift in risk-management processes. Another consideration relates to changing consumer behaviour and spending habits. Finally, the elevated place of climate change issues on policymakers' agendas will undoubtedly affect not only the volume of future trade, but also the way goods are transported.

One of the key assumptions adopted in this Outlook is that global GDP will continue growing in the years to come, although at a slower pace compared with 2021. This will result in growing shipping activity and oil demand in the sector, at least over the current decade, as the turnover time in the shipping industry is long. However, long-term oil demand prospects for marine bunkers is less certain given the possibilities of substitution options, improved efficiencies and a potentially weakening link between economic growth and maritime trade.

In this regard, the IMO targets for efficiency improvements in the industry are of particular importance. The next IMO target is to achieve 30% efficiency improvements by 2025 for all new ships compared with those built in 2014. The main tools to enforce the regulation are the Energy Efficiency Design Index (EEDI), mandatory for new ships, and the Ship Energy Efficiency Management Plan, mandatory for all ships. In the long-term, the IMO aims to achieve a 50% reduction in overall GHG emissions from marine transport by 2050, compared with 2008 levels. This is a challenging target, which, if achieved, would have significant implications for future oil demand in the sector.

It is clear that technology will contribute to efficiency improvements for ICEs used in maritime transport, though current engines are already quite efficient. One method to improve fuel efficiency is the use of waste heat recovery units, which are widely available on the market. Some improvements could be achieved through reduced internal friction, eliminating losses caused by scavenging and other fluid flows, as well as improved combustion processes. Another option offers slow steaming. However, a slower ship also needs more time to get to its destination, and fuel and cost savings are lower when referring to specific fuel consumption per tonne-mile.

However, the aforementioned measures will not be sufficient to achieve required emissions reductions. As a result, oil substitution by other energy sources will be needed and the shipping industry is currently at a technology crossroads in its search for alternative powertrains.

The most likely alternative is LNG. The availability of LNG bunkering facilities has increased significantly in recent years and LNG engines constitute more than 10% of the share of order books for new-build vessels. Other alternatives include the use of hydrogen, ammonia and electricity as energy sources for maritime transport. Prototype vessels for each of these alternative powertrains

already exist, demonstrating their advantages, but also their disadvantages. However, it is unlikely that a significant penetration of these engines would be reached before 2045.

Table 3.8 translates the impact of these factors on future marine bunker demand to 2045. The overall change between 2020 and 2045 is limited to only 0.7 mb/d, with demand increasing mostly in the period to 2030. This growth is partly related to offsetting the 2020 demand decline, with the rest driven by expanding international trade on the back of robust economic growth in developing countries. Demand for marine bunkers is projected to remain virtually flat after 2030. During this period, LNG vessels are expected to achieve sufficient penetration, and combined with higher efficiency of oil-based vessels will counterbalance the still-growing trade.

Table 3.8
Oil demand in the marine bunkers sector by region, 2019–2045

mb/d

	2019	2020	2025	2030	2035	2040	2045	Growth 2020–2045
OECD Americas	0.5	0.5	0.5	0.5	0.5	0.4	0.4	–0.1
OECD Europe	0.8	0.7	0.8	0.7	0.7	0.6	0.6	–0.1
OECD Asia Oceania	0.3	0.3	0.2	0.2	0.2	0.2	0.2	–0.1
OECD	**1.6**	**1.5**	**1.5**	**1.5**	**1.4**	**1.2**	**1.1**	**–0.4**
Latin America	0.3	0.2	0.3	0.3	0.4	0.4	0.4	0.1
Middle East & Africa	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1
India	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0
China	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.1
Other Asia	1.2	1.0	1.2	1.3	1.4	1.5	1.6	0.5
OPEC	0.5	0.4	0.5	0.6	0.6	0.6	0.6	0.2
Russia	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Other Eurasia	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Non-OECD	**2.6**	**2.4**	**2.8**	**3.1**	**3.2**	**3.4**	**3.5**	**1.1**
World	**4.2**	**3.9**	**4.3**	**4.5**	**4.6**	**4.6**	**4.6**	**0.7**

Source: OPEC.

The largest incremental demand is projected for Other Asia, followed by OPEC and Latin America. However, incremental demand in Other Asia is more than three times higher than in other regions. This is mainly due to a large demand base in the region, which is home to the largest bunkering port in the world. In contrast, and despite their long coastlines, combined demand for marine bunker fuels in the Middle East & Africa (excluding OPEC countries), India, Russia and Other Eurasia was just 0.4 mb/d in 2020. Therefore, the growth potential for these regions is rather low in volume terms, though India, followed by the Middle East & Africa, is projected to see the fastest growth in relative terms.

Demand for marine bunker in the OECD shows a different pattern. It is projected to remain relatively stable at around 1.5 mb/d during the current decade. However, a marginal demand decline is projected in the second part of the forecast period, as growth in international trade increasingly shifts to non-OECD regions.

3.2.4 Petrochemicals

Like many other industries, this sector was hit hard by the COVID-19 pandemic due to its close link to economic growth and the uncertainties that surround the recovery also affect prospects for the industry.

The impact of the pandemic did, however, work in two ways for the industry. A decline in economic activity, such as in construction and car manufacturing, lowered demand for petrochemical products and various restrictions made the flow of petrochemicals challenging. On the flip side, households increased online shopping and takeaways, inducing a rise in plastic demand for packaging materials, including single-use plastics. Demand for this type of plastic also strongly increased in the health care sector. To some extent, the petrochemical industry proved indispensable as a provider of basic means and daily life products – especially in healthcare – during the pandemic. This, however, does not overshadow the fact that plastic pollution remains a major concern for the world community.

Another important issue for the sector is that projected growth rates going forward may not be as healthy as the industry requires in order to incentivize sound and sustained investment. Environmental considerations and regulations, such as regulations on single-use plastics and recycling, in general, will play an increasingly important role in shaping long-term prospects by adding another layer of uncertainty and disruption to future petrochemical demand growth.

These issues and concerns are fully reflected in oil demand projections in the petrochemical sector, as presented in Table 3.9. Demand in this sector is set to grow by 4.3 m/d from 13 mb/d in 2020 to 17.3 mb/d in 2045. Essentially all of this growth will come from non-OECD countries, where growth potential remains strong. OPEC countries will lead long-term growth with almost 1.6 mb/d of additional demand, followed by three Asian regions, each contributing in the range of 0.7 mb/d to 0.9 mb/d.

In fact, these four regions are expected to account for more than 90% of oil demand growth in the petrochemical sector by 2045, cumulatively adding 3.9 mb/d to future growth. The concentration of petrochemical facilities in these regions is driven by two major factors – feedstock availability and its competitiveness, and demand for petrochemical products. China's cracking capacity is mostly naphtha-based. China is encouraging the refining integration of oil-to-chemicals (OTC) for ethylene and/or aromatics in an effort to overcome an overcapacity in transportation fuel demand

Table 3.9
Oil demand in the petrochemical sector by region, 2019–2045

mb/d

	2019	2020	2025	2030	2035	2040	2045	Growth 2020–2045
OECD Americas	3.5	3.1	3.7	4.1	3.9	3.7	3.5	0.4
OECD Europe	1.9	1.7	1.8	1.8	1.7	1.6	1.4	–0.3
OECD Asia Oceania	2.1	1.9	2.0	2.0	2.0	2.0	2.0	0.0
OECD	**7.4**	**6.8**	**7.6**	**7.9**	**7.6**	**7.2**	**6.9**	**0.1**
Latin America	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.1
Middle East & Africa	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
India	0.4	0.4	0.6	0.7	0.9	1.0	1.1	0.7
China	2.0	2.0	2.2	2.4	2.5	2.6	2.7	0.8
Other Asia	1.3	1.2	1.5	1.6	1.8	2.0	2.1	0.9
OPEC	1.2	1.2	1.4	1.7	2.1	2.5	2.8	1.6
Russia	1.0	1.0	1.1	1.1	1.1	1.1	1.1	0.1
Other Eurasia	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.0
Non-OECD	**6.3**	**6.2**	**7.2**	**8.0**	**8.9**	**9.7**	**10.3**	**4.2**
World	**13.7**	**13.0**	**14.8**	**15.9**	**16.5**	**16.9**	**17.3**	**4.3**

Source: OPEC.

from refineries. Non-conventional technologies – coal-to-olefins (CTO) and methanol-to-olefins (MTO) – are expected to increase in the medium-term, despite rising environmental concerns. Naphtha and other liquid feedstock still lead the expansion in China and Other Asia.

Among other regions, only OECD Americas (mainly the US) will be a source of a meaningful increase at 0.4 mb/d. It is to be noted, however, that petrochemical demand in this region is projected to increase by 1 mb/d between 2020 and 2030. Nevertheless, demand will start falling sometime after 2030 on the back of declining tight oil production and slowing GDP growth. Bearing in mind the current uncertainties, it is likely that almost all additional sectoral demand in this region will be sourced from cheap ethane. However, naphtha cracking could be back on a competitive trajectory in the US, despite the large dominance of ethane crackers.

The outlook for the petrochemical sector is less optimistic for OECD Europe, where oil demand for petrochemicals is anticipated to decline, despite expected NGLs trade from the US. Other regions, essentially the Middle East, China and India, will determine European petrochemical choices in the future as maturing demand and domestic constraints may trigger sectoral rationalization. OECD Asia Oceania is, to some extent, in the same position as Europe, with the exception of South Korea, where some growth is foreseen to reflect the implementation of several recent projects.

Minor demand growth increments, in the range of 0.1 mb/d, are expected in other regions like Russia, Latin America and the Middle East & Africa, albeit with no significant impact on the sector's overall demand. Russia has an ambitious plan for the petrochemical sector, but it is unlikely that all projects from the current list will be completed within the medium-term horizon given the recent demand hit. Demand dynamics and global growth in petrochemicals have been attenuated by the recent demand shock in the sector, but a rebound in the coming years and beyond the medium-term are expected, although at a slower pace than previously anticipated.

Oil demand in the petrochemical sector of OPEC is set to continue focusing on the use of ethane during the forecast period. Out of a total sectoral growth of 1.6 mb/d between 2020 and 2045, ethane is forecast to increase by 1.1 mb/d. Some growth in the use of LPG (and marginally naphtha) is also expected in OPEC Member Countries with the development of new petrochemical projects in OPEC's African Member Countries.

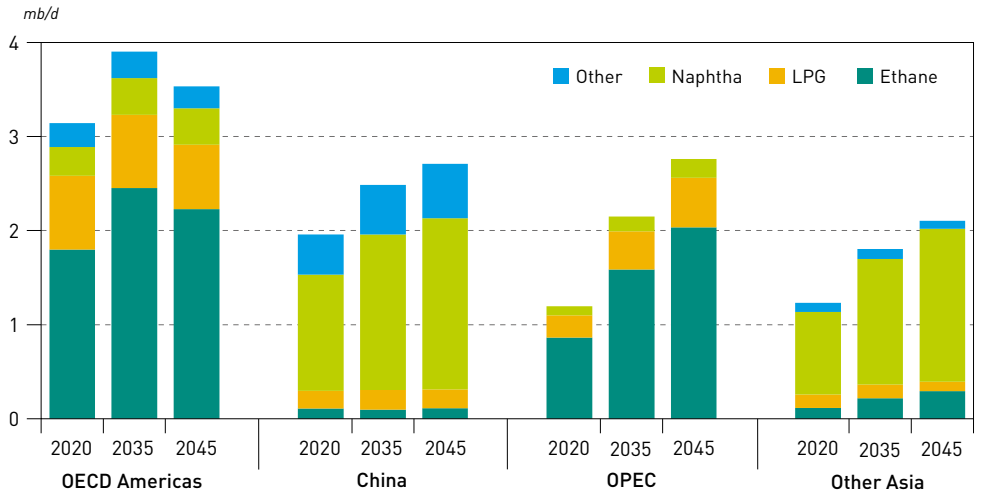
In the Middle East, ethane-cracking projects are under development in the IR Iran and the UAE. In Saudi Arabia, Saudi Aramco and SABIC had intended to build the first OTC petrochemical plant in Yanbu, which was expected to produce nine million tonnes (mt) per year of chemicals and base oils. However, with much lower demand after the outbreak of COVID-19, both companies announced their intention to reassess the project and integrate the plant within the existing Yanbu refinery.

The Yanbu OTC project is a manifestation of the future need to incorporate increased resilience and flexibility to meet very dynamic demand in the refinery business. This is expected to be done via integrating petrochemical production in refining systems and OTC developments, which will represent a viable alternative for the future petrochemical and refining industries.

Figure 3.21 summarizes regional trends in the petrochemical industry from the perspective of major oil products, mainly examining feedstock, but also for energy use. In the period from 2020–2035, demand for all feedstock increases at the global level. The largest increase is seen for ethane use in OPEC and OECD Americas at around 0.7 mb/d in each region. Significant growth is also projected for naphtha, mainly in Other Asia and China. The total increase in naphtha use is 1 mb/d, while LPG and other products combined are projected to increase by only 0.3 mb/d.

This pattern changes significantly during the last ten years of the forecast period. By then, demand for all products in the OECD petrochemical sector are anticipated to be in decline. Overall growth

Figure 3.21
Regional demand in the petrochemical sector by product, 2020–2045



Source: OPEC.

in Other Asia and China is forecast to drop 0.3 mb/d and 0.2 mb/d, respectively. A somewhat larger demand increase is projected for OPEC Member Countries, where ethane is set to expand by an additional 0.4 mb/d and LPG adds another 0.1 mb/d.

3.2.5 Other sectors

The overall impact of the COVID-19 pandemic on oil demand in the **residential, commercial and agricultural** grouping was less pronounced. The main reason is that these sectors are combined in the Outlook, thus some demand shift from the commercial to the residential sector is not visible in cumulative numbers. Certainly the pandemic has increased teleworking and changed household behaviour. This gave rise to additional demand for electricity in residences, space heating/cooling, and the extended use of home appliances. On the other hand, demand in the commercial service and hospitality sectors declined sharply during the lockdown period and recovery stage. However, the declining demand in the commercial building segment was offset by a surge in the residential sector. To some extent, teleworking will likely continue for longer, since it offers the opportunity for businesses to cut operational costs. However, it remains to be seen what proportion of it will be used to balance other business requirements.

According to recent projections, oil demand in this sector is set to increase steadily over the next 10–15 years and then decline at the end of the forecast period due to fuel switching, technology and efficiency gains. This can be observed in Table 3.10, in which oil demand is forecast to increase from 10.9 mb/d in 2020 to 12 mb/d by 2035, before declining to 11.6 mb/d in 2045.

OECD oil demand in this sector is set to remain relatively stable over the current decade, though the expected accelerated energy transition in the latter part of the forecast period is likely to result in more oil substitution by electricity. Moreover, efficiency improvements and low-energy building codes form the foundation of OECD energy optimization in new buildings. The EU Commission presented a plan in late 2020 to reduce energy consumption in inefficient buildings by 14% through revamps and retrofits. The plan involved efforts to further reduce heating and cooling energy use by an even higher percentage (18%), which will affect oil demand in this sector. Similar regulations also exist in other OECD regions.

Table 3.10
Oil demand in the residential/commercial/agriculture sector by region, 2019–2045 *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Growth 2020–2045
OECD Americas	1.7	1.7	1.7	1.8	1.7	1.6	1.1	–0.6
OECD Europe	1.6	1.5	1.5	1.5	1.3	1.1	1.1	–0.4
OECD Asia Oceania	0.8	0.9	0.8	0.8	0.6	0.6	0.5	–0.5
OECD	**4.1**	**4.1**	**4.0**	**4.0**	**3.7**	**3.3**	**2.7**	**–1.4**
Latin America	0.8	0.7	0.8	0.9	1.0	1.1	1.2	0.4
Middle East & Africa	0.6	0.6	0.7	0.8	0.9	1.0	1.1	0.5
India	1.1	1.0	1.3	1.4	1.6	1.7	1.8	0.8
China	2.3	2.3	2.6	2.6	2.6	2.7	2.7	0.4
Other Asia	0.9	0.9	0.8	0.8	0.8	0.8	0.9	0.0
OPEC	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.0
Russia	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.0
Other Eurasia	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0
Non-OECD	**7.0**	**6.8**	**7.4**	**8.0**	**8.4**	**8.7**	**8.9**	**2.1**
World	**11.1**	**10.9**	**11.4**	**12.0**	**12.0**	**12.0**	**11.6**	**0.7**

Source: OPEC.

Part of the demand reduction is also due to the deployment of more efficient technologies like district heating, PV panels and heat pumps. Switching from oil to gas and electricity will further impact oil demand in this sector. However, oil use in agriculture will be more difficult to substitute.

Considering these factors, OECD oil demand in this sector is estimated to decline by 1.4 mb/d to reach 2.7 mb/d by 2045.

Driven strongly by urbanization and a rising middle class, oil use in the non-OECD is set to increase in the long-term. Fuel-switching from solid biomass to oil-based products will drive oil demand in sub-Saharan Africa, India and Southeast Asia, although the economic stress caused by the pandemic compelled some households to revert back to traditional biomass cooking.

Oil will also continue to support the provision for off-grid power in hard-to-access rural settlements for household lighting, heating and cooling. Moreover, some households and commercial buildings, mainly in West Africa, use gasoline-generated engines for the provision of electricity due to the unreliability of utility grid systems. Major oil use growth is driven by India and China for space heating, cooling and agriculture. Oil is used in the Middle East & Africa for space cooling, cooking and lighting.

As a result, non-OECD oil demand in the residential/commercial/agricultural sector is projected to increase by 2.1 mb/d over the forecast period to 8.9 mb/d in 2045.

Oil use in **rail and domestic waterways** is the lowest among all sectors considered in this Outlook. Global demand in this sector is just below 2 mb/d and is projected to move in a very narrow band around 2 mb/d over the forecast period. Moreover, more than half of this demand is currently concentrated in only two regions, OECD Americas and China (Table 3.11). In the case of OECD Americas, the majority of the demand is linked to diesel used for rail transport. This is also the case for all other regions, with the exception of China, where a larger part of demand relates to domestic waterways.

Table 3.11
Oil demand in the rail and domestic waterways sector by region, 2019–2045 *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Growth 2020–2045
OECD Americas	0.5	0.5	0.5	0.5	0.5	0.4	0.3	–0.2
OECD Europe	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0
OECD Asia Oceania	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0
OECD	**0.8**	**0.8**	**0.7**	**0.7**	**0.6**	**0.6**	**0.5**	**–0.3**
Latin America	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1
Middle East & Africa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
India	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
China	0.6	0.6	0.7	0.8	0.8	0.8	0.9	0.2
Other Asia	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1
OPEC	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Russia	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Other Eurasia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-OECD	**1.1**	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**0.5**
World	**1.9**	**1.8**	**2.0**	**2.0**	**2.1**	**2.1**	**2.0**	**0.2**

Source: OPEC.

From a regional perspective, the highest demand base in this sector is in China. Part of this demand relates to the use of diesel in the railway system. Although the electrification rate in China is relatively high at around 70%, the remaining part of the railway system still provides a solid basis for oil demand, considering that the entire system comprises almost 150,000 km. For future prospects, the electrification rate will likely further increase and most new Chinese railways will be built using electricity as the energy source. Therefore, oil demand in this sub-sector will remain relatively stable to slightly declining in the long-term.

The opposite is expected for domestic waterways in China. Currently there are 127,000 km of inland waterways in China and the country has a plan to expand this by a further 25,000 km in the period to 2035. This will lead to continuing growth in domestic waterway traffic in China, both for passengers and freight. More traffic, even accounting for better efficiencies in the future, will provide support to oil demand. The country's combined rail and waterway oil demand growth is estimated in the range of 0.2 mb/d between 2020 and 2045.

Oil demand in the second largest-market for this sector will likely move in the opposite direction. Rail electrification in the US is not expected to increase significantly over the forecast period. Neither is a significant increase expected for rail traffic. Therefore, oil demand is projected to remain relatively stable during the current decade. However, some shifts are to be expected afterwards, due to improved efficiencies and some oil substitution, for example, by hydrogen.

Minor demand growth is projected in other non-OECD countries, in particular Latin America, Other Asia and Russia. However, projected demand growth in all these regions is below 0.1 mb/d.

Although electricity demand remained resilient during the pandemic, the use of oil for **electricity generation** continues to trend in the previously established negative trajectory. This is also reflected in this Outlook, which expects the further displacement of oil by gas and renewables, in line with major policy initiatives. It is worth noting that electricity generation remains the only sector where oil use will decline at the global level over the forecast period.

Indeed, global oil demand for electricity generation is projected to contract by 1 mb/d and reach 3.9 mb/d in 2045 (Table 3.12). Most of this decline will be in the OECD region, where the fast-progressing expansion of wind, both offshore and onshore, solar and geothermal energy, mainly in OECD Europe, and the availability of relatively cheap gas is set to almost completely eliminate the use of oil in the sector. The overall decline for the OECD region is 0.9 mb/d, which will push regional demand as low as 0.4 mb/d in 2045.

Table 3.12
Oil demand in the electricity generation sector by region, 2019–2045 *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Growth 2020–2045
OECD Americas	0.4	0.5	0.3	0.2	0.2	0.1	0.1	–0.5
OECD Europe	0.3	0.3	0.3	0.2	0.2	0.2	0.1	–0.1
OECD Asia Oceania	0.4	0.4	0.4	0.3	0.3	0.2	0.2	–0.3
OECD	**1.2**	**1.3**	**1.0**	**0.8**	**0.7**	**0.5**	**0.4**	**–0.9**
Latin America	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Middle East & Africa	0.6	0.5	0.6	0.7	0.8	0.8	0.9	0.4
India	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
China	0.2	0.2	0.2	0.2	0.2	0.2	0.2	–0.1
Other Asia	0.4	0.4	0.4	0.4	0.4	0.4	0.3	–0.1
OPEC	1.7	1.6	1.6	1.5	1.4	1.3	1.2	–0.3
Russia	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0
Other Eurasia	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Non-OECD	**3.8**	**3.6**	**3.7**	**3.7**	**3.6**	**3.5**	**3.5**	**–0.1**
World	**4.9**	**4.9**	**4.7**	**4.5**	**4.3**	**4.0**	**3.9**	**–1.0**

Source: OPEC.

Another region with a significant demand drop in electricity generation is OPEC, where two counterbalancing trends are projected to take place. On one side, several OPEC Member Countries intend to reduce the direct use of crude oil for power generation in order to benefit from the higher added value of available oil resources. On the other side, part of this decline will be offset by the increased use of diesel and fuel oil for power generation, especially in African countries. The net result is estimated to be a decline of 0.3 mb/d between 2020 and 2045.

The above demand decline will be partly compensated by increased oil use in off-grid captive power generation in the Middle East & Africa region, especially in sub-Saharan Africa. The global push to achieve SDG7 – which seeks to expand energy access and clean cooking fuel for all by 2030 – is assisting sub-Saharan Africa (and other regions) to further alleviate energy poverty. This is providing some momentum for the growth of oil-based generation via rural electrification in remote locations without gas supply infrastructure. Consequently, oil demand for electricity generation in non-OECD regions is set to grow during the current decade and marginally decline at the end of the forecast period.

Contrary to electricity generation, much higher base consumption and positive incremental demand is projected for the **'other industry'** sector. This covers a wide range of sub-sectors such as iron and steel, glass and cement production, construction and mining and internal refinery use. Thus, consumption in this sector results from often-diverging trends at the regional and product levels, with plentiful options for fuel substitution, even on a temporary basis.

Regional prospects for future oil demand in this sector are presented in Table 3.13. These are broadly similar to those discussed earlier for the residential, commercial and agricultural sector,

although the weighting of contributing regions differs. Common features are growing global demand until around 2035 and declining demand thereafter, along with steadily declining OECD demand and expanding demand in the non-OECD region.

Besides these major trends, Table 3.13 also reflects the link between oil consumption in this sector and its relative contribution to the GDP of respective countries/regions. Clearly, the largest incremental demand is expected in countries with growing industrialization, which typically supports the consumption of diesel, residual fuel and LPG. This goes hand-in-hand with urbanization and the rapid expansion of necessary infrastructure, which, in turn, will support demand for asphalt, bitumen and other related products. This is the case for India, the Middle East & Africa, OPEC and Other Asia.

China represents another stage of economic development, in which the industrial sector contribution starts to decline. This trend is expected to accelerate in the coming years. However, some expansion of road infrastructure will partially offset this decline, so that the net result is a decline of around 0.2 mb/d during the forecast period.

At the other end of the scale are OECD countries where the weight of the industrial sector is shrinking and fuel consumption is switching towards natural gas. This sector is also seeing technology and policy-driven efficiency improvements. The road network in these countries is already well developed and only limited expansion is required. Therefore, OECD oil demand in the 'other industry' sector will steadily decline over the forecast period. The range of the decline is expected to be around 1.2 mb/d between 2020 and 2045.

Table 3.13
Oil demand in the 'other industry' sector by region, 2019–2045 *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Growth 2020–2045
OECD Americas	3.0	2.9	3.0	3.0	2.8	2.5	2.3	–0.7
OECD Europe	1.5	1.4	1.4	1.3	1.3	1.3	1.3	–0.2
OECD Asia Oceania	0.8	0.9	0.8	0.7	0.7	0.6	0.5	–0.4
OECD	**5.3**	**5.3**	**5.2**	**5.0**	**4.8**	**4.3**	**4.0**	**–1.2**
Latin America	0.9	0.9	1.0	1.0	1.1	1.1	1.1	0.3
Middle East & Africa	0.6	0.6	0.6	0.7	0.8	0.8	0.9	0.3
India	1.0	0.9	1.0	1.1	1.3	1.4	1.5	0.6
China	1.9	2.1	2.0	2.1	2.0	2.0	1.9	–0.2
Other Asia	0.9	0.9	0.9	1.0	1.1	1.1	1.2	0.3
OPEC	1.3	1.2	1.4	1.6	1.6	1.6	1.5	0.3
Russia	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.1
Other Eurasia	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.1
Non-OECD	**7.6**	**7.4**	**7.9**	**8.5**	**8.8**	**9.1**	**9.2**	**1.8**
World	**12.9**	**12.7**	**13.1**	**13.5**	**13.7**	**13.4**	**13.3**	**0.6**

Source: OPEC.

3.3 Oil demand outlook by product

The COVID-19 pandemic has significantly altered demand for specific refined products. Since the pandemic strongly impacted mobility, the largest demand decline in 2020 was observed in jet fuel, gasoline and diesel. These products were disproportionally affected, each in a range between 2 mb/d and 3 mb/d, compared with other products, which declined by 0.2 mb/d to 0.4 mb/d. Moreover, prospects for demand recovery vary across products. While demand for products like naphtha, LPG and most heavy products will likely recover in most regions as soon as 2021, diesel

demand is expected to be back to pre-pandemic levels only sometime in 2022, gasoline most likely in 2023 and jet kerosene only in 2024.

Clearly, these expectations will to a large extent determine demand for refined products during the medium-term and will have some implications on long-term prospects, though these will be driven rather by various policy measures, fuel substitution options and efficiency improvements than short-term developments. For these reasons, it is important to consider medium- and long-term trends separately.

A summary of results on global product demand are presented in Table 3.14. Figure 3.22 shows demand growth broken down to the medium-term period (2020–2026) and the remaining part of the forecast period (2027–2045). The first important difference between the two periods is that all types of refined products are projected to grow during the medium-term. This is primarily due to very low demand seen in 2020, which provides ample room for growth. The same argument explains in part the large differences, except for naphtha, between growth in the medium- and long-term. Another issue of note is that gasoline and heavy products will see negative growth in the long-term, while the demand increase for diesel/gasoil will be minimal.

Table 3.14
Global oil demand by product, 2019–2045

mb/d

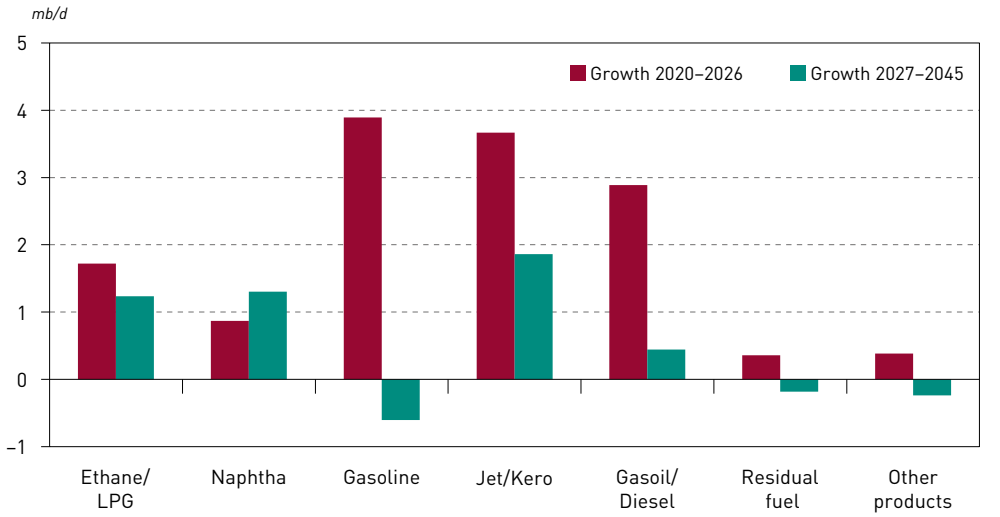
	2019	2020	2025	2030	2035	2040	2045	Growth 2020–2045
Ethane/LPG	12.7	12.2	13.7	14.7	15.1	15.3	15.2	3.0
Naphtha	6.3	6.0	6.8	7.2	7.6	7.9	8.2	2.2
Gasoline	26.5	23.8	27.6	27.7	27.4	27.2	27.1	3.3
Light products	**45.5**	**42.0**	**48.1**	**49.6**	**50.1**	**50.4**	**50.4**	**8.4**
Jet/kero	7.6	4.4	7.9	8.4	9.0	9.5	9.9	5.5
Gasoil/diesel	28.4	26.3	29.0	29.5	29.8	29.7	29.6	3.3
Middle distillates	**36.0**	**30.7**	**37.0**	**38.0**	**38.8**	**39.1**	**39.5**	**8.9**
Residual fuel	7.2	6.8	7.2	7.4	7.3	7.2	7.0	0.2
Other products	11.3	11.1	11.4	11.6	11.7	11.4	11.2	0.1
Heavy products	**18.5**	**17.9**	**18.5**	**19.0**	**19.0**	**18.6**	**18.3**	**0.3**
World	**100.0**	**90.6**	**103.6**	**106.6**	**107.9**	**108.1**	**108.2**	**17.6**

Source: OPEC.

Turning to specific products, growing demand for ethane/LPG reflects trends in the petrochemical, residential and industrial sectors. Since these sectors are projected to grow, demand for ethane and LPG will also expand during both the medium- and long-term periods. A similar pattern applies to naphtha, which is primarily used as a feedstock for the petrochemical industry. Since this industry is projected to grow over the entire forecast period, incremental demand for naphtha in the long-term will be even higher than in the medium-term. From a regional perspective, incremental demand for naphtha will be concentrated in Asian countries, with the largest increments projected for Other Asia (+0.7 mb/d), China (+0.6 mb/d) and India (+0.5 mb/d).

Differing from naphtha, gasoline demand growth is mostly concentrated in the medium-term period. Demand for this product will increase by almost 4 mb/d between 2020 and 2026, and a large part of this will be absorbed by demand recovery in the road transportation sector.

Figure 3.22
Growth in global oil demand by product



Source: OPEC.

Thereafter, demand for gasoline is set to peak towards the end of the current decade. In 2045, it is expected to be around 0.6 mb/d, lower than in 2026. This is a result of broad trends in the passenger car segment, where improving fuel efficiencies and the increasing penetration of AFVs, primarily EVs, more than offset the potential demand increase resulting from an expansion in the number of vehicles.

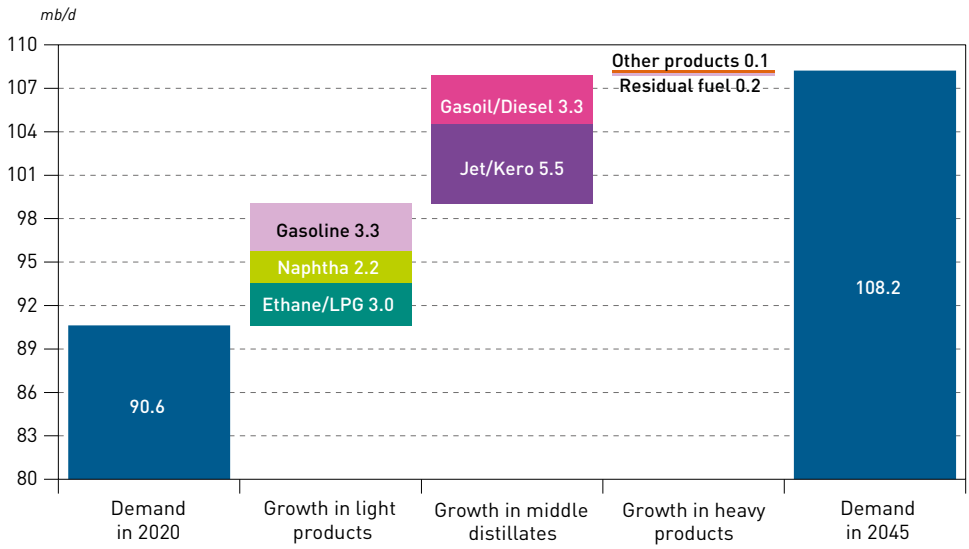
Demand for jet/kerosene also grows over the entire forecast period, but its increase during the 2020–2026 period is almost double that projected for 2027–2045. Clearly, this is due to the sharp decline in jet fuel in 2020. The same argument holds for diesel/gasoil demand, although proportions between the two periods differ. In the case of diesel/gasoil, demand is expected to peak sometime around 2035 and decline over the last ten years of the forecast period, which will offset part of the growth between 2027 and 2035.

For the remaining part of refined products, primarily the heavy part of the refined barrel, projected changes are minimal. Generally, some growth during the medium-term period, in the range of 0.4 mb/d each for residual fuel oil and 'other products', will be largely offset over the long-term, with it ending the forecast period at slightly higher levels than recorded in 2020.

The net effect of these trends for the entire forecast period is presented in Figure 3.23. With 2020 as the base year for the Outlook, the largest incremental product demand is projected for jet fuel and domestic kerosene, although in fact demand for domestic kerosene is seen to marginally decline. The total demand increase for this group of products stands at 5.5 mb/d between 2020 and 2045.

This is followed by diesel/gasoil and gasoline, contributing almost the same volume at 3.3 mb/d and 3.2 mb/d, respectively. Incremental demand for ethane/LPG is projected at 2.9 mb/d and naphtha is at 2.2 mb/d. Finally, only marginal growth of 0.3 mb/d is projected for the combined demand of residual fuel and 'other products' between 2020 and 2045.

Figure 3.23
Demand growth by product category between 2020 and 2045



Source: OPEC.

Liquids supply

Key takeaways

- Non-OPEC liquids supply is expected to continue its recovery, growing y-o-y in 2021 and returning to pre-pandemic levels in 2022.

- As oil demand picks up, aided by the surging global economy and the market stabilization efforts of OPEC and non-OPEC countries in the DoC, market fundamentals are anticipated to remain stable and supportive, thus encouraging a return to upstream activity and investment.

- Medium-term non-OPEC total liquids supply is projected to grow by 7.5 mb/d, from 62.9 mb/d in 2020 to 70.4 mb/d in 2026. Key contributors to growth in this period are the US, Brazil, Russia, Guyana, Canada, Kazakhstan, Norway and Qatar.

- US crude oil production, which slumped as the COVID-19 pandemic hit, quickly recovered some of its losses in the latter part of 2020. US total liquids supply in 2021 is expected to be relatively flat as producers remain cautious, but supportive market fundamentals should incentivize a return to growth from 2022.

- US tight oil is projected to grow from 11.5 mb/d in 2020 to 14.8 mb/d in 2026, before peaking around 15.2 mb/d in the late 2020s – around 0.6 mb/d lower than expected in the WOO 2020. As a result, US total liquids, which are expected to grow from 17.6 mb/d in 2020 to 20.5 mb/d in 2026, peak and plateau shortly afterwards, and then decline to 16.9 mb/d by 2045.

- In the long-term, after US liquids supply peaks, only a few non-OPEC producers are expected to see output growth, including Canada, Guyana, Kazakhstan, Brazil and Qatar, in addition to refinery processing gains. Therefore, due to the decline in the US and in maturing producers such as post-peak Norway, China, Colombia, Azerbaijan, the UK and Indonesia, among others, total non-OPEC liquids supply is set to decline from 70.4 mb/d in 2026 to 65.5 mb/d in 2045, basically level with pre-pandemic 2019 (though higher than depressed 2020).

- OPEC liquids supply is forecast to recover from a pandemic-induced 2020 low of 30.7 mb/d, increasing as demand recovers. Levels are projected to rise quickly to around 34 mb/d in the 2023–2026 period. Beyond that, as non-OPEC liquids supply plateaus and peaks in the late 2020s, OPEC liquids begin to increase again, growing from 35.7 mb/d in 2030 to 42.7 mb/d in 2045. In terms of market share, relative to global liquids supply, this implies a rise from 33% at the nadir in 2020 to 39% in 2045.

- The average API gravity of global crude supply is expected to increase to 33.7° in 2025 due to rising light production, then decline to around 33.2° by 2045. This is in line with the longer-term rising share of heavier grades, mostly from the Middle East.

- Cumulative investment requirements in the oil sector amount to $11.8 trillion in the 2021–2045 period. The upstream accounts for some 80% of this, or $9.2 trillion, the bulk of which is in North America, as US tight oil, in particular, drives medium-term non-OPEC supply growth. The downstream and midstream need another $1.5 trillion and $1.1 trillion, respectively, in order to expand and maintain the associated refinery, storage and pipeline systems that bring oil to the market.

This chapter describes the outlook for liquids supply from 2020–2045. As in previous Outlooks, the medium-term projections for 2020–2026 and the longer-term outlook are discussed separately, due to the different methodologies employed. The medium-term view relies upon 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 upon an assessment of the available resource base. US tight oil is also modelled and discussed separately.

Due to the distorting effect of large-scale supply shut-ins in 2020 as a result of the COVID-19 pandemic, the tables in this year's Outlook will also include production figures for 2019. This allows for a better comparison with previous WOOs and other forecasts.

4.1 Global liquids supply

The repercussions of and recovery from the effects of the COVID-19 pandemic continue to shape global liquids supply. While OPEC and its partners in the DoC agreed in April 2020 to adjust down production by nearly 10 mb/d, other producers also took, or were forced to take, measures to limit output until demand began to return. As a result, non-OPEC liquids supply declined by 2.6 mb/d in 2020, of which just over half was in DoC participating countries.

Table 4.1
Medium-term global liquids supply outlook

mb/d

	2019	2020	2021	2022	2023	2024	2025	2026	Change 2020–2026
US	18.4	17.6	17.7	18.4	19.3	19.9	20.3	20.5	2.9
of which: tight liquids	*11.7*	*11.5*	*11.6*	*12.3*	*13.3*	*14.0*	*14.5*	*14.8*	*3.3*
Canada	5.4	5.2	5.5	5.6	5.6	5.6	5.6	5.6	0.4
of which: oil sands	*2.9*	*2.8*	*3.0*	*3.1*	*3.1*	*3.2*	*3.2*	*3.1*	*0.3*
OECD Americas	25.8	24.7	25.1	26.0	26.9	27.4	27.8	27.9	3.2
OECD Europe	3.7	3.9	3.9	4.1	4.4	4.5	4.4	4.2	0.3
of which: Norway	*1.7*	*2.0*	*2.1*	*2.3*	*2.4*	*2.5*	*2.4*	*2.3*	*0.3*
OECD Asia Oceania	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.1
OECD	**30.0**	**29.1**	**29.6**	**30.7**	**31.9**	**32.5**	**32.8**	**32.7**	**3.6**
Latin America	6.1	6.0	6.2	6.5	6.8	7.1	7.5	8.0	1.9
of which: Brazil	*3.6*	*3.7*	*3.8*	*4.0*	*4.2*	*4.5*	*4.8*	*5.0*	*1.3*
Middle East	3.2	3.2	3.2	3.3	3.3	3.3	3.4	3.5	0.3
Africa	1.5	1.4	1.3	1.3	1.3	1.4	1.5	1.6	0.2
China	4.0	4.1	4.2	4.3	4.3	4.3	4.2	4.1	0.0
Other Asia	3.5	3.3	3.2	3.2	3.1	3.1	3.1	3.1	–0.2
Russia	11.6	10.6	10.6	11.1	11.2	11.3	11.4	11.4	0.9
Other Eurasia	3.2	3.0	3.1	3.1	3.3	3.4	3.4	3.4	0.3
Non-OECD	**33.2**	**31.6**	**31.9**	**32.8**	**33.3**	**33.9**	**34.5**	**35.1**	**3.5**
Processing gains	**2.4**	**2.2**	**2.3**	**2.4**	**2.4**	**2.5**	**2.5**	**2.6**	**0.4**
Non-OPEC	**65.5**	**62.9**	**63.8**	**65.9**	**67.6**	**68.8**	**69.8**	**70.4**	**7.5**
Total OPEC liquids	**34.6**	**30.7**	**30.9**	**33.8**	**34.0**	**34.0**	**34.0**	**34.1**	**3.5**
World*	**100.0**	**93.6**	**94.7**	**99.7**	**101.6**	**102.8**	**103.8**	**104.6**	**10.9**

* *The sum of the countries/regions may not add up to the global supply total due to rounding and stock change assumptions.*

Source: OPEC.

Subsequently, as vaccination programmes and other remedies began to beat back the pandemic, economic recovery picked up speed in 2021, and after stabilizing, non-OPEC liquids have started to grow again. Other than DoC volumes and US tight crude, most shut-in volumes have returned to the market. In the US, crude production has stabilized again above 11 mb/d.

With the global economy and oil demand expected to reach pre-pandemic levels during the course of 2021 and 2022, and keep growing thereafter, non-OPEC liquids supply is projected to expand by 7.5 mb/d from 2020–2026, rising from 62.9 mb/d in 2020 to 70.4 mb/d by the end of this period (Table 4.1). Towards the end of the 2020s, non-OPEC liquids supply is expected to peak and plateau at around 71 mb/d as US tight oil, in particular, reaches a high point, and then decline to 65.5 mb/d by 2045. Meanwhile total OPEC liquids supply is set to rise again from a low of 30.7 mb/d in 2020, when supply was impacted by production adjustments, to 34.1 mb/d by 2026 and gradually higher to reach 42.7 mb/d by 2045.

4.1.1 Key developments related to the liquids supply outlook

After markets re-stabilized over the course of 2020, not least due to the extensive and timely production adjustments agreed by OPEC Member Countries and their partners in the DoC, non-OPEC liquids supply similarly evened out and started to grow again, albeit at initial modest levels.

Table 4.2
Long-term global liquids supply outlook

mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2020–2045
US	18.4	17.6	20.3	20.3	19.3	18.1	16.9	–0.7
of which: tight liquids	*11.7*	*11.5*	*14.5*	*15.2*	*15.0*	*14.2*	*13.3*	*1.8*
Canada	*5.4*	*5.2*	*5.6*	*5.7*	*5.9*	*5.9*	*6.1*	*0.9*
of which: oil sands	*2.9*	*2.8*	*3.2*	*3.3*	*3.6*	*3.8*	*4.1*	*1.3*
OECD Americas	25.8	24.7	27.8	27.8	26.9	25.7	24.6	–0.1
OECD Europe	3.7	3.9	4.4	3.9	3.6	3.3	3.1	–0.8
of which: Norway	*1.7*	*2.0*	*2.4*	*2.1*	*1.8*	*1.6*	*1.3*	*–0.7*
OECD Asia Oceania	0.5	0.5	0.6	0.6	0.5	0.5	0.4	–0.1
OECD	**30.0**	**29.1**	**32.8**	**32.4**	**31.0**	**29.5**	**28.1**	**–1.0**
Latin America	6.1	6.0	7.5	8.5	8.6	8.5	8.4	2.3
of which: Brazil	*3.6*	*3.7*	*4.8*	*5.1*	*5.2*	*5.2*	*5.3*	*1.6*
Middle East	3.2	3.2	3.4	3.7	3.7	3.7	3.7	0.5
Africa	1.5	1.4	1.5	1.7	1.7	1.6	1.5	0.1
China	4.0	4.1	4.2	4.1	4.0	3.9	3.7	–0.4
Other Asia	3.5	3.3	3.1	3.0	2.8	2.6	2.4	–0.9
Russia	11.6	10.6	11.4	11.6	11.4	11.4	11.3	0.7
Other Eurasia	3.2	3.0	3.4	3.4	3.4	3.4	3.3	0.3
Non-OECD	**33.2**	**31.6**	**34.5**	**35.9**	**35.5**	**35.0**	**34.2**	**2.6**
Processing gains	**2.4**	**2.2**	**2.5**	**2.7**	**2.9**	**3.0**	**3.1**	**1.0**
Non-OPEC	**65.5**	**62.9**	**69.8**	**71.0**	**69.4**	**67.5**	**65.5**	**2.5**
Total OPEC liquids	**34.6**	**30.7**	**34.0**	**35.7**	**38.5**	**40.6**	**42.7**	**12.0**
World*	**100.0**	**93.6**	**103.8**	**106.7**	**107.9**	**108.1**	**108.2**	**14.6**

* *The sum of the countries/regions may not add up to the global supply total due to rounding and stock change assumptions.*

Source: OPEC.

Annual growth is expected to pick up momentum in 2022 and grow solidly in the medium-term, rising from 62.9 mb/d in 2020 to 70.4 mb/d in 2026, or by 7.5 mb/d.

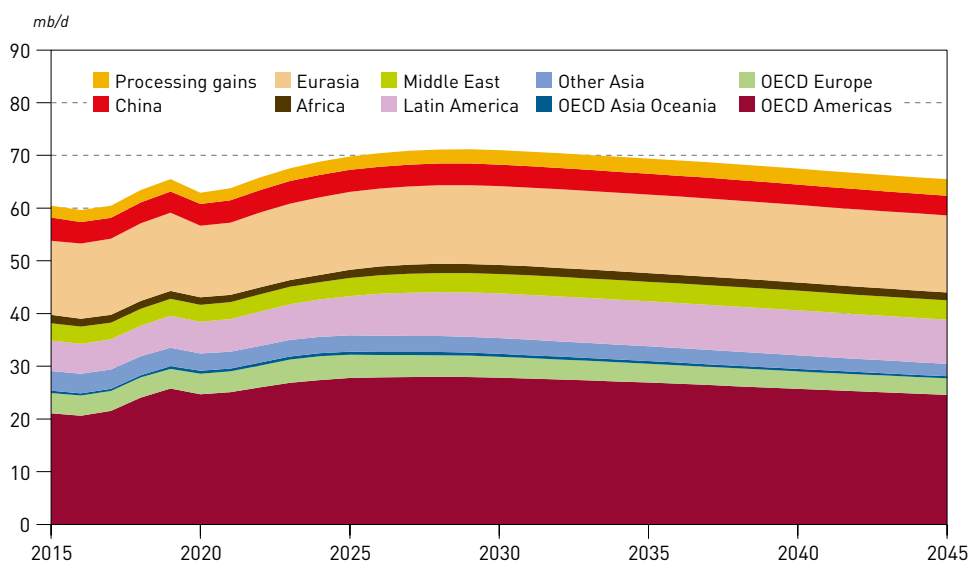
The expected return to growth is driven by a supportive fundamentals background, with demand set to rebound healthily as economies re-open and consumers generally return to pre-pandemic behavioural patterns. DoC discipline has steadily helped draw down the previous massive stock overhang, and oil prices have been consistently above $50/b since early 2021. Perhaps more importantly, expectations are for continued stability in oil markets, allowing for more optimism and medium- and long-term planning by oil companies. As a result, shut-in production continues to recover, capital expenditure in the upstream is rising again, and, despite some delays, new projects are being given the go-ahead.

At the same time, major developed and emerging economies are beginning to make increasingly strong commitments to reduce CO_2 emissions in the coming decades, many even committing to 'net-zero' emissions by around 2050. How precisely this will affect the upstream sector and liquids supply is as yet unclear. It is safe to say, however, that it has triggered debate and heightened concern about potential medium-term oil market tightness, as well as longer-term investment into the sector.

The change in policy direction is underpinned by a range of other more specific and nearer-term developments. In the US, the new Biden administration initially imposed a number of executive orders, including temporary moratoria on new lease sales and on drilling on federal lands (subsequently challenged). The administration effectively cancelled the disputed Keystone XL pipeline, while other pipeline projects remain in doubt or suspended. Meanwhile, highly-publicized votes at shareholder meetings of a number of super-majors, and a court decision ordering Royal Dutch Shell to accelerate its pace of decarbonization, have in some quarters been seen as heralding in the beginning of the end for oil, or fossil fuels, in general.

Nonetheless, this Outlook's Reference Case assumes that only some of these measures will be implemented in the medium- to long-term, and not comprehensively across both developed and

Figure 4.1
Long-term non-OPEC liquids supply outlook



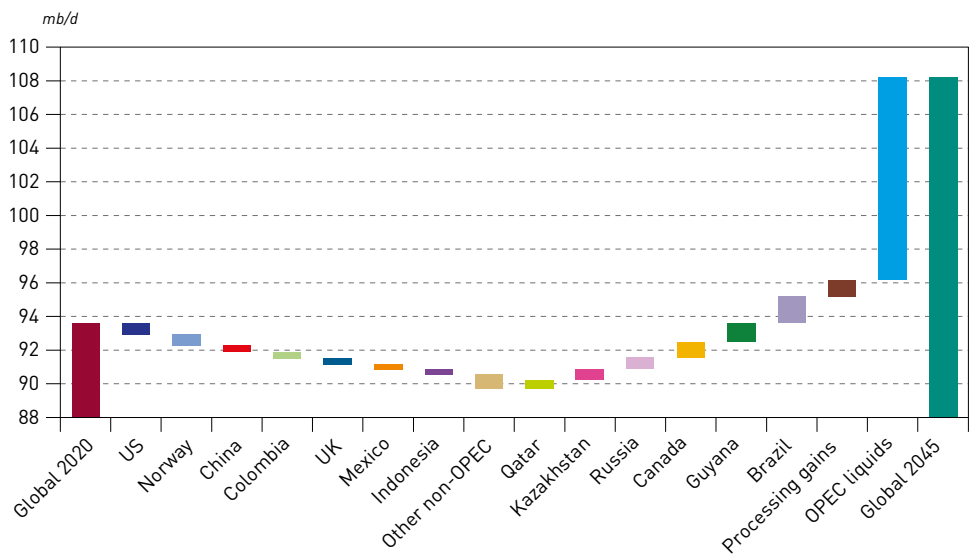
Source: OPEC.

developing economies. Even with emissions curbs and other efforts to reduce the use of fossil fuels, oil will remain an important part of the energy mix for years to come.

As a result, non-OPEC liquids supply will continue to grow throughout the 2020s, before plateauing around the turn of the decade with a high point of around 71 mb/d. The main reason will be a projected peak in US liquids supply at just over 20 mb/d, of which tight liquids will make up around 15 mb/d, or around 14% of global supply. With only a few sources of long-term non-OPEC supply growth – including notably Brazil, Guyana, Canada, Russia and Kazakhstan – the natural decline in most other non-OPEC producers is expected to see total non-OPEC supply falling to 65.5 mb/d by 2045 (Figure 4.2).

As a result, total OPEC liquids is forecast to first recover to around pre-pandemic levels of 34.1 mb/d in the medium-term, before growing to 42.7 mb/d in the long-term.

Figure 4.2
Composition of long-term global liquids supply growth, 2020–2045



Source: OPEC.

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

Lifted by a wave of optimism and economic growth, a resulting demand recovery, and a supportive market environment as the world gradually overcomes the COVID-19 pandemic, non-OPEC liquids supply is set to rebound. On a quarterly basis, non-OPEC liquids supply had already stabilized around mid-2020 and has grown modestly since. On an annual basis, liquids supply in 2020 averaged 62.9 mb/d and is set to recover to 63.8 mb/d in 2021. Thereafter, growth is projected to pick up, with supply rising by 2.1 mb/d in 2022 and an average 1.1 mb/d p.a. in the remainder of the medium-term, reaching 70.4 mb/d by 2026.

The key drivers behind this projected growth are visible signs of near-term recovery. For example, shut-in production resuming; rig counts, drilling and fracking activity rising; and upstream investment returning, albeit cautiously. According to Wood Mackenzie, the number of final investment decisions on new field start-ups is now assessed at around 30 for 2021, up from just 12 in 2020. Moreover, profitability has returned, with equity valuations (for publicly-traded

oil companies) having jumped on bumper quarterly results. The resulting dividend pay-outs and share buybacks make the entire E&P sector one of the success stories of the year so far, despite the headwinds from an increased investor and media focus on the energy transition and ESG concerns.

Furthermore, the shock of sharply lower oil prices triggered by the unprecedented huge, albeit temporary, drop in oil demand in 2Q20 kept pressure on costs (Figure 4.3), bringing down break-even prices. The slashing of overheads and head counts, further efficiency gains in the design stage of upstream projects, pressure on oil service companies, and in some cases, lower energy and other costs have resulted in significant savings for oil companies. Now that oil prices have recovered, even while belts have effectively remained tightened, companies are enjoying bumper results. Oil demand is evidently making a strong recovery, and based on the assumption that oil markets will remain relatively stable and supportive this is expected to result in continued investment.

Figure 4.3
Cost of drilling US oil & gas wells (January 2010 = 100)

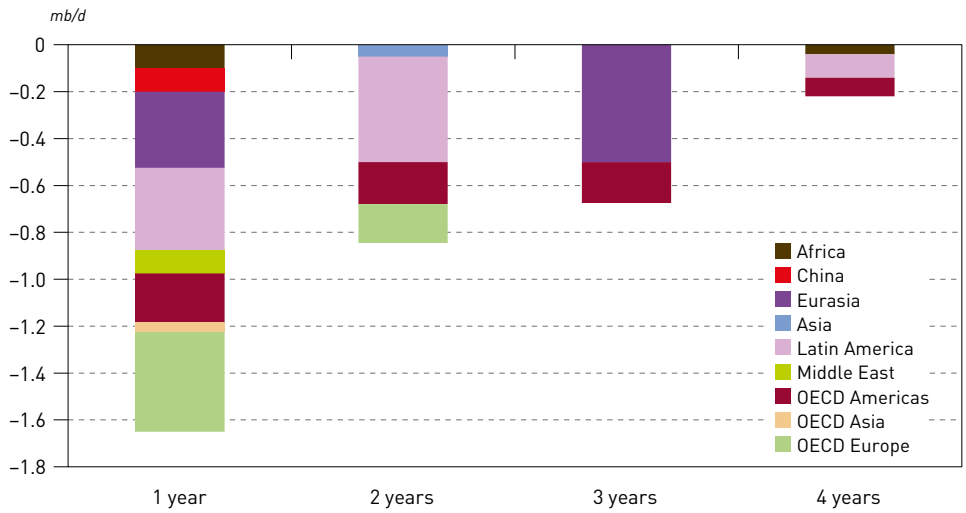
Source: US Bureau of Labor Statistics.

Given the usual assessment of medium-term project start-ups that are either already confirmed or expected to receive a final investment decision (FID) in the near-term, the outlook is for a strong recovery in non-OPEC liquids supply, with pre-pandemic levels already attained (on an annual basis) in 2022. From 62.9 mb/d in 2020, production is expected to grow to 70.4 mb/d in 2026, or by an average 1.25 mb/d p.a. After only modest growth in 2021, incremental supply in 2022 is expected to be strong, at 2.1 mb/d, as the recovery in US tight oil supply picks up pace, and as non-OPEC countries in the DoC continue to return shut-in capacity to the market.

Despite some delays, new project start-ups in countries such as Brazil, Canada, newcomer Guyana, Russia, Kazakhstan and Qatar are set to contribute to healthy long-term non-OPEC liquids supply. Most other non-OPEC producers – including Norway, China, Colombia, the UK, Mexico and Indonesia – are expected to experience declining output over the long-term. Analysis of the sum of non-OPEC upstream projects that have experienced delays (relative to start-up dates

assumed before the COVID-19 pandemic hit) indicates substantial affected volumes. Of a total of 3.4 mb/d, around half, or 1.7 mb/d, were postponed by one year, some 0.8 mb/d by two years, and the rest by three-to-four years (Figure 4.4).

Figure 4.4
Non-OPEC liquids supply: select upstream project start-up delays*



* *Figure shows the number of years by which project start-ups have been delayed, comparing the WOO 2021 assessment with that of pre-pandemic WOO 2019.*
Source: OPEC.

Box 4.1

Supply crunch on the horizon?

As oil markets recover swiftly from the pandemic-induced slump, warnings of an impending or eventual oil supply crunch surface periodically. The premise is that, as oil demand rebounds post-pandemic, investment in new oil supply fails to keep pace. The result would be a future period of pronounced market tightness; a bust followed by a boom. It would also lead to widespread volatility and uncertainty, which is in the interest of neither producers nor consumers.

Looking beyond the next couple of years, some voices are increasingly pointing towards the energy transition and the potential for a long-term, structural supply crunch, due to the policy implications of a push towards the use of more renewables (and subsequently less fossil fuels) in the energy mix.

Already, some investors, activists and companies are highlighting the need to limit investment in what they term 'stranded assets', or assets deemed to have ESG concerns. The risk is that withholding investments in the medium- and long-term could lead to a disorderly, volatile and one-sided transition, even while – as this Outlook projects – the world will continue to need oil for the foreseeable future.

However, while there is a possibility of production falling short – indeed, supply sensitivity modelling in Chapter 8 presents a potential Lower Supply Case in detail, without assigning any probability to this happening – there are a number of reasons to believe that this is unlikely to occur.

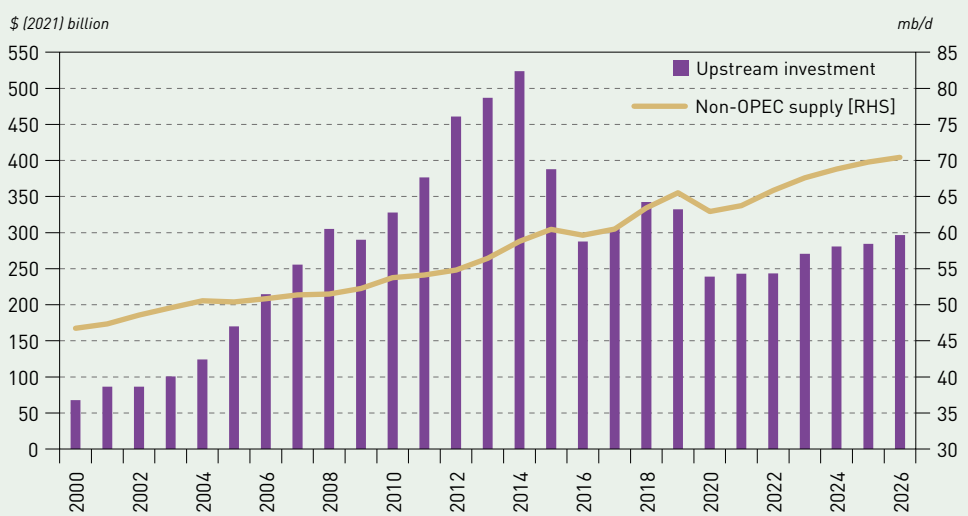
The key question in the short- to medium-term is whether upstream investment will be sufficient. Indeed, one of the main reasons this issue has resurfaced is due to the fact that capital expenditure in 2020 was down by 28%, from around $330 billion in 2019, to only $240 billion in 2020, according to Rystad Energy (Figure 1). Wood Mackenzie, similarly, estimates that spending was down by 28% in 2020. The outlook for 2021 is uncertain, but Wood Mackenzie projects that upstream spending will rise again, by a modest 4%, picking up to 10% in 2022. Rystad Energy thinks a recovery will take longer, seeing very flat spending in 2021–2022, and a more sizeable rise of 11% only in 2023.

However, there is a risk of extrapolating too much from one data point. Arguably, there was significant cost inflation in the years before total spending reached a high point in 2014. Even at its reduced level, estimated spending in 2020 roughly matches that of 2006–2007, by no means a low point for supply growth. Moreover, while in 2016, following two successive years of 26% drops in upstream investment, non-OPEC liquids supply did decline by 0.8 mb/d, it rebounded by the same amount in the subsequent year. Thereafter, it expanded by a stunning 5 mb/d in 2018–2019, before COVID-19 struck, even though upstream investment only rose more gradually compared to earlier periods.

A key characteristic of commodity markets is their cyclicality, and eventually, any supply shortfall, if it emerges, typically results in higher prices, which in turn stimulates more investment again. Thus, in oil's 150-year history, there have been numerous boom and bust cycles.

In any case, in the short- to medium-term, before any investment-related supply tightness could emerge, OPEC Members and other countries participating in the DoC still have spare

Figure 1
Global upstream capital expenditure (oil only); non-OPEC liquids supply



Source: Rystad Energy, OPEC.

capacity, even as they gradually unwind production adjustments made at the onset of the COVID-19 crisis. An agreement struck in July 2021 extended the arrangement through the end of 2022, formalizing the return of the adjustments in a timely fashion as demand recovers, even while leaving open the option to continually re-adjust, should the need occur. Some OPEC Member Countries are also in the course of expanding production capacity.

In the longer-term, concerns about potential supply tightness rather stem from expectations that policies enacted to achieve the goals of the Paris Agreement will have a bearing on the oil sector, in general, and the upstream, in particular. Besides plans to significantly reduce emissions, as spelled out by the major G7 economies and China, as well as others, additional possible reforms include tightening environmental regulations surrounding the production, refining, transport and consumption of oil (such as future bans on ICEs in some regions), carbon taxes, and similar.

At least indirectly, this is already influencing some oil companies, with many of the western majors rolling out ambitious plans to reduce their own emissions, and to transition towards becoming a more integrated energy company, rather than specifically an oil company. In mid-2021, a court decision ordering Royal Dutch Shell to cut its CO_2 emissions by 45% compared to 2019 levels, in line with the Paris Agreement, and activist members being elected to ExxonMobil's board attracted much commentary.

However, this is arguably a very western, or even Eurocentric perspective, and drawing conclusions that pressure on a certain cohort of companies will necessarily lead to lower investments may be erroneous. It is so far mostly European major oil companies that have been most vocal about their environmental credentials – US-based integrated oil companies have been noticeably more reticent, let alone Asian, Latin American or Russian ones. Moreover, while publicly-traded companies must adhere to their shareholders' wishes, the same is not true for national oil companies (NOCs), nor for privately-held companies, such as US shale operators owned by private equity money.

Much has also been made about some European banks' reluctance to lend money for projects they consider environmentally sensitive; but the same may not be true for large financial institutions from elsewhere. Even those IOCs with ambitious environmental goals are not planning to exit the oil and gas business entirely.

Ultimately, this Outlook assumes – at least in the Reference Case – that there will be continued demand for oil, even in the long-term, and that market mechanisms will ensure that it is attractive to invest in the required upstream capacity. It should also be recognized that in a case where world oil demand peaks or declines, oil will be needed. In fact, just to keep production flat requires significant investments to offset some 3–5 mb/d of natural decline p.a. due to mature fields seeing production drop off.

In an interesting twist, after years of periodically warning of underinvestment in new oil production capacity, the International Energy Agency (IEA) in large part triggered the more recent debate with the publication of its much-quoted 'Net Zero by 2050' report, which suggested investment in new oil and gas fields would no longer be needed in a world that pushes to achieve net-zero emissions by 2050.

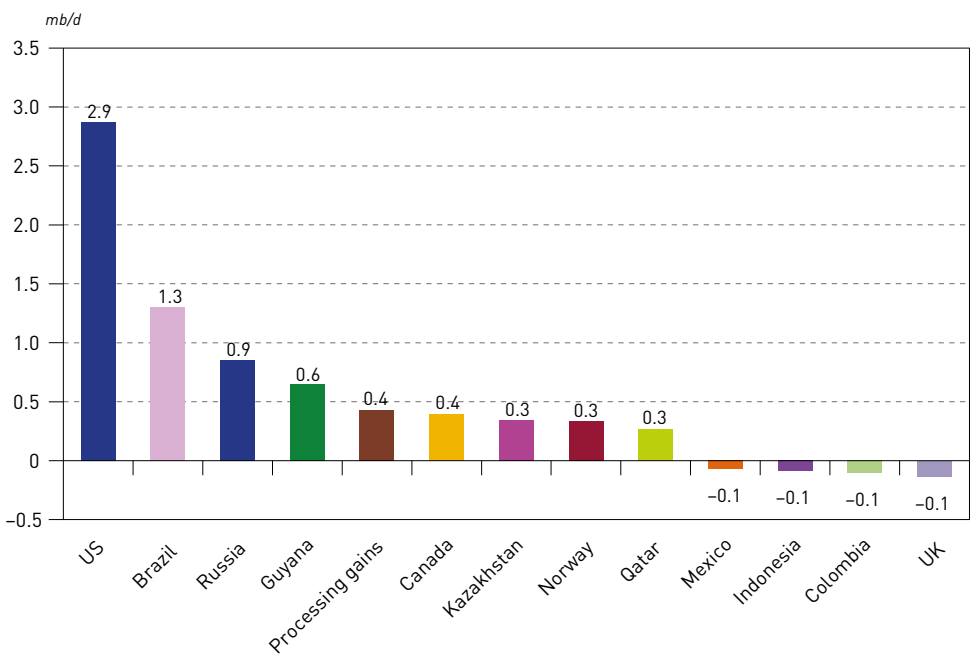
It is without doubt prudent to monitor investments and other factors that could herald tightness in the upstream sector. This is a constant; it is what all forecasters and companies do. OPEC's WOO 2021 continues to call for upstream investment to be sustained (see Section 4.6 in Chapter 4), given that oil demand continues to expand over most of the forecast period.

With the likelihood of a supply crunch on the horizon quite low, undue pessimism may not be helpful. On the other hand, if necessary investments fail to materialize in the coming years, for one reason or another, this opinion may need to be revisited.

4.3 Liquids supply outlook by main regions

The main driver of near-term recovery will be US tight oil, with particularly strong growth in the initial years of the medium-term, albeit from a lower base, as US crude oil saw the largest single shut-ins when the pandemic hit. Despite some project delays, Brazil and Guyana are likely to see steady growth in the next five years. DoC participants, Russia, Kazakhstan and others, are expected to return shut-in production adjustment volumes to market, in addition to some new capacities being brought online. Lastly, stalwarts Canada, Norway and Qatar are also set to add meaningful volumes in the medium-term (Figure 4.5).

Figure 4.5
Select contributors to non-OPEC total liquids change, 2020–2026

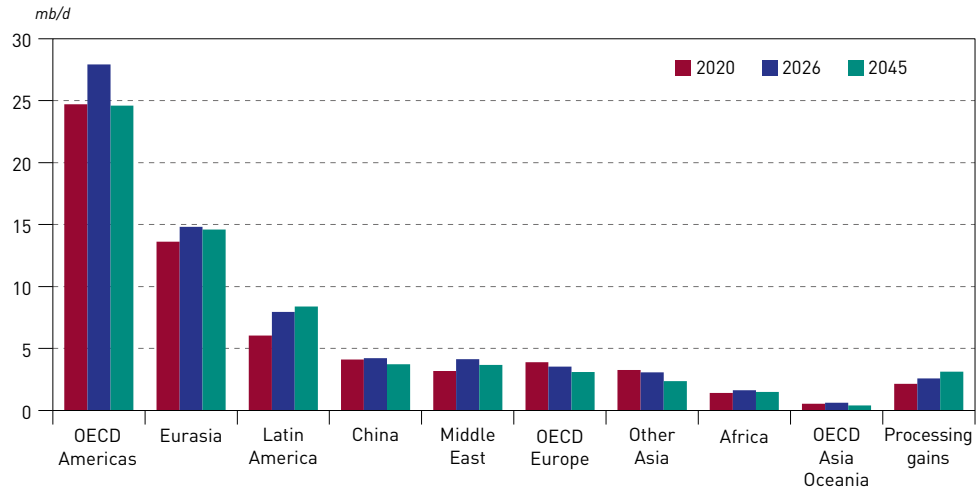


Source: OPEC.

Beyond the medium-term, the key shift in the non-OPEC liquids supply dynamic is the projected peak and slow decline in US tight liquids supply beginning around 2030. Norway too will see declining output. Otherwise, the drivers of growth in terms of countries are similar to the medium-term, albeit with Brazil, Canada and Guyana more dominant. Most other non-OPEC producers are expected to see stagnation or slow long-term decline.

Regionally, this decline results in non-OPEC medium-term liquids supply growth taking place mainly in OECD Americas, Latin America and Eurasia, and to a lesser extent in the Middle East, Africa and OECD Europe. By contrast, in the long-term, OECD Americas is more or less flat, and major growth is only present in Latin America, Eurasia and the Middle East (Figure 4.6).

Figure 4.6
Long-term non-OPEC liquids supply outlook by region



Source: OPEC.

4.3.1 Major countries

US

Outside of the DoC participating countries, the US saw the single largest (temporary) adjustment to its liquids supply as a result of the pandemic-related price slump. Crude oil production fell from a 1Q20 average of 12.8 mb/d to below 10 mb/d by May 2020, although it picked up again to around 11 mb/d by the end of the year. On an annual average basis, 2020 crude production fell from 12.2 mb/d in 2019 to 11.3 mb/d in 2020. Total liquids supply dropped from 18.4 mb/d in 2019 to 17.6 mb/d in 2020, with lower crude partly offset by a modest increase in natural gas liquids (NGLs) output. However, US tight crude and, consequently, total liquids supply, is expected to grow again in the coming years. While operators have remained highly disciplined in 2021, indications are for a return to growth from 2022. Rig counts continue to rise, more wells are being fracked, more frac crews are being deployed, and with firms again flush with free cash flow, the outlook is for a return to reinvesting more of these funds into new capacity.

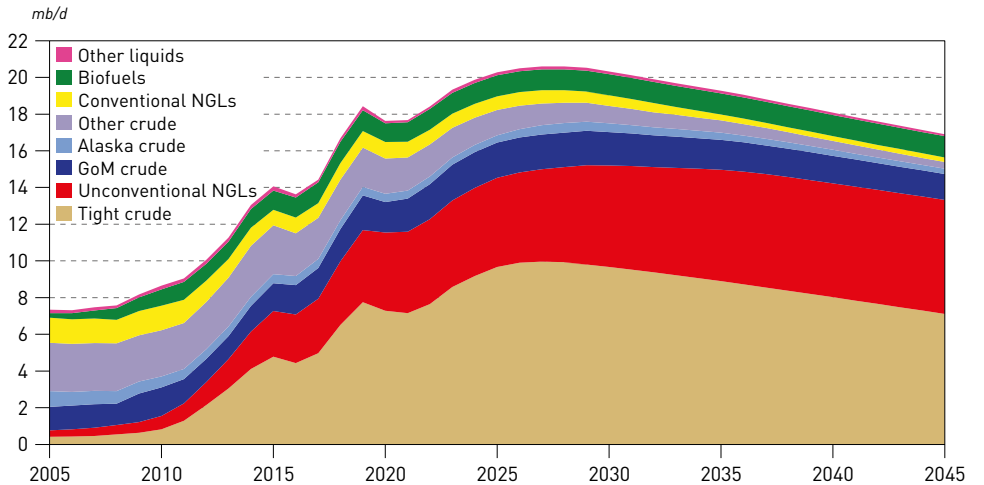
In essence, companies will soon be in a position to return cash to investors and invest in new capacity at the same time. As a result, the outlook is for US tight crude to rise from 7.3 mb/d in 2020 to 9.9 mb/d by 2026, with growth front-loaded (Figure 4.7).

Besides tight crude, conventional crude produced offshore in the Gulf of Mexico is also expected to rebound over the medium-term, with several new fields coming online, albeit with some delayed due to the pandemic. The area also suffered from a powerful hurricane season in 2020, with large volumes temporarily shut-in.

New capacities stem from the expansions of BP's Atlantis and Thunder Horse complexes, adding 35 tb/d and 50 tb/d, respectively, in 2021. A slew of new projects are expected in 2022, including the large 120 tb/d Mad Dog 2 start-up (also BP), as well as the 80 tb/d Vito and King's Quay developments, operated by Shell and Murphy, respectively. Towards the end of the medium-term period, the 80 tb/d Anchor, Whale and North Platte fields are expected to come on-stream.

As a result of these and other start-ups, US Gulf of Mexico offshore production is set to recover from a low of 1.7 mb/d in 2020, rising to 1.8 mb/d in 2021 and nearly 2 mb/d in 2024. Thereafter,

Figure 4.7
US total liquids supply outlook



Source: OPEC.

production is expected to slowly decline again. Nonetheless, a long list of potential projects, if sanctioned, and depending among other things on policy developments, could maintain Gulf of Mexico production at higher levels.

Meanwhile, various developments on the policy front have the potential to impact medium- and long-term US liquids supply. The Biden administration made waves by announcing several interim measures, including the halt to leases and a moratorium on drilling (subsequently challenged) – all on federal lands. It also halted the development of oil resources in the Alaska National Wildlife Refuge (ANWR), a large tract of adjacent land to the east of current producing areas, and long off-limits to drillers. The Trump administration had given the green light to lease sales there in its final days.

Elsewhere, the disputed Keystone XL pipeline from Canada to Nebraska was cancelled after the Biden administration revoked the previous administration's approval. Other pipelines designed to bring Canadian and/or tight oil from the Bakken in North Dakota south to refining hubs, notably including the Line 3 expansion and Dakota Access pipelines, also remain uncertain.

While the ANWR was put off limits again for drillers (and in any case, no major E&P companies had shown interest in bidding for leases), the Biden administration has given the go-ahead to the large Willow field. Willow and some other related deposits are in an area called the National Petroleum Reserve in Alaska (NPR-A), a mostly untapped area to the west of the Alaska's main producing areas, and originally put aside as a strategic reserve for the Navy in the 1920s. Willow had received the go-ahead from the previous administration, but faced a setback in early 2021 following a federal court decision related to an environmental lawsuit. Willow is a potentially large project, which with some related assets, could add up to 150 tb/d of new capacity in the latter half of the decade.

In combination with the large Pikka field that is expected to come online from around mid-decade and with a nameplate capacity of 100 tb/d, Alaska's crude output, long in decline, could experience a bit of a resurgence. The state could recover 2020 production levels of 440 tb/d by 2026, growing to some 530 tb/d in the late 2020s, before declining again, unless other new large fields are sanctioned.

In the longer-term, the Biden administration has also recommitted to the Paris Agreement and has published plans to achieve full decarbonization of the power sector by 2035, and a fully 'net-zero' economy by 2050. Oil and gas producers will likely face higher taxes and royalties; tighter environmental restrictions, especially regarding methane emissions and gas flaring; and eventually possibly a CO_2 tax.

At least in the medium-term, however, it remains questionable what, if any, impact these measures will have on US-based oil production. First of all, the halt to drilling and leasing were only intended to be temporary, and in mid-June, a court ruled that the leasing ban potentially overstepped federal authority.

It should be noted that only a relatively modest share of total oil and gas production activity actually takes place on federal lands, at least onshore. According to the US Energy Information Administration (EIA), in 2019 oil produced on federal lands made up 22% of total output; the figure was 12% for natural gas – although the majority of this is produced offshore. According to the Bureau of Land Management (BLM), onshore acreage alone accounts for 8% of oil and 9% of gas production in the US.

Moreover, even were a drilling ban to be implemented, tight oil producers in particular have large inventories of drilled-but-uncompleted wells (DUCs), as well as prime acreage already leased to them to fall back upon. S&P Platts estimated in January 2021 that a full ban on drilling on federal lands could cut output by 1.1–1.6 mb/d. If the ban were only to apply to onshore territory, it would arguably take even longer to have an impact, due to existing leases and acreage held by companies, some of which is already pre-drilled.

In sum, total US crude oil supply is set to decline from 11.3 mb/d in 2020 to 9.2 mb/d in 2045. By contrast, total NGLs (including the shale-derived unconventional type) is forecast to rise steadily from 5.2 mb/d in 2020 to 6.5 mb/d in 2045. Total biofuels is anticipated to inch up marginally to 1.2 mb/d, while other liquids (mostly refinery additives) is set to stay flat at 0.1–0.2 mb/d in this timeframe. As a result, US total liquids supply is projected to decline from 17.6 mb/d in 2020 to 16.9 mb/d in 2045, after peaking at around 20.6 mb/d in the late 2020s (Table 4.3). For more discussion on US tight oil, see Section 4.5.

Table 4.3
US total liquids supply in the long-term

mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2020–2045
US tight oil	11.7	11.5	14.5	15.2	15.0	14.2	13.3	1.8
of which: tight crude	*7.8*	*7.3*	*9.7*	*9.7*	*8.9*	*8.0*	*7.1*	*–0.2*
of which: unconventional NGLs	*3.9*	*4.3*	*4.9*	*5.5*	*6.1*	*6.2*	*6.2*	*1.9*
US Gulf of Mexico crude	1.9	1.7	1.9	1.8	1.6	1.5	1.4	–0.2
US Alaska crude	0.5	0.4	0.4	0.5	0.4	0.3	0.3	–0.2
US other crude	2.1	1.9	1.4	1.0	0.7	0.5	0.4	–1.6
US other NGLs	0.9	0.9	0.7	0.6	0.3	0.3	0.3	–0.6
US biofuels	1.1	1.0	1.1	1.1	1.1	1.2	1.2	0.1
US other liquids	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.0
Memo item: US total crude	*12.2*	*11.3*	*13.4*	*12.9*	*11.6*	*10.3*	*9.2*	*–2.1*
Memo item: US total NGLs	*4.8*	*5.2*	*5.6*	*6.1*	*6.4*	*6.5*	*6.5*	*1.3*
Total US liquids production	**18.4**	**17.6**	**20.3**	**20.3**	**19.3**	**18.1**	**16.9**	**–0.7**

Source: OPEC.

Canada

Liquids supply in Canada was also affected by the pandemic-related demand slowdown, with production dipping from 5.4 mb/d in 2019 to 5.2 mb/d in 2020. Some Albertan production was also forced to shut-in as the provincial government mandated curtailments in an attempt to shore up differentials *vis-à-vis* US crude grades. However, these curtailments were phased out and finally came to an end in December 2020.

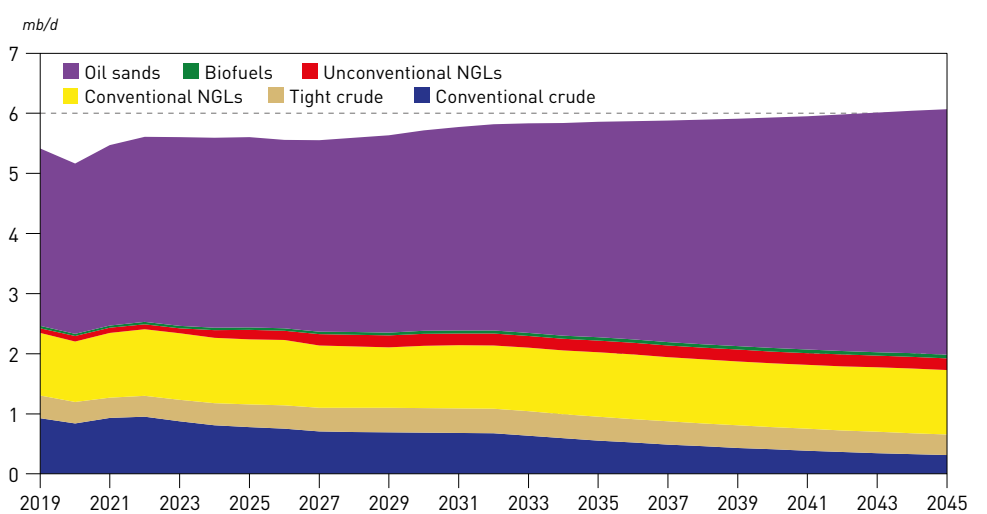
Canadian oil production has recovered so far in 2021 and over the medium-term period is expected to grow from an average 5.2 mb/d in 2020 to 5.6 mb/d in 2026. The majority of this incremental supply stems from oil sands-derived production, even as conventional crude supplies decline slowly. There is a degree of uncertainty over some large-scale conventional on- and offshore crude upstream projects, including notably the 75 tb/d West White Rose field, offshore Newfoundland, with start-up now likely to be delayed until 2025, from 2022. The delay came after operator Husky merged with Cenovus Energy in late 2020, and the field's scope and costs were re-evaluated.

The Bay du Nord offshore field, which was also put on hold because of the pandemic, now looks likely to go ahead, with an FID expected in 2023/24, after increased drilling enlarged its reserves base significantly. It now has estimated reserves of nearly 1 billion barrels, while production capacity could be 150 tb/d, with output starting from 2028. The field is located in challenging circumstances, in more than 1,000 metres of water and with drifting icebergs in the area.

In the longer-term, the outlook is for further steady growth in liquids supply from Canadian oil sands, with total output rising from 2.8 mb/d in 2020 to 3.1 mb/d in 2026, and to 4.1 mb/d by 2045. The revoking of the Keystone XL pipeline permit by the Biden administration is potentially a blow to further export increases, but expectations are for sufficient offsets from other pipelines, eventual exports to Asia, and increased rail shipments. The possibility of mergers between railway operators in the US and Canada may provide an extensive network to facilitate exports of Albertan oil to US Gulf Coast refiners.

Growth in oil sands-derived production and a modest increase in NGLs output will, however, be partly offset by continued declines in conventional crude. Total Canadian liquids production is thus

Figure 4.8
Canada total liquids supply outlook



Source: OPEC.

expected to rise from 5.2 mb/d in 2020 to 6.1 mb/d by 2045, providing one of the largest sources of non-OPEC liquids supply growth (Figure 4.8).

Mexico

Mexico's total liquids supply is projected to stay flat at around 1.9 mb/d over the course of the medium-term. National oil company Pemex is scheduled to bring on-stream a string of smaller developments, but is suffering some delays resulting from pandemic-related financial and operational hurdles. Nonetheless, the start-up of the Area 1 field cluster, Ixachi expansion and Hokchi fields, as well as the larger Zama and Trion developments towards the end of the medium-term period, will help to stem and reverse the decline in output seen in recent years. Over the long-term, however, unless new resources can be tapped, Mexican liquids supply is projected to decline to 1.6 mb/d by 2045.

Norway

Norway's total liquids supply increased to 2 mb/d in 2020, from 1.7 mb/d in 2019, as production at the super-giant Johan Sverdrup field continued to increase steadily, and amid a range of other, smaller field start-ups. Phase 1 of Johan Sverdrup is now expected to reach full capacity of around 535 tb/d in the course of 2021, and starting from 2022, a second phase will add another 220 tb/d.

Despite a series of pandemic-related delays to projects including Nova (ex-Gjoa), Johan Castberg and Martin Linge, Norwegian production continues to benefit from expected small- to medium-sized fields being tied back to production hubs. From 2023 and 2024, production from Johan Castberg will likely add another 200 tb/d, pushing the country's total supply to a new peak of 2.5 mb/d in 2024, a level last reached in 2008. Thereafter, underlying decline in the mature base will see Norwegian liquids supply slide again, reaching around 2 mb/d by 2030 and an estimated 1.3 mb/d by 2045.

UK

Compared to Norway, the UK will see a more modest string of new field start-ups in the medium-term, and is thus projected to see a decline in liquids supply from 1.1 mb/d in 2020 to 0.9 mb/d in 2026. Starting from 2021, new projects include Cragganmore, Vorlich, the Evelyn tieback to the Triton complex, Galapagos and the Penguins redevelopment.

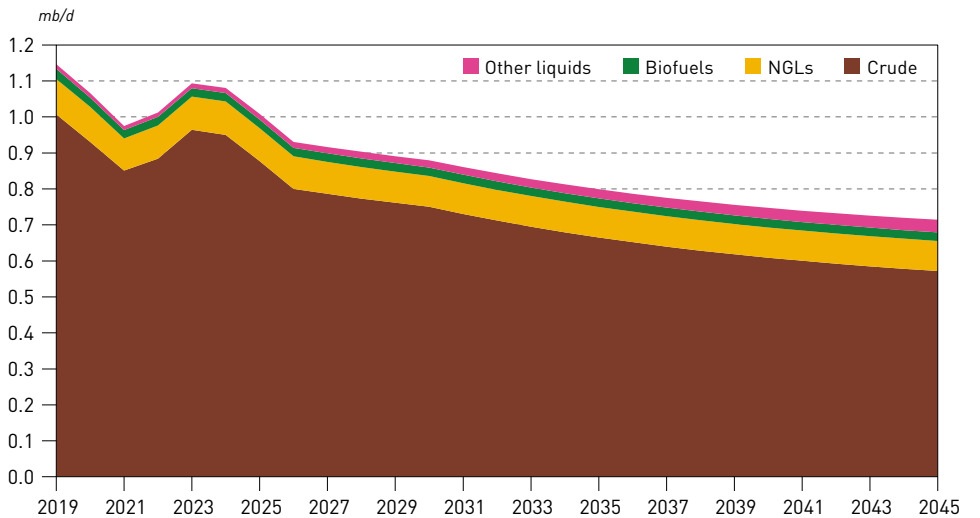
Like other countries, the UK suffered numerous delays and the postponement of decisions for field start-up dates and investment commitments due to the COVID-19 pandemic. At the same time, if some of the larger fields postponed get the go-ahead, such as the 100 tb/d Rosebank project, there is also some upside to this outlook.

In March 2021, industry body Oil & Gas UK warned of the impact of underinvestment in the UK's upstream sector if the government failed to provide more policy certainty. Under pressure to live up to its environmental promises, the government announced a $22 billion plan in March 2021 to decarbonize the North Sea oil and gas sector, likely raising costs and potentially making further development less attractive. It will also likely evaluate whether the current upstream licensing system is in line with its climate commitments. Any significant tightening of restrictions could lead to an even steeper decline than currently projected in the long-term outlook, which sees UK liquids supply edging down to 0.7 mb/d by 2045 (Figure 4.9).

Brazil

Both in the medium- and long-term, Brazil remains one of the largest contributors to non-OPEC liquids supply growth. As with other producers, it experienced some project delays due to the pandemic, mainly related to workforce restrictions in Asian shipyards involved in the construction of floating production, storage and offloading (FPSO) vessels destined for Brazil's huge offshore production zones.

Figure 4.9
UK total liquids supply outlook



Source: OPEC.

Nonetheless, due to the extraordinary productivity and attractive economics of its large deepwater fields, no fewer than ten major FPSOs are expected to be launched in the medium-term, with a net nameplate capacity of 1.8 mb/d. These include the Buzios 5 and 6 projects, with capacities of 150 tb/d and 220 tb/d, respectively, adding to the already-large overall Buzios complex. Additionally, in 2022, the first stage of the major Mero complex is expected to see first production, followed by Mero 2 in 2023, Mero 3 in 2024 and Mero 4 in 2025, each with nameplate capacity of 180 tb/d.

A new milestone is also expected in 2024 with the start-up of the 220 tb/d Bacalhau field, the first to be run by an IOC – in this case Equinor, the operator, and with other stakes held by ExxonMobil, Petrogal and the Brazilian government.

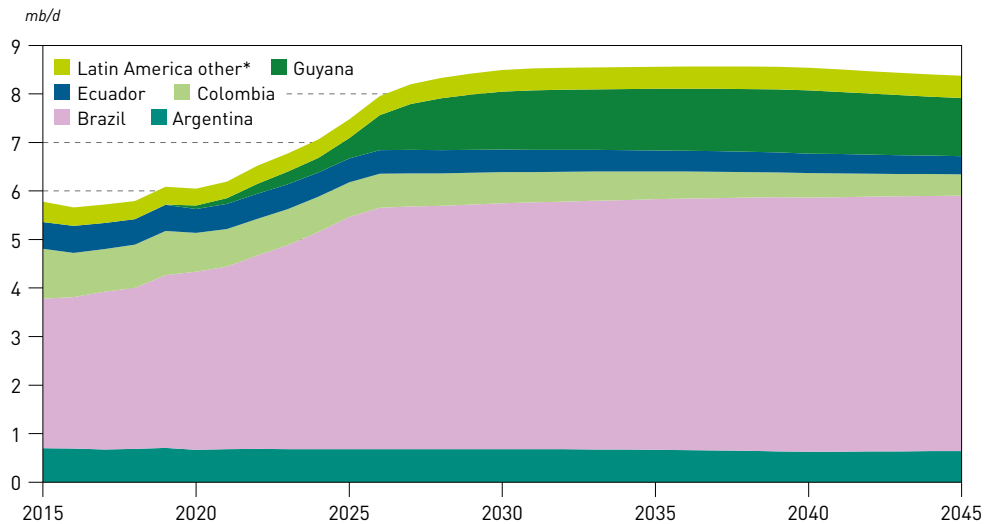
As a result, total Brazilian liquids supply is expected to rise from 3.7 mb/d in 2020 to 5 mb/d in 2026, largely driven by new output from its ultra-deepwater pre-salt sector. Thereafter, assuming continued investment in its prolific resource base, production is set to rise to a slightly higher 5.3 mb/d, albeit gradually, and plateau at this level in the long-term (Figure 4.10).

Guyana

Following initial oil production from the Liza complex in late 2019, Guyana produced an average 70 tb/d in 2020. With the expected start-up of Liza Phase 2 in 2022 and Liza Phase 3 in 2024, FPSOs with nameplate capacity of 220 tb/d and 180 tb/d, respectively, and further additions thereafter, medium-term production should rise to just over 0.7 mb/d by 2026. Following numerous discoveries on the wider Stabroek block, further expansion to at least 1.2 mb/d should be possible by around 2030, with potential upside to this outlook. Operator ExxonMobil, together with partners Hess and China National Offshore Oil Corporation (CNOOC), expect to have five FPSOs operating by 2026 and as many as seven-to-ten in the longer-term.

In neighbouring **Suriname**, a similar string of recent, prolific discoveries, essentially adjacent to those in Guyana, will likely result in it also becoming an oil producer in the latter half of the 2020s.

Figure 4.10
Latin America total liquids supply outlook



* *Latin America other includes Bolivia, Cuba, Peru, Trinidad & Tobago, Suriname and smaller producers, but excludes OPEC Member Venezuela.*

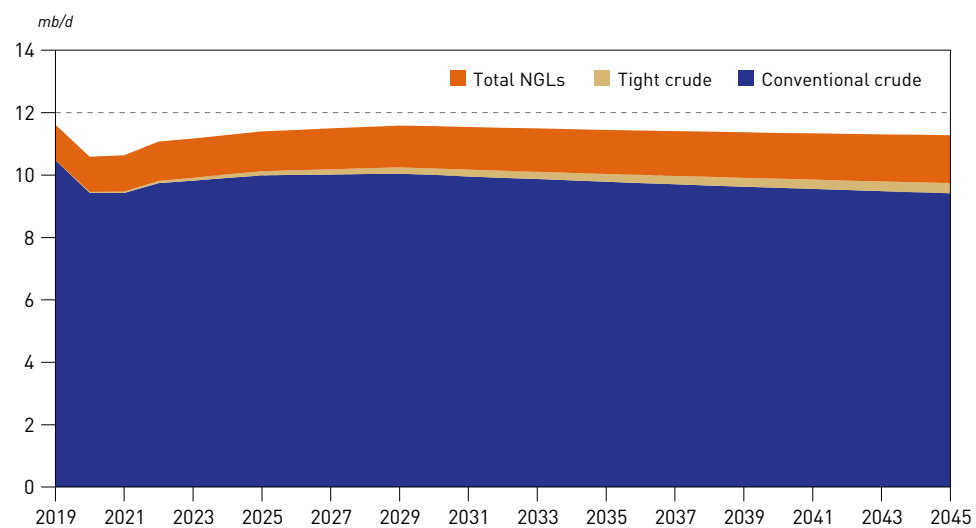
Source: OPEC.

4

Russia

Russia's total liquids supply is projected to rise from 10.6 mb/d in 2020 to around 11.5 mb/d in 2026, as production adjustments are unwound and some new projects start up. Thereafter, the outlook is for a long-lasting plateau at around a similar level, before an expected slow decline sets in towards the end of the long-term forecast period (Figure 4.11).

Figure 4.11
Russia total liquids supply outlook



Source: OPEC.

On the one hand, despite the Russian government having eliminated some Mineral Extraction Tax (MET) breaks on high-viscosity fields, several producers of heavy oil claimed that investments and further growth in this sector are at risk. Similar warnings are regularly heard when the government adjusts or announces tweaks to other specific tax breaks, including for offshore, heavy or other types of crude oil. At the same time, the government continues to, in effect, experiment with the recently-introduced excess profit tax, having expanded trials to a far wider set of fields.

The government acknowledged – in a draft report released in early 2021 – the challenges the Russian oil sector faces in the light of a weaker post-pandemic global demand outlook, and mounting pressure for potential climate-related policy changes.

Again, taxation levels and implementation remain key to developing more expensive, technically challenging or remote reserves, including offshore – especially the Arctic – and in Eastern Siberia. This Outlook assumes that while western sanctions remain in place, development of offshore Arctic oil, in particular, will likely remain prohibitively expensive.

Nonetheless, Rosneft is increasingly likely to go ahead with its ambitious Vostok Oil mega-project, which would help to sustain, or potentially even grow, long-term output. In reality this is a collection of existing assets already under production, including the Vankor, Suzun and Tagul fields, among others, and would also include new fields such as the Payakha complex, as well as the Zapadno-Irkinskoye field, and other so-far largely unexplored assets. Located in the Krasnoyarsk region in Eastern Siberia, close to Russia's northern Arctic coast, the oil would be gathered and exported from a new terminal on the Taimyr peninsula and shipped to markets via the new Northern Sea Route. Given the existing infrastructure around the large Vankor complex, it would be used as a hub from which a new pipeline would be built to the export terminal on the coast.

The Vostok mega-project has so far attracted significant MET and other tax breaks. Moreover, large commodity traders Trafigura and Vitol bought stakes of 10% and 5%, respectively, in late 2020 and mid-2021, while many contracts for related infrastructure have been signed. According to statements, Rosneft hopes to be able to export as much as 600 tb/d of Vostok-related crude oil from 2024, with later phases of the entire project seeing production potentially rising to 1–2 mb/d. However, it remains somewhat unclear how much of this would rely upon existing production assets and, given the huge size of the project, there may be delays.

Kazakhstan

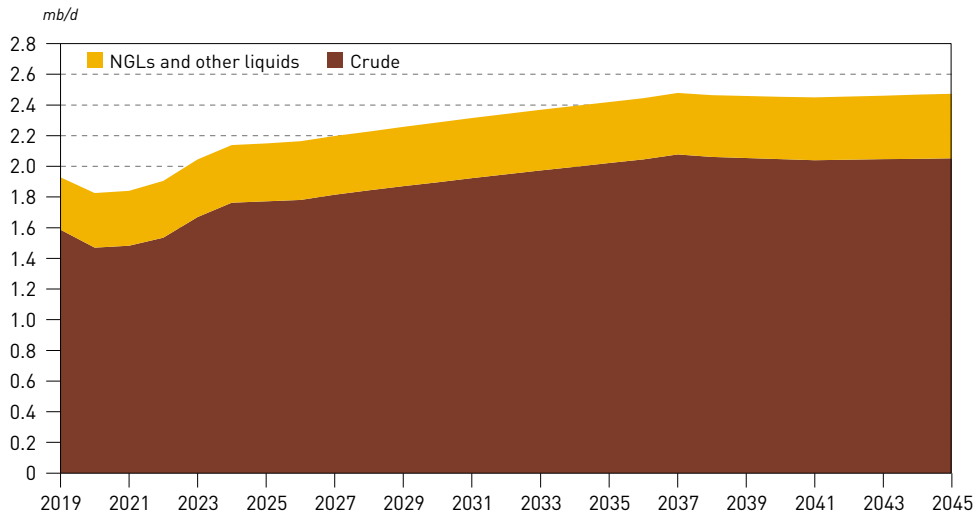
Kazakhstan is projected to be a major driver of future non-OPEC liquids supply with output rising from 1.8 mb/d in 2020 to 2.2 mb/d in 2026, with production at existing assets increasing.

The Kashagan gas re-injection project should add around 100 tb/d by 2025, and the Future Growth Project at the super-giant Tengiz field should come online from 2024, adding 260 tb/d. In late December 2020, the Karachaganak condensate field got the go-ahead for some smaller incremental production, helping to keep production at the field flat until the 2030s. Beyond the medium-term, further, modest expansion at existing fields is projected to result in total liquids supply rising to 2.5 mb/d in the 2030s and then plateauing at that level (Figure 4.12).

Uganda, Kenya and Senegal

In Uganda, the long-awaited final investment decision to proceed with the construction of a strategic pipeline was made in April 2021, which will enable the development of the 230 tb/d Lake Albert complex of fields. The pipeline will be the longest heated pipeline in the world, stretching some 1,500 km from Hoima near Lake Albert in Uganda, to Tanga on the Tanzanian coast. Joint-venture partners TotalEnergies and China's CNOOC will then develop the 190 tb/d Tilenga and

Figure 4.12
Kazakhstan total liquids supply outlook

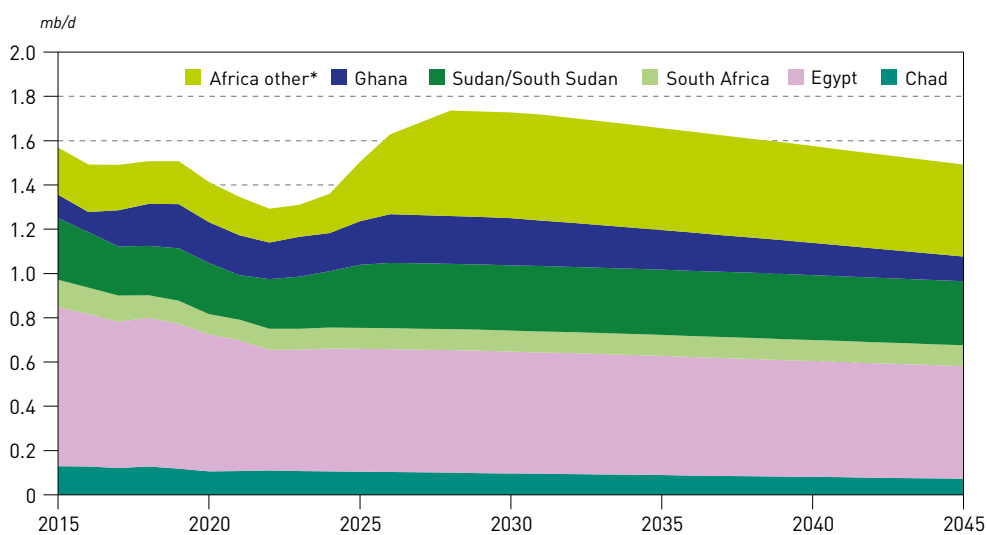


Source: OPEC.

40 tb/d Kingfisher fields to feed the pipeline, as well as a 60 tb/d refinery to be built in Hoima. The first oil is expected from around mid-decade (Figure 4.13).

In further regional developments, the go-ahead in Uganda may sway Kenya towards developing similarly landlocked fields in the South Lokichar Basin. Meanwhile, in West Africa, Senegal is expected to see the first oil from the Sangomar Phase 1 project from around 2024, ultimately adding 100 tb/d with the potential to be developed in further phases.

Figure 4.13
Africa total liquids supply outlook



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

Source: OPEC.

4.4 Liquids supply by type

As observed in previous publications, crude oil supply growth is the main medium-term driver, making up 4.9 mb/d, or two-thirds of total non-OPEC supply growth of 7.5 mb/d to 2026. Over the long-term, crude oil production is set to drop by 4.1 mb/d, as US tight oil and other sources mature and decline. By contrast, NGLs are expected to see long-term growth of 2.8 mb/d, with global biofuels and other liquids (mainly Canadian oil sands, but also small volumes of GTLs and CTLs projected to increase by 1.5 mb/d and 1.4 mb/d, respectively (Table 4.4).

Table 4.4
Long-term global liquids supply outlook by type

mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2020–2045
Non-OPEC	**65.5**	**62.9**	**69.8**	**71.0**	**69.4**	**67.5**	**65.5**	**2.5**
Crude	45.8	43.5	48.0	47.5	44.7	41.9	39.3	–4.1
NGLs	11.0	11.2	12.3	13.3	13.8	14.0	14.1	2.8
Global biofuels	2.6	2.4	2.8	3.2	3.5	3.8	3.9	1.5
Other liquids	3.8	3.7	4.1	4.3	4.6	4.8	5.0	1.4
Total OPEC liquids	**34.6**	**30.7**	**34.0**	**35.7**	**38.5**	**40.6**	**42.7**	**11.7**
World	**100.1**	**93.6**	**103.8**	**106.7**	**107.9**	**108.1**	**108.2**	**14.3**

Source: OPEC.

The outlook for global biofuels supply growth has been revised up since the WOO 2020, as policy support for non-fossil fuels of various kinds is seen increasing in many parts of the world. Global supply is projected to grow from 2.4 mb/d in 2020 to 3.9 mb/d by 2045, with incremental volumes spread fairly evenly around the world (Table 4.5).

Table 4.5
Long-term non-OPEC biofuels supply outlook

mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2020–2045
OECD Americas	1.2	1.1	1.2	1.2	1.2	1.2	1.2	0.2
of which: US fuel ethanol	*1.0*	*0.9*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*0.1*
OECD Europe	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.4
OECD Asia Oceania	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
OECD	**1.5**	**1.4**	**1.6**	**1.7**	**1.8**	**1.9**	**2.0**	**0.6**
Latin America	0.8	0.7	0.8	0.9	0.9	1.0	1.0	0.3
of which: Brazilian fuel ethanol	*0.6*	*0.5*	*0.6*	*0.6*	*0.7*	*0.7*	*0.7*	*0.2*
China	0.1	0.1	0.1	0.2	0.3	0.3	0.3	0.2
Other Asia	0.2	0.3	0.3	0.4	0.5	0.6	0.6	0.3
Non-OPEC	**2.6**	**2.4**	**2.8**	**3.2**	**3.5**	**3.8**	**3.9**	**1.5**
of which: fuel ethanol	*1.8*	*1.7*	*1.9*	*2.1*	*2.2*	*2.4*	*2.4*	*0.7*
of which: biodiesel	*0.7*	*0.8*	*0.9*	*1.1*	*1.3*	*1.4*	*1.5*	*0.8*

Source: OPEC.

OECD Europe and Other Asia are expected to see growth of 0.4 mb/d and 0.3 mb/d, respectively, in addition to incremental supply from Latin America, China and OECD Americas. Numerous countries in Europe, with support from the EU, are hiking incentives or mandates for biofuels shares in regular petroleum fuels. Asian countries such as Indonesia, Malaysia and India already have domestic biofuels industries and these are expected to benefit from low-cost feedstock.

Another driver of biofuels supply growth is the trend towards converting uneconomic refineries into biofuels plants, rather than mothballing them entirely – a trend observed mainly in Europe so far. In addition, the focus on recycling wastes, such as cooking oil and other types of biomass, are especially boosting the outlook for biodiesel supply.

Lastly, so far biofuels have been almost exclusively used in the road transportation sector as additives to conventional gasoline or diesel. Yet there is considerable scope for use of so-called SAF in the airline industry. This is driven both by policymakers, as well as aeroplane builders and the airline industry, which are experiencing unprecedented scrutiny, not least because in most countries jet fuel use is taxed very lightly compared to road transportation fuels. In addition, from a technical point of view, the use of electrification, hydrogen or LNG in large aeroplanes is more challenging due to the large, heavy batteries or tanks required.

4.5 Tight oil: US and other countries

4.5.1 Global tight oil supply outlook

The picture for global tight oil supply outside of the US is largely unchanged compared to previous Outlooks. Global tight oil supply is projected to grow from 12.1 mb/d in 2020 to 14.7 mb/d in 2045, with the US making up over nine-tenths of this throughout the forecast period (Table 4.6). US tight oil supply also provides the majority of growth, rising by 1.8 mb/d in this timeframe. Canada, Russia and Argentina are forecast to see output rise to a respectable 0.3–0.5 mb/d in the long-term, with most of the increment provided by Russia. Other countries, such as China, Colombia and Mexico, to name just a few, also have significant potential to eventually develop capacity, if market and investment conditions permit.

Table 4.6
Global tight oil supply outlook

mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2020–2045
US	11.7	11.5	14.5	15.2	15.0	14.2	13.3	1.8
Canada	0.5	0.4	0.5	0.6	0.6	0.6	0.5	0.1
Russia	0.0	0.0	0.1	0.2	0.3	0.4	0.4	0.4
Argentina	0.1	0.1	0.1	0.2	0.3	0.3	0.3	0.3
Other	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
Total tight liquids	**12.2**	**12.1**	**15.4**	**16.3**	**16.2**	**15.6**	**14.7**	**2.6**

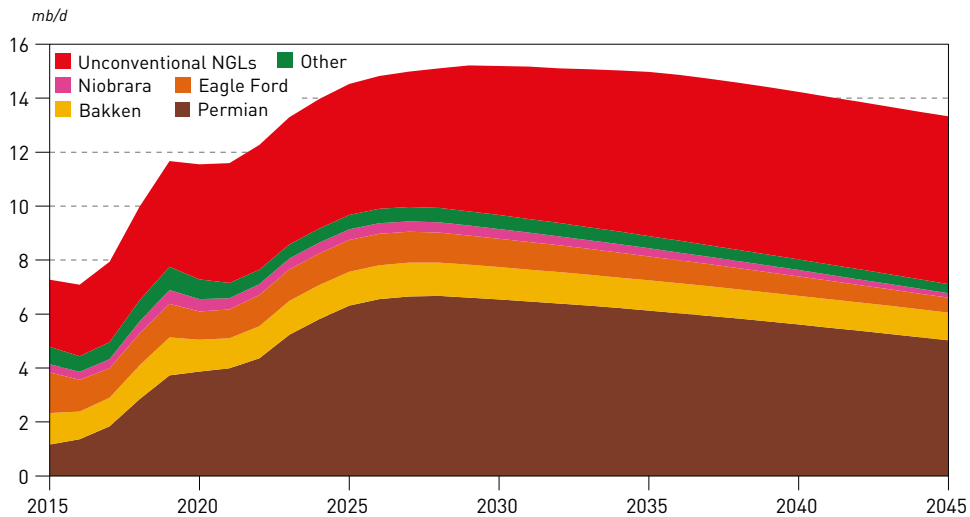
Source: OPEC.

4.5.2 US tight oil outlook

During the initial months of the pandemic-induced slump, US tight crude took a sharp downturn. In the end, however, due to a rapid restabilization of the market, not least due to the actions taken by the DoC participating countries, production evened out again, and on an annual basis it fell by only 470 tb/d in 2020. To some extent this was offset by continued growth in unconventional NGLs,

which grew by 340 tb/d in 2020. This pattern should be repeated in 2021, albeit less pronounced, but from 2022, US tight oil is expected to grow again. Thus, total US tight liquids is forecast to rise from 11.5 mb/d in 2020 to 14.8 mb/d by 2026, or by 3.3 mb/d (Figure 4.14). This is around 40% of total non-OPEC growth in this period.

Figure 4.14
US tight liquids supply outlook breakdown



Source: OPEC.

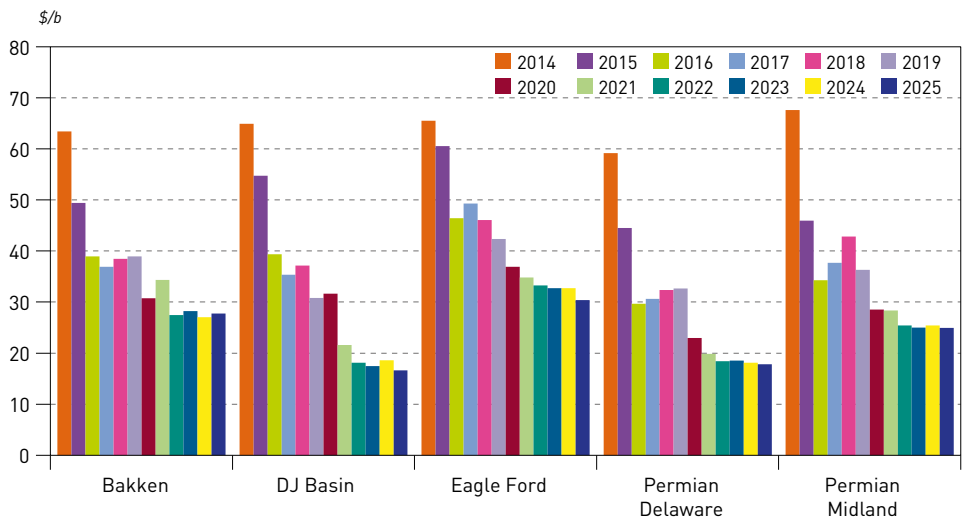
This growth trajectory represents a modest downward revision from the outlook presented in the WOO 2020. In late 2020, and so far in 2021, investors and tight oil producers have appeared cautious, with much talk of capital discipline, and attempts to avoid overproduction and a resulting boom and bust cycle. Moreover, besides the mighty Permian, most of the key producing basins are expected to soon reach their peak, as crucial 'Tier 1' acreage and drilling opportunities have largely been used up.

Nonetheless, for a number of reasons, US tight oil is expected to see a strong recovery in the latter part of the medium-term period. Assuming a continued supportive market environment, conditions are expected to gradually incentivize producers to boost output. Essentially this is also visible in forward-looking short-term indicators, including a rise in rig counts, increased drilling and fracking activity, a return to more upstream investment (albeit so far cautious), and increased mergers and acquisitions (M&A) activity. Key oilfield services provider Halliburton in July 2021 flagged what it saw as a bright outlook for upstream activity in North America (and internationally) in 2H21 and into 2022, speaking of double-digit growth in drilling and completion spending in the US shale patch.

Most importantly, at current and expected price levels, developing new tight oil production capacity remains eminently profitable. Recently, there has been an increased focus on generating free cash flow and returning funds to investors – in contrast to the initial years of the US shale boom when many companies redirected nearly all their revenue towards expanding production. The key point now is that with global demand expected to recover and grow further, at some point market conditions are expected to incentivize and enable tight oil producers to do both: increase production again, while returning money to shareholders.

This is evident in break-even prices which, according to Rystad Energy, averaged at the well-head, and depending on the basin, in a range of $20–$35/b (and falling) in 2021 (Figure 4.15). Even taking into account returns to investors and a degree of caution, especially among publicly-traded operators, prices consistently above $50–$60/b or more should allow for reinvestment beyond the level required to keep production steady.

Figure 4.15
Evolution of US tight oil wellhead breakeven prices by basin



Source: Rystad Energy, July 2021.

While much has been made of curbs to capital access, and some investors moving away from what has historically not been the best investment, private operators (as opposed to public ones) have taken the lead in hiking drilling activity, suggesting that once freed of (some of) the financial pressure, public companies may follow suit. Indeed, US E&Ps active in the US shale sector have been vocal about their appreciation of the actions of the DoC in terms of stabilizing markets, and not shy to highlight their renewed vigilance and conservatism in terms of curbing investment and growth. Therefore, the implication is that once market fundamentals have 'rebalanced', by which these companies seem to mean not just demand and supply becoming re-aligned, but also stocks and OPEC spare capacity having been drawn down, they will likely return to growth mode.

Thus, annual growth in total US tight liquids supply is expected to pick up again sharply in 2022 and 2023, growing at 0.7 mb/d and 1 mb/d, respectively, to some extent making up for the ground lost during the pandemic. It should also be noted that expansion at these levels is far from the record-high levels of 2 mb/d seen in 2018, or 1.7 mb/d in 2019, before COVID-19 struck.

In the latter years of the medium-term, annual growth is set to average 0.5 mb/d, before slowing further and peaking around the end of the decade. In 2030, total US tight liquids supply is estimated to average just over 15 mb/d, out of total US supply of 20 mb/d. After a long slow plateauing, US tight oil is expected to decline again, reaching 13.3 mb/d by 2045, and thus resulting in a concurrent decline in total US liquids production.

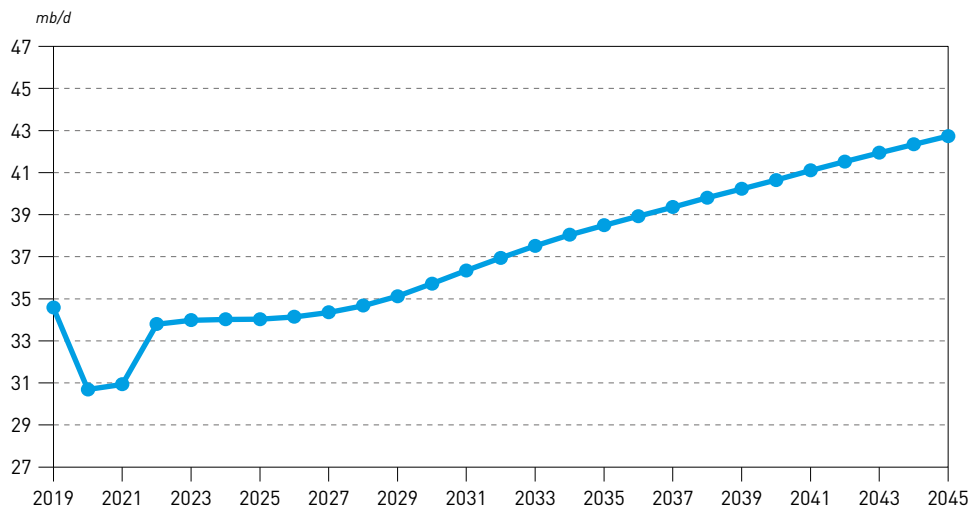
Although peaking at a lower level than estimated in previous reports, US tight oil remains an important medium-term driver of non-OPEC liquids supply growth, averaging around 50% of incremental supply in the 2022–2026 period.

4.6 OPEC liquids supply

OPEC total liquids supply is projected to recover from its 2020 low, when the DoC production adjustments were initiated due to the pandemic-related demand slump. In 2020, OPEC liquids fell to 30.7 mb/d on average, down from 34.6 mb/d in 2019. But as demand recovers and non-OPEC supply – especially US tight oil – takes time to get up to speed again, OPEC liquids is set to increase again quickly in the medium-term, rising to 34 mb/d by 2023, nearly back to pre-pandemic levels. The level is then set to plateau for several years.

In the longer-term, and especially when non-OPEC liquids supply itself is projected to plateau and peak in the late 2020s (in turn due to US tight oil peaking at that point), OPEC liquids begin to rise again, increasing from 35.7 mb/d in 2030 to 42.7 mb/d in 2045. In terms of market share, this implies a rise from 33% at the nadir in 2020, to 39% in 2045, relative to global liquids supply (Figure 4.16).

Figure 4.16
OPEC total liquids supply



Source: OPEC.

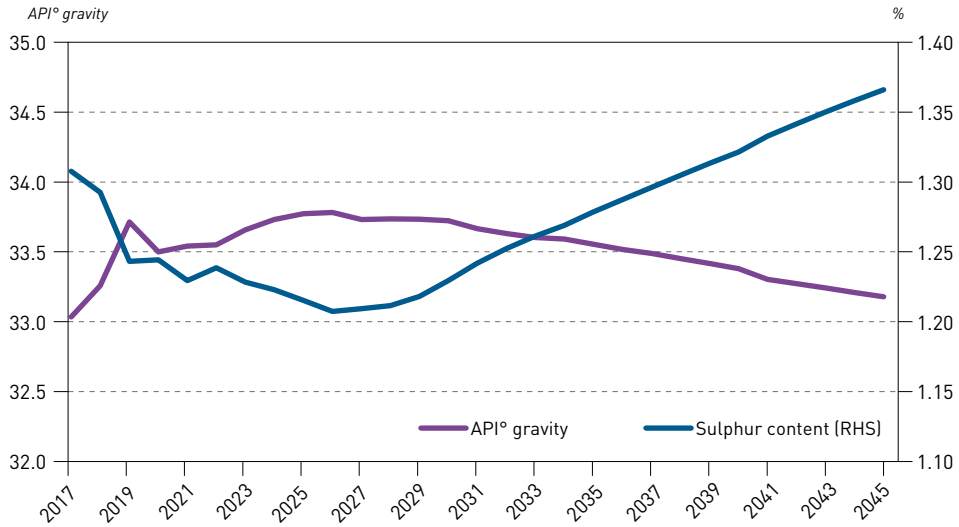
4.7 Crude quality

In recent years, the expansion of US tight oil production has had the biggest impact on global crude oil quality. Tight oil barrels are mostly light-sweet, with very high API gravity. Some tight oil grades have API gravity close to or even higher than 55°.

This is the major reason why the global average API gravity of crude and condensate supply increased from below 33° in 2016 to 33.7° in 2019. At the same time, sulphur content fell from around 1.3% to 1.24% in 2019. Consequently, refinery intake has lightened mostly in the US, but elsewhere too. The average barrel processed in the US had an average API gravity of just 30.5° in 2013. According to EIA data, this average increased to around 33° in 2019 and 2020, in line with the rising intake of locally produced tight oil and lower imports. Some countries in the Asia-Pacific (e.g. India and China) have recently increased imports of US tight oil barrels, thus increasing the average API gravity (Figure 4.17).

The sudden supply drop in 2020, as already discussed, led to a temporary drop of 0.2° in API gravity to 33.5°. Nevertheless, medium- and long-term trends are expected to remain similar to what was projected in previous WOOs. The expected rise in US tight oil production and further additions

Figure 4.17
Global crude oil quality*



* *Includes crude, condensate and synthetic crudes.*

Source: OPEC.

of light-sweet barrels elsewhere (e.g. Kazakhstan) are likely to lead to a recovery of the API gravity in the global average barrel, reaching around 33.7° in 2024.

After 2024, the global API gravity is likely to remain stable until 2030. This is the result of several forces. US tight oil production is expected to peak in the late 2020s, while light production will continue increasing in Kazakhstan. Additions of heavier crude production in the Middle East will be offset by losses of heavy production in Latin America (e.g. Colombia and Mexico). Some large additions in this period (e.g. Guyana) include mostly medium grades close to the global average.

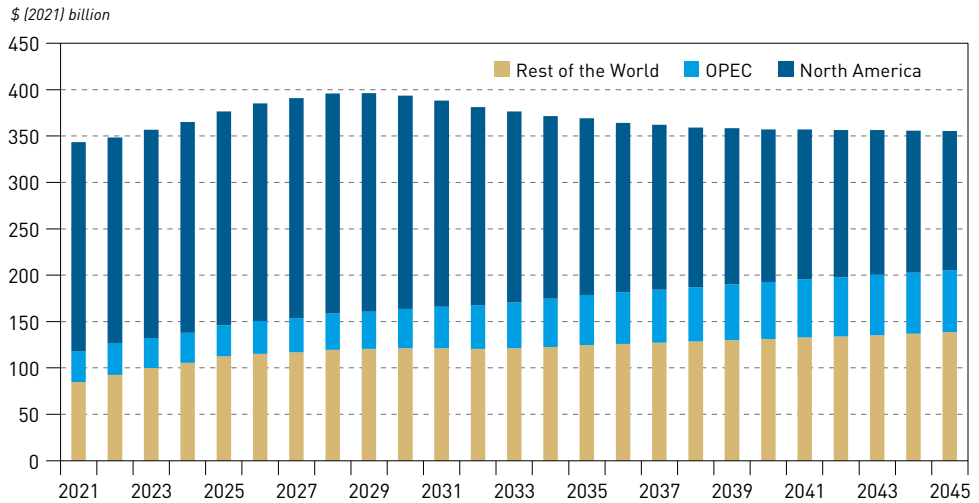
Beyond 2030, the global API gravity average is expected to decline gradually to levels around 33.2° in 2045. This is in line with a rising share of heavier barrels from the Middle East, Canada and, to some extent, Latin America, and by declining light production in the US, Europe and Asia.

At the same time, the sulphur content of an average crude barrel is expected to drop from around 1.24% in 2020 to just above 1.2% in 2026, in line with additions of sweet grades, mostly from the US, Latin America and Kazakhstan. In the long-term, rising production in regions such as the Middle East and Canada increase the global sulphur average to 1.36% in 2045, which is higher relative to levels seen in previous years. Rising sulphur content, in combination with stricter environmental regulation, is likely to result in increasing requirements for refining desulphurization capacities (see Chapter 5).

4.8 Upstream investment requirements

In order to meet the demand needs as set out in this Outlook's Reference Case, the required investment in the global upstream sector is estimated to average around $370 billion p.a. in the 2021–2045 timeframe (in 2021 US dollars). From around $350 billion in 2021, investment needs are expected to rise to a peak of just under $400 billion around 2030, in line with the projected recovery and growth in non-OPEC liquids supply, in particular, for US tight oil in this period (Figure 4.18).

Figure 4.18
Annual upstream investment requirements for capacity additions, 2021–2045



Source: OPEC.

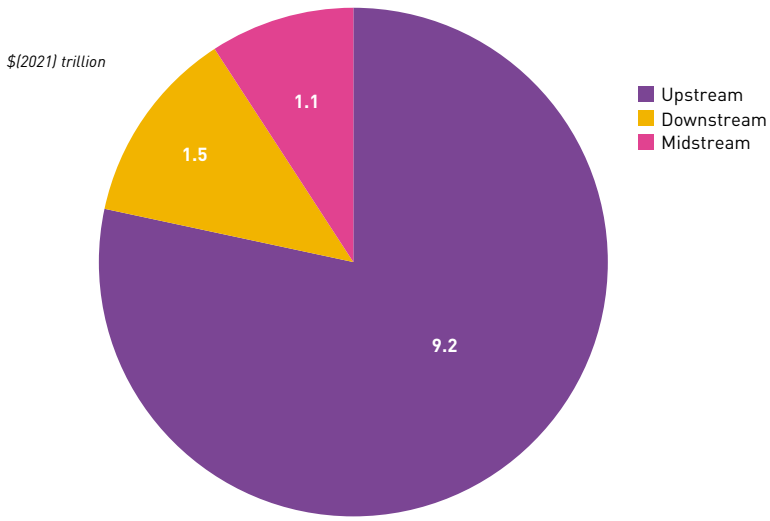
Adding in the investment needs in Canada's upstream, including from the country's relatively capital-intensive oil sands industry, as well as spending required in Mexico, North America's total upstream investment requirements make up approximately two-thirds of global medium-term investment needs. Parallel with tight oil's peak and decline from around 2030, North America's share is reduced in the long-term, falling below 50% of global spending from the mid-2030s, and shrinking further to just over 40% in 2045. At the same time, annual investment needs are reduced in the long-term.

The relative share of both OPEC and the rest of the world rise over the long-term, with the former's investment requirements increasing from around a 10% share in 2021 to nearly 20% by 2045, as OPEC's market share is set to increase from 33% to 39% over the time horizon of this Outlook. The relative share of the rest of the world's upstream investment requirements, meanwhile, rises from 25% to 40% in this period. In sum, over 25 years, cumulative upstream investment requirements are estimated to be $9.2 trillion.

In the downstream sector, total required investments are estimated at $1.5 trillion in the 2021–2045 period. These include investments of nearly $450 billion in new refinery projects and expansions of existing units located mostly in developing countries, including those in the Middle East, Asia-Pacific, Africa and Latin America. Furthermore, required investments for continuous maintenance and replacement are estimated at around $1 trillion, spread across all regions.

Required investments in the midstream sector are estimated at around $1.1 billion in the same time horizon and are attributed to the expansion of the infrastructure for refining, storage and pipeline systems, predominantly in developing regions, but also in large oil exporting regions (e.g. the US & Canada and the Russia & Caspian). Thus globally, oil-related investment needs in the long-term are estimated at $11.8 trillion (Figure 4.19).

Figure 4.19
Cumulative oil-related investment requirements by sector, 2021–2045



Source: OPEC.

Refining outlook

Key takeaways

- Last year's oil demand shock caused by the COVID-19 pandemic saw in increased pressure on the global downstream sector, which has experienced numerous refinery closures and is set to see additional closures in the coming years.

- In the medium-term (2021–2026), around 6.9 mb/d of new refining capacity is projected to come online, mostly in the Middle East, Asia-Pacific and Africa. Other regions are expected to see only minor new refining capacity additions.

- The medium-term outlook contains several large projects in line with anticipated oil demand developments. Many of these projects will entail petrochemical integration.

- Long-term (2021–2045) capacity additions are expected at 14 mb/d, mostly in developing countries. However, the Reference Case projects a significant slowdown in the rate of additions. Africa and Other Asia-Pacific are the regions where significant incremental capacities are expected even after 2030.

- Potential medium-term refining capacity is around 4.5 mb/d higher than incremental required refining capacity. However, projected closures should help to offset this imbalance by 2026.

- Global refinery utilization rates are forecast at 81% in 2024 and slightly lower by 2026, which is still higher relative to 2019 levels. This is in line with recovering demand, but also due to the realization of numerous closures triggered by the COVID-19 pandemic.

- In the long-term, utilization rates are set to decline to just above 76% in 2045 as more capacity comes online and demand declines in developed regions. Utilization rates in the US & Canada, Europe and developed Asia-Pacific regions will be affected the most. This will call for further closures if rates are to be kept at sustainable levels.

- The COVID-19 pandemic and related demand shock accelerated the rationalization wave in the global downstream sector. The Reference Case estimates closures of 4.5 mb/d between 2020 and 2026, mostly in the US & Canada (1.1 mb/d), Europe (1.4 mb/d) and the Asia-Pacific (1.8 mb/d).

- On the secondary capacity side, projections indicate the need to add some 7.1 mb/d of conversion units, 16.7 mb/d of desulphurization capacity and 4.7 mb/d of octane units in the period from 2021–2045, alongside 14 mb/d of new distillation capacity.

- Total downstream investments are estimated at around $1.5 trillion in the period 2021–2045. Of this, about $450 billion is set to be invested in new refinery projects and expansions of existing units, mostly in developing countries. Required investments for continuous maintenance and replacement are estimated at around $1 trillion and are spread across all regions.

- In total, investment requirements in the downstream sector between 2021 and 2025 are estimated at nearly $1.5 trillion.

This chapter presents the outlook for the refining sector in the period to 2045. It is fully consistent with OPEC Reference Case projections on oil supply (Chapter 4) and demand (Chapter 3). It examines how different factors could impact the global refining sector in the future. The analysis is conducted in two timeframes – the medium-term (2021–2026) and long-term (2021–2045).

It first highlights recent developments in the downstream sector during 2020 and 2021. This is followed by an updated assessment of current 'base' capacity by region (as of January 2021), which serves as the basis for medium- and long-term projections. Furthermore, new refining capacity projections in the medium- and long-term by region and globally are covered.

The analysis in this chapter shows how the downstream market balance changes in the medium-term at the global and regional levels, based on the projected refining capacity additions and the oil demand outlook. The so-called 'call-on-refining' is compared to potential refining capacity, globally and regionally. As a result, significant differences between regions become evident, with different implications for the downstream sector. In the long-term, based on the modelling cases, global and regional refinery throughputs and utilization rates are projected.

Recent and future refinery closures are also analyzed. In the medium-term, projections are based on announcements (firm closures) and the assessment of potential closures by 2026. Based on the projected regional utilization rates (including the assumptions on refinery closures in the medium-term), the analysis gives an indication of the level of necessary long-term closures to keep utilization rates at sustainable levels.

Secondary capacity additions are also examined in detail with projections for conversion and desulphurization capacity, as well as octane units, in the medium- and long-term. The potential consequences of capacity additions on the market balance in the medium-term are also highlighted.

Based on projected refinery additions (primary and secondary), the necessary investment requirements are calculated. Finally, this chapter looks at the key uncertainties to this Outlook and highlights the major challenges to the downstream sector in the years to come.

5.1 Existing refinery capacity

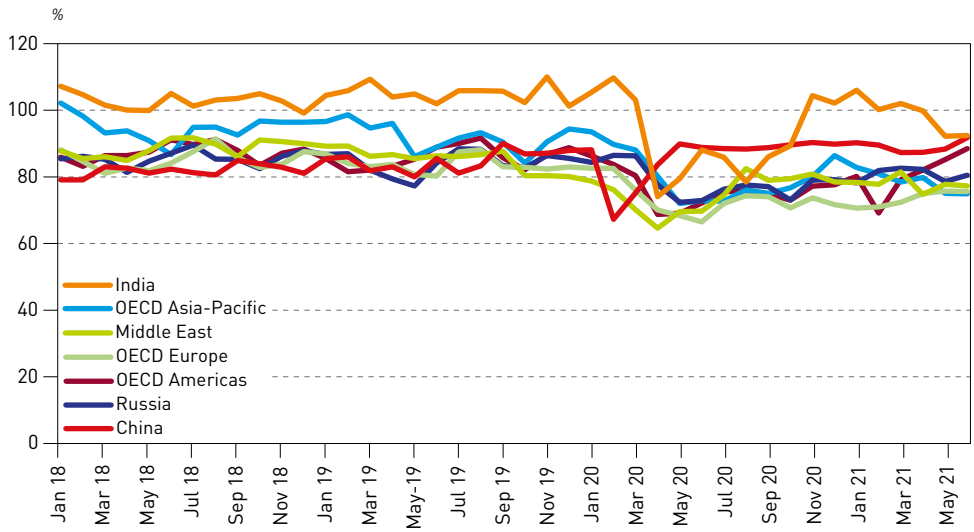
5.1.1 Recent developments in the downstream sector

As already highlighted in the WOO 2020, the COVID-19 pandemic had a severe impact on the global refining system. Severe declines in oil demand led to lower utilization rates, as well as decreasing refinery margins in all major refining hubs. Refinery downtime, including planned and unplanned maintenance, surged temporarily to more than 22 mb/d in mid-2020 and utilization rates dropped below 70% in many major refining regions (Figure 5.1)

The recovery started in mid-2020 and was largely underway by 2H20. It followed different pathways depending on local lockdown policies and related oil demand levels. Chinese utilization rates recovered rapidly and had already increased to levels close to 90% in May 2020. They remained strong throughout 2020 and in early 2021, in line with recovering demand in the country. This was even more impressive when considering that China actually added new refining capacity and its refinery throughputs reached all-time high levels, surpassing 14 mb/d in 2H20. This was considerably higher compared to 2019 average levels of around 13 mb/d

Refinery utilization rates in other regions recovered during 2H20, but remained lower relative to pre-pandemic levels. This trend continued in 1H21 with utilization rates in most of the regions still below pre-pandemic levels, due to lockdown measures brought on by second and third pandemic

Figure 5.1
Refinery utilization rates in selected regions



Source: OPEC.

waves. However, during the summer of 2021, the relaxation of measures in several regions, including the US and most of the EU, helped to lift refinery throughputs considerably. For instance, US refinery utilization in June and July 2021 came close to levels seen in the respective months of 2019.

Furthermore, the 2020 demand shock triggered a downstream rationalization wave with numerous announcements for closures or longer shutdowns. The refining sector was exhibiting overcapacity even in 2019 and a rationalization phase seemed unavoidable even before the outbreak of COVID-19. The pandemic, however, seems to have accelerated this streamlining significantly with around 4.5 mb/d of capacity closures expected for the period 2020–2026, mostly in developed regions. This development will certainly help to stabilize utilization rates at more sustainable levels.

Refinery closures were also partly due to lacklustre prospects for oil demand in developed regions as many countries have been pushing for a faster substitution of oil in an effort to reduce emissions. Accordingly, many oil and gas companies reacted to this policy shift and announced divestments in their oil portfolios, including downstream.

Nevertheless, the above-mentioned rationalizations are still lower relative to refinery capacity new builds in the period to 2026. Many projects are in construction or will reach a FID soon, mostly in developing regions with considerable oil demand growth prospects.

5.1.2 Base refinery capacity in 2021

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 during 2020.

The OPEC Secretariat's approach is that refineries, unless officially closed, are included in the database of so-called 'nameplate' capacity, although their effective capacity may be identified as

being well below the nameplate level, where appropriate. Overall, it should be stated 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, primary and secondary alike, as well as for new projects and closures.

Table 5.1 provides details by region and process on the 101.9 mb/d of assessed base refinery capacity (distillation) as of January 2021. This level represents a net reduction *versus* the 102.6 mb/d listed in the WOO 2020 for January 2020. As such, it constitutes an exception to the almost constant trend of global capacity increases y-o-y. It should be noted that the assessed 102.6 mb/d for January 2020 included the 400 tb/d from Saudi Aramco's Jizan refinery. This refinery was physically completed in late 2019, but commercial operations at the facility did not start until spring 2021. Removing that project, now set for a 2021 start-up, adjusts the January 2020 capacity, as shown in the WOO 2020, down to 102.2 mb/d.

Table 5.1
Assessed available base capacity as of January 2021

mb/d

	US & Canada	Latin America	Africa	Europe	Russia & Caspian	Middle East	China	Other Asia-Pacific	World
Distillation									
Crude oil (atmospheric)	20.2	7.7	3.9	15.7	7.6	9.9	17.4	19.5	101.9
Vacuum	9.1	3.4	0.9	6.7	3.1	2.8	7.0	6.1	39.2
Upgrading									
Coking	2.9	0.8	0.1	0.8	0.5	0.4	2.2	1.1	8.8
Catalytic cracking	5.8	1.6	0.2	2.3	0.9	1.0	4.0	3.7	19.6
Hydro cracking	2.5	0.2	0.2	2.3	0.8	0.9	2.3	1.7	10.9
Visbreaking	0.1	0.4	0.2	1.5	0.7	0.6	0.2	0.6	4.1
Solvent deasphalting	0.4	0.1	0.0	0.2	0.0	0.2	0.2	0.2	1.2
Gasoline									
Reforming	3.8	0.6	0.5	2.4	0.8	1.2	2.1	3.0	14.5
Isomerization	0.8	0.1	0.1	0.6	0.3	0.5	0.2	0.4	3.0
Alkylation	1.3	0.2	0.0	0.2	0.1	0.1	0.2	0.4	2.5
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	4.7	0.8	0.6	3.1	1.0	2.0	2.3	3.3	17.6
Gasoline	2.9	0.5	0.1	0.7	0.3	0.4	1.5	1.4	7.7
Middle distillates	6.6	2.4	0.8	5.9	2.4	2.8	4.5	7.0	32.4
Heavy oil/Residual fuel	3.2	0.4	0.0	1.8	0.3	0.7	1.1	3.1	10.7
Sulphur (short tons/day)	42,616	7,242	3,889	20,211	7,818	13,018	18,923	33,048	146,765
Hydrogen (million scf/d)	6,423	1,221	397	5,001	2,033	3,157	6,676	6,422	31,331

Source: OPEC.

The main contributor to the reduction in January 2021 base capacity, compared to the previous year, was the very high level of refinery closures that occurred during 2020. These were precipitated by the COVID-19 pandemic and the resulting historic drop in global liquids demand. Nearly 1.5 mb/d of refinery closures occurred in 2020 (see section 5.2.4), which was far above the average of around 0.6 mb/d of annual closures that had occurred in the preceding five years. It also exceeded the 1.2 mb/d of new capacity that came online in 2020. Together, with minor adjustments to the base capacities of individual refineries, these factors led to a net assessed capacity of 101.9 mb/d at the start of 2021.

At the regional level, the US and Europe in 2020 lost over 0.5 and 0.4 mb/d of distillation capacity, respectively, whereas China, Other Asia-Pacific, the Middle East and, to a smaller extent, Africa, were the regions where capacities increased. It is worth noting that the capacity increases evident in China during 2020 were achieved despite a set of closures of a number of smaller 'tea pot' refineries.

These changes reflect the continuation of a trend that has been evident for several years, namely the capacity shift from West to East. In the five years since January 2016, refinery distillation capacity has remained flat in the US & Canada at just over 20 mb/d, resulting in a small decline in its associated percentage of global capacity, from 20.5% in 2016 to under 20% in 2021. This absence of refinery growth has been despite large increases in domestic crude and condensate production, and represents the effect of limited expansions being offset by limited closures. In the same period, capacity in Europe has declined by 1.4 mb/d, with its global share dropping from 17.5% to 15.4%, mainly through ongoing rationalization that has more than offset limited additions. Conversely, capacity in the Russia & Caspian region has risen by 1 mb/d. Latin America and Africa have each registered small capacity declines over the same period.

In contrast, over the past five years, the Middle East and the Asia-Pacific combined have added over 5 mb/d of new capacity to total almost 47 mb/d in January 2021. This equates to 46% of the global total today, up from 43% (41.7 mb/d) in 2016. Moreover, this shift in capacity has occurred despite – and net of – some 1.4 mb/d of closures over the period in Other Asia-Pacific, primarily Japan and Australia. In short, beneath a relatively stable global picture lie significant regional differences in refinery capacity trends.

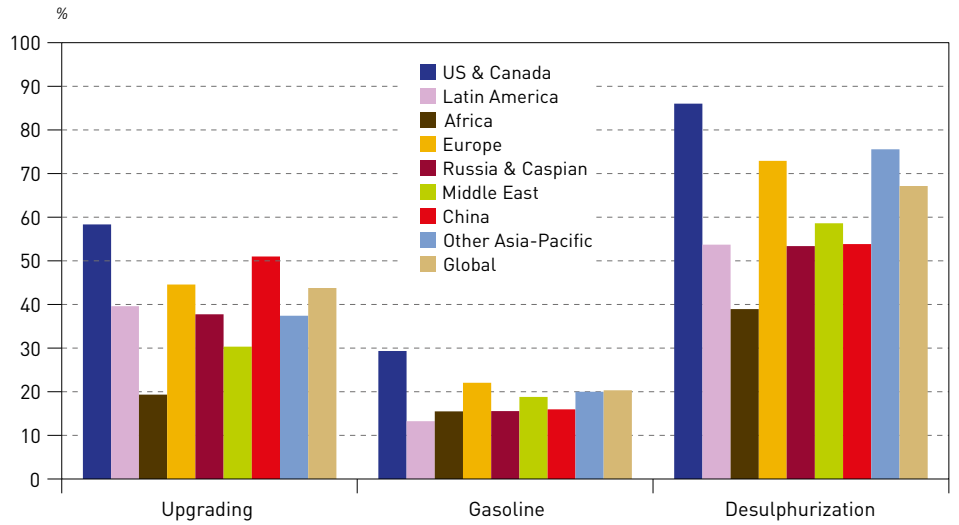
Secondary capacity

Today's refineries are increasingly complex with expanding secondary processing capacity per barrel of primary distillation capacity. This global trend is the result of a combination of the tendency to close older, simpler refineries; progressively add secondary processing at existing plants; and, generally, build new refineries at a high level of complexity from the outset. In the latter instance, the new refineries are increasingly designed to yield high outputs of petrochemical feedstocks.

The underlying drivers of these trends are the long-term shift towards incremental demand predominantly for light clean products, including petrochemicals, an associated steady decline in demand for residual fuel oil and increasingly stringent fuel quality regulations. Together, these call for higher levels of upgrading, desulphurization, octane and related supporting capacities, including hydrogen and sulphur recovery. Global vacuum distillation capacity currently stands at an average 38.4% of crude (atmospheric) distillation capacity, upgrading at 43.8%, gasoline octane units at 20.3% and desulphurization at 67.2%. A review of data from previous years confirms these ratios reflect a steady increase over time.

Figure 5.2 summarizes the data from Table 5.1 as percentages of crude distillation capacity. The table highlights the variations in refinery complexity between regions. The US & Canada continue to hold the highest levels of upgrading, gasoline production and desulphurization relative

Figure 5.2
Secondary capacity relative to distillation capacity, January 2021



Source: OPEC.

to distillation, reflecting a traditionally very complex refining system. However, continued state-of-the-art refinery capacity additions, particularly in the Middle East and Asia, are raising overall secondary capacity there relative to distillation, coming closer to the US & Canada levels.

For upgrading capacity, the US & Canada has the highest ratio, at greater than 58% of distillation capacity, followed by China at 51% and Europe at 45%. All other regions show values in the 30–40% range, apart from Africa at 19%.

In terms of upgrading, the distribution by type of unit varies significantly from region-to-region. The US & Canada, Latin America and China account for the highest levels of coking, around 25% of total upgrading in each region. They also account for two thirds of total global coking capacity. The same regions, plus Other Asia-Pacific, have the highest proportions of catalytic cracking at around 50%. All regions other than Latin America show significant proportions (21–33%) of hydrocracking in total upgrading. The distribution of mild upgrading, notably visbreaking, varies widely with significant proportions only in Africa, Europe, Russia & Caspian and the Middle East.

For gasoline units, the US & Canada is an outlier at over 29% of distillation capacity in line with the region's exceptionally high gasoline consumption. Europe is at around 22%, illustrating the presence of installed gasoline capacity before the continent's dieselization shift that led to a gasoline surplus. At 19–20%, levels in the Middle East and Other Asia-Pacific are close to those in Europe, while the remaining regions – Latin America, Africa, Russian & Caspian and China – exhibit lower proportions of gasoline units, in the range of 13–16%.

Desulphurization levels vary widely across regions depending on their fuel standards and crude slates. The highest share of desulphurization is seen in the US & Canada at 86%, which is more than double that of the lowest region, Africa, at 39%. Refineries in the US & Canada have traditionally processed a large proportion of heavy and medium-sour crudes, mainly imported from other regions, such as Latin America and the Middle East. However, the upswing in light-sweet tight oil production in recent years and declines in heavy crude production in some regions have led the share of heavier crudes in the slate to decline significantly despite the increase in heavy

Canadian output. Related capacity, notably coking and desulphurization, nonetheless, remains in place.

Europe and Other Asia-Pacific, which includes countries such as Japan, South Korea and others that possess substantial amounts of residual desulphurization, also have relatively high proportions of desulphurization capacity, at 73% and 76%, respectively. The Middle East is approaching 59%, while in the remaining regions – Latin America, Russia & Caspian and China – the level is in the 53–54% range. Africa's lower level (39%) reflects the fact that the region is in the earlier stages of progressing toward ultra-low sulphur (ULS) standards for gasoline and diesel.

In Europe, as is the case in the US & Canada, the high desulphurization ratio reflects the long-established implementation of ULS fuel standards, while in Other Asia-Pacific and the Middle East, the high and rising levels reflect a strong movement to ULS standards, plus a situation where large new refineries are today invariably built for high levels of clean fuel output to ULS standards. The same trend is under way in China.

With the continuing progressive adoption of the Euro 4/5/6 standards, reinforced by the recent IMO Sulphur Rule, which has been met only partially by the use of scrubbers, the trend towards higher desulphurization levels can be assumed to continue.

As would be 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

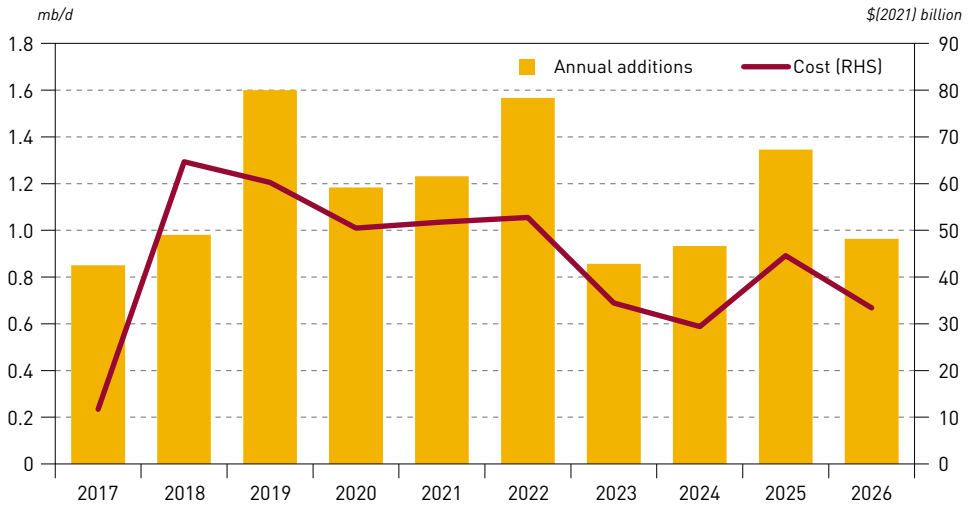
Based on a review of medium-term refining projects, a projected 6.9 mb/d of new refining capacity is expected to come online between 2021 and 2026. This forecast is more optimistic relative to the WOO 2020 in terms of the total volume of new refining capacity and the annual rate of additions. Demand recovery, especially in developing countries, and progress on many refining projects are the main drivers behind this more optimistic outlook. Furthermore, some additions, initially scheduled for 2020, were shifted to later years, and are reflected in this forecast. Finally, the 400 tb/d Jizan refinery in Saudi Arabia, which was physically finished in 2019, but only started commercial operations in 2021 is thus part of this outlook too.

In contrast, last year's medium-term outlook saw additions of around 5.2 mb/d in the period 2020–2025. The outlook reflected medium-term oil market uncertainties, leading to conservative estimates related to refinery new builds, especially for projects in the pre-FID phase. This is why the WOO 2020 pointed out the possibility of delaying and shifting some refining projects to the period beyond the medium-term and showed only minor additions in the second half of the medium-term period.

Figure 5.3 shows annual medium-term refining capacity additions in combination with estimated annual investments. This outlook does not include minor capacity additions aimed at debottlenecking existing facilities, so-called 'creep' capacity. The average annual addition rate between 2021 and 2026 is around 1.15 mb/d, which is in line with the 2017–2019 average. In contrast to last year's outlook, the rate of additions is expected to remain at levels close to 1 mb/d p.a. or above throughout the medium-term. This is in line with rising oil demand in developing countries and increasing optimism related to new refinery projects.

The rate of uncertainty in the downstream sector, however, remains high. Oil demand growth in the coming years will continue to be the key determinant of the refining sector. Even though oil demand has recovered considerably from the 2020 shock, further pandemic developments, such

Figure 5.3
Annual distillation capacity additions and total projects investment



Source: OPEC.

as ongoing restrictions and potentially new lockdown measures may pose further challenges. For instance, new lockdown measures due to new virus variants were introduced in some countries in July 2021, for example, in Australia, Russia, parts of Latin America and Europe. Any new lockdown measures, or extension of current ones, could negatively influence oil demand growth and potentially refinery capacity additions too.

Moreover, delays to some refinery projects due to financing and/or technical issues remain a possibility, as has been witnessed in the past. This is why some of the additions, projected to come online in the medium-term, could be delayed and only come online beyond 2026.

Projections for refinery additions by region in this year's Reference Case are presented in Table 5.2 and Figure 5.4. Similar to previous outlooks, refinery additions are concentrated in developing regions, such as the Asia-Pacific, the Middle East and Africa. These regions account for almost 90% of the additions in the period 2021–2026. The medium-term outlook contains several large projects, many of which have petrochemical integration as well. These developments are in line with expected oil demand growth. Other regions are likely to see only marginal refinery capacity expansions in the same period, with relatively small projects in the US and Latin America, mostly the expansion of existing plants. Europe is the only region where no new distillation projects are expected in the medium-term.

The Chinese downstream market will likely witness the commissioning of several large refineries with a strong focus on petrochemicals. These include PetroChina's Jieyang 400 tb/d plant, Shenghong's 320 tb/d refinery in Lianyungang, as well as the 400 tb/d plant being built by Shandong Yulong Petrochemical. The latter project will replace several teapot refineries, which have already been, or will be closed. In addition, there are several smaller projects in China that are expected to start operations in the medium-term, including expansions of existing plants. In total, China's medium-term refining capacity expansion is forecast to reach 1.4 mb/d.

Other Asian countries are also expected to boost their capacities in the medium-term (1.8 mb/d) in line with growing demand. In India, there are several ongoing projects, including expansions of existing facilities. All major refiners in India are involved in capacity expansion, with an increasing

Table 5.2
Distillation capacity additions from existing projects by region, 2021–2026 *mb/d*

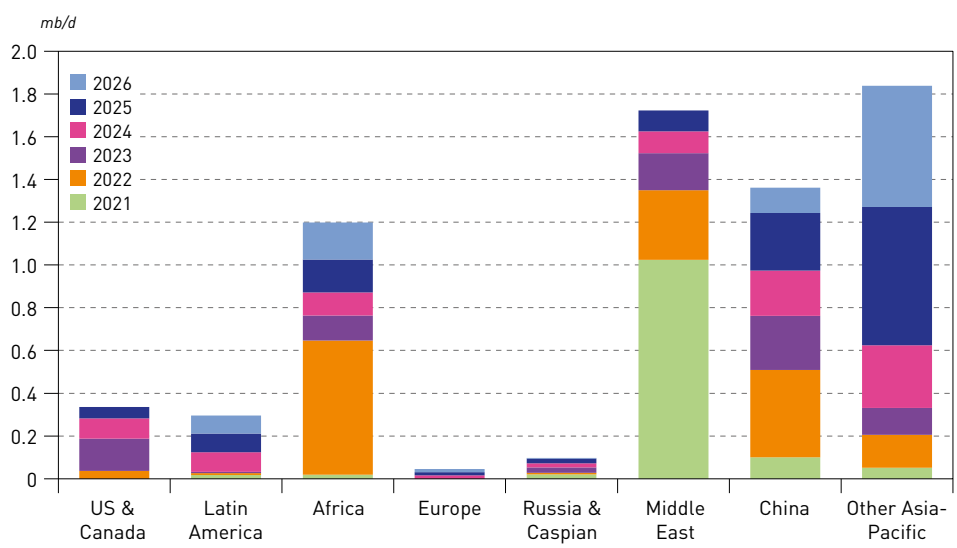
	US & Canada	Latin America	Africa	Europe	Russia & Caspian	Middle East	China	Other Asia Pacific	World
2021	0.0	0.0	0.0	0.0	0.0	1.0	0.1	0.1	1.2
2022	0.0	0.0	0.6	0.0	0.0	0.3	0.4	0.2	1.6
2023	0.2	0.0	0.1	0.0	0.0	0.2	0.3	0.1	0.9
2024	0.1	0.1	0.1	0.0	0.0	0.1	0.2	0.3	0.9
2025	0.1	0.1	0.2	0.0	0.0	0.1	0.3	0.6	1.3
2026	0.0	0.1	0.2	0.0	0.0	0.0	0.1	0.6	1.0
2021–2026	**0.3**	**0.3**	**1.2**	**0.0**	**0.1**	**1.7**	**1.4**	**1.8**	**6.9**
%	*4.9%*	*4.3%*	*17.4%*	*0.7%*	*1.4%*	*25.0%*	*19.7%*	*26.7%*	*100.0%*

Source: OPEC.

focus on the petrochemical sector. Elsewhere, there are several important projects in other countries of the region. These include plants in Indonesia, led by Pertamina, but also with foreign participation. Malaysia, Brunei, Laos, Thailand and Pakistan are some of the countries that are expected to witness medium-term refining capacity expansions. However, several of these projects are small and have capacities below 50 tb/d.

The Middle East is another region where significant medium-term refining expansions are expected, totalling 1.7 mb/d. More than half of the total is accounted for by two projects, starting in 2021. Besides the already noted 400 tb/d Jizan refinery in Saudi Arabia, another large project that is expected to be commissioned in 2021 is Kuwait's 615 tb/d Al-Zour refinery. Oman's 230 tb/d

Figure 5.4
Distillation capacity additions from existing projects, 2021–2026



Source: OPEC.

Duqm plant should be finalized by 2022. On top of this, there are several projects in Iraq, IR Iran, Bahrain and UAE, which may be commissioned before 2026.

Africa's medium-term outlook looks more optimistic relative to the WOO 2020, with 1.2 mb/d of new capacity expected by 2026. Half of this is accounted for by the 650 tb/d Dangote project in Nigeria, which is likely to come online in 2022. In addition, there are several smaller projects in West Africa, mostly located in Nigeria, Angola and Ghana. These projects include a number of pre-fabricated modular facilities. Once commissioned, these projects will help to reduce product imports to Nigeria and West Africa and will, in turn, increase the use of local crude. In North Africa, refinery capacity expansions are likely in Algeria and Egypt.

In other regions, capacity expansions remain limited. In Latin America, where demand growth would justify capacity expansion, there is only one large project, the 340 tb/d Dos Bocas refinery in Mexico, which is under construction and could materialize in the medium-term. Projects in other countries are limited at the moment partly due to the financial situation of some oil companies. In order to reduce its debt and advance market liberalization, Brazil's Petrobras is seeking to sell eight of its refineries, one of which, the Landulpho Alves Refinery, was recently sold to the UAE's Mubadala. One project, which was initially considered in this Outlook was the 200 tb/d Limetree Bay refinery in St. Croix. The refinery was commissioned – the restart of an older facility with extensive modifications – in early 2021 with the aim to profit from the IMO Sulphur Rule, introduced as of 1 January 2020. However, due to financial and technical problems, the refinery was shut down in mid-2021 and is not likely to come back online.

In the US & Canada, medium-term refinery expansions are seen at around 300 tb/d. While no new projects are expected in Canada, in the US, ExxonMobil's Beaumont refinery expansion is the most significant medium-term project. Most of the other projects are smaller expansions of existing plants. Interestingly, this cumulative expansion will be much smaller relative to estimated closures for the medium-term period, which means that total refining capacity in this region is set to decline.

It is important to highlight that OPEC's Reference Case with 6.9 mb/d of new capacity additions consists of projects identified from a list of announced projects that total more than 30 mb/d. However, only some of these projects will materialize in the future. Furthermore, the total medium-term capacity additions of 6.9 mb/d are composed of projects in different development stages. Around 3.5 mb/d of capacity is under construction or close to this stage, hence, these are the projects with the highest certainty to materialize in the medium-term. There are also projects totalling 3.4 mb/d that are mostly in early stages of development, but still advanced enough in terms of financing and engineering to be considered 'firm' medium-term additions. Nevertheless, the uncertainty surrounding these projects is high with a potential risk that some of the projects only start beyond the medium-term horizon, or get cancelled for various reasons.

5.2.2 Long-term distillation capacity additions

This section looks at long-term additions at the global and regional levels, taking into account Reference Case assumptions on regional oil demand (Chapter 3) and oil supply (Chapter 4), as well as medium-term refinery capacity additions (Section 5.2.1) and refinery closures (Section 5.2.4). Table 5.3 shows assessed medium-term projects and projected additions beyond the medium-term based on the long-term downstream sector modelling.

As shown in Table 5.3, on top of the 6.9 mb/d of assessed projects in the medium-term, around 7.1 mb/d of new projects will be needed at the global level between 2027 and 2045. This means that the medium-term additions are almost equal to required additions in the period 2027–2045, in line with the slowdown of oil demand and required refinery throughputs. Consequently, total estimated refinery capacity expansions between 2021 and 2045 amount to 14 mb/d.

Table 5.3
Refinery distillation capacity additions by period

mb/d

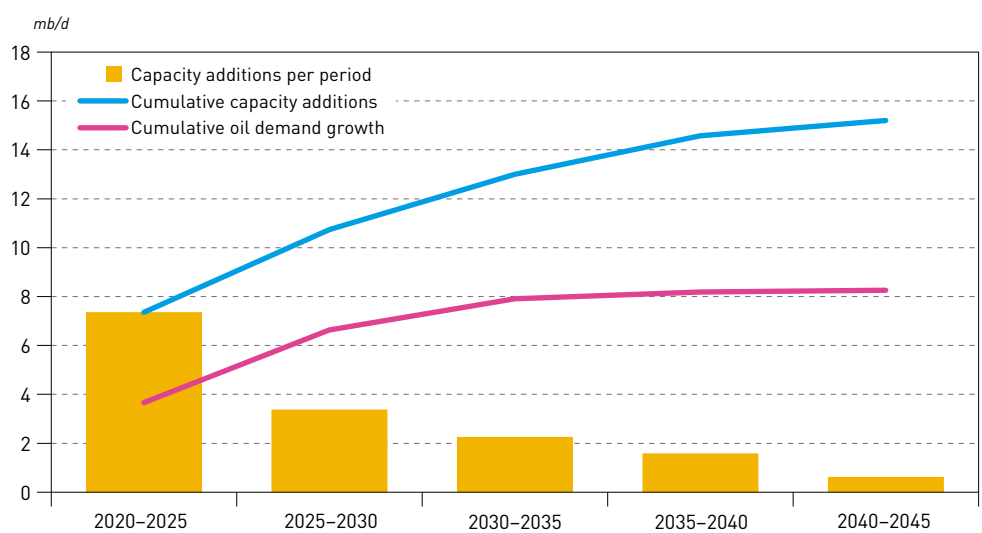
	Distillation capacity additions starting 2021			
	Assessed projects*	New units	Total	Annualized
2021–2025	5.9	0.2	6.2	1.0
2025–2030	1.0	2.4	3.4	0.7
2030–2035	0.0	2.3	2.3	0.5
2035–2040	0.0	1.6	1.6	0.3
2040–2045	0.0	0.6	0.6	0.1
	Cumulative distillation capacity additions			
	Assessed projects*	New units	Total	Annualized
2021–2025	5.9	0.2	6.2	1.0
2021–2030	6.9	2.7	9.6	0.9
2021–2035	6.9	4.9	11.8	0.7
2021–2040	6.9	6.5	13.4	0.6
2021–2045	6.9	7.1	14.0	0.5

* *Firm projects exclude additions resulting from capacity creep.*

Source: OPEC.

Figure 5.5 shows cumulative demand growth between 2019 and 2045 compared with cumulative additions between 2020 and 2045. Since this analysis operates with cumulative increments related to the base year, 2019 was chosen as the oil demand base year, which helps avoid demand distortions as a result of the COVID-19 pandemic. It is obvious that the level of refining capacity additions

Figure 5.5
Distillation capacity additions and oil demand growth, 2020–2045



Source: OPEC.

(15.2 mb/d) is significantly higher compared to the demand growth of 8.3 mb/d. The main reason for this is the regional distribution of refining additions, which occur mostly in developing countries, where demand still grows in the long-term. For instance, demand growth in the Asia-Pacific is expected to increase (net of declines in OECD Asia) by almost 11 mb/d between 2019 and 2045. In the same period, oil demand in the Middle East is projected to increase by over 3 mb/d and in Africa by almost 3.5 mb/d.

However, in line with the overall oil demand slowdown and the rising share of non-refinery feedstocks (NGLs, CTLs, GTLs and biofuels), the pace of refinery expansion is expected to decelerate significantly, from 7.4 mb/d in the period 2020–2025 to 3.4 mb/d in the period 2025–2030. This rate decreases further and reaches only 0.5 mb/d in the last five years of the outlook. This means that the period between 2040 and 2045 would possibly see only expansions of existing plants and no new refinery builds.

As a result of global demand development and long-term refinery additions, global refinery utilization rates are set to come under pressure. After the recovery projected for 2025 due to rising oil demand and estimated refinery medium-term closures, refinery utilization rates are expected to drop from 80.5% to around 76% by 2045. This will probably call for further downstream sector consolidation, especially in regions where demand declines in the long-term (see Section 5.2.3).

Regional additions

Similar to the medium-term outlook, long-term refinery capacity additions are located in developing regions with growing demand. This is why the majority of long-term refinery additions (14 mb/d) are located in the Asia-Pacific, Middle East, Africa and Latin America, with almost 95% of the total. Nevertheless, there is a significant slowdown in the rate of additions in the Middle East and China, while additions in Other Asia-Pacific and Africa are still considerable beyond the medium-term.

In China, the total expected distillation expansion is around 2.1 mb/d between 2021 and 2045. However, as the medium-term outlook for China shows an increase of almost 1.4 mb/d, the expansion from 2027 onwards is set to be only around 0.7 mb/d. The major reason for this is substantial capacity expansions in recent years and in the medium-term, as well as a demand growth slowdown in the latter outlook period.

Middle East refinery capacity expansions are projected at around 2.8 mb/d between 2019 and 2045, with more than 1.7 mb/d already commissioned in the medium-term. Consequently, around 1.1 mb/d are expected over the period 2027–2045. Recent capacity additions in this region, partly focused on export markets, in combination with medium-term increments, are sufficient to reach market saturation in the long-term.

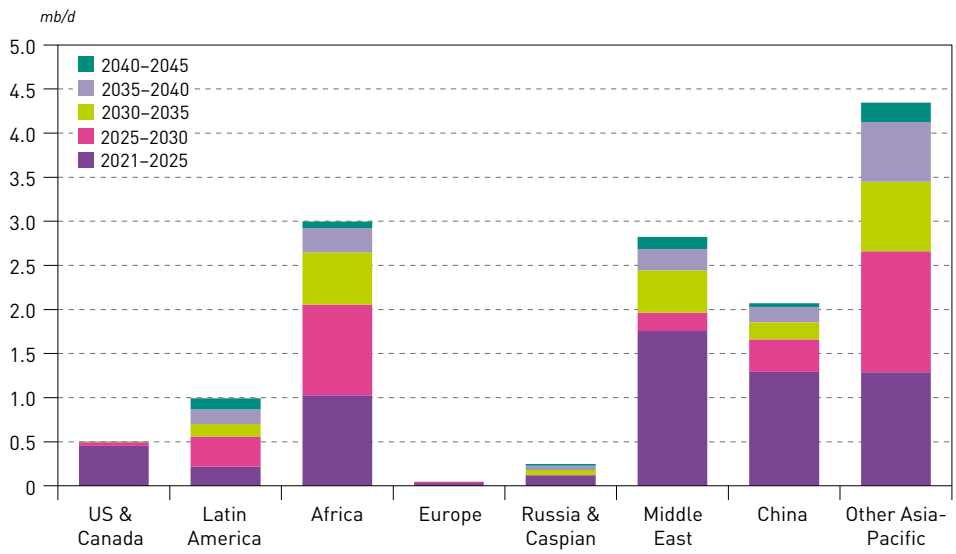
At the same time, refinery expansions in Other Asia-Pacific are estimated at around 4.3 mb/d by 2045, of which 1.8 mb/d is accounted for by medium-term additions. Beyond the medium-term, additions are expected to remain strong at levels of around 0.7 mb/d–0.8 mb/d in the period 2030–2035 and 2035–2040 as demand still increases at significant rates. There are several large projects in this region, such as in India, Indonesia and Vietnam, which could materialize in the long-term. In the last five years of the outlook, other Asia-Pacific additions show similar trends to other regions and are expected to drop to around 0.2 mb/d.

In Africa, total long-term refinery expansions are estimated at around 3 mb/d. Between 2021 and 2030, 2 mb/d of new refinery capacity is expected, which could help to reduce product imports during this period. Beyond 2030, capacity additions are likely to see a gradual slowdown, reaching only 0.1 mb/d in the period 2040–2045.

Latin America is also projected to see moderate long-term expansion due to rising oil demand, which increases by around 1.3 mb/d between 2019 and 2045. Relatively low additions in the period 2021–2025 of just 0.2 mb/d will support higher increments of almost 0.35 mb/d in the period 2025–2030. Post 2030, refining capacities are forecast to increase by around 0.4 mb/d in total.

US & Canada, Europe and Russia & Caspian are expected to see only minor expansions beyond 2025, some of which can be explained by the continuous need to add capacity for debottlenecking purposes and minor projects at existing plants. These regions are expected to see declining demand and potentially lower product exports, which, in turn, should lead to lower refinery utilization rates. Consequently, more refinery closures can be expected, both in the medium- and long-term.

Figure 5.6
Crude distillation capacity additions, 2021–2045



Source: OPEC.

5.2.3 Medium-term balance for the refining sector

This section focuses on the downstream market outlook by taking into consideration capacity additions, regional oil demand and oil supply. The outlook is divided into two sub-sections – the medium-term and long-term outlook – which follow two different methodologies.

The medium-term outlook looks at refinery additions as laid out in Section 5.2.1 and compares this with the so-called 'call-on-refining' (relative to 2019). Even though the current base year is 2020, this analysis will refer to the period 2019–2026 for oil demand and 2020–2026 for refining capacity expansion. This will help eliminate the effect of the large market distortions in 2020, which could make medium-term analysis difficult and misleading.

The long-term outlook looks at modelling results to 2045 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 shown in Section 5.2.1, medium-term distillation capacity additions at the global level were assessed at 6.9 mb/d. The assumption (based on the modelling results) is that by 2026 around 0.2 mb/d of debottlenecking additions or 'creep capacity' will be required, which is added in stages throughout the medium-term period. The majority of debottlenecking additions are expected in the US & Canada, due to the large base of existing refineries.

The conservative estimate of 'capacity creep' applied here is tightly linked to the detailed project list that was used for capacity assessments. As a result, total additions, or nameplate capacity, in the medium-term are estimated at 7.1 mb/d by 2026. If 2020 capacity additions are included, this increases to around 8.3 mb/d. As per the methodology applied, refinery closures are not taken into consideration at this stage, but are highlighted later.

The methodology also assumes that new refining capacities may reach the maximum assumed utilization rate of 90%. This assumption provides insight into the potential incremental crude runs on an annual basis between 2020 and 2026. Furthermore, as this outlook is presented on an annual basis, the methodology tries to capture uncertainties related to the start-up 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).

In the following step, the maximum potential incremental crude runs are calculated with incremental refined product demand, or the 'call-on-refining'. The 'call-on-refining' is the result of demand patterns that take into account non-refinery streams such as NGLs, biofuels, CTLs and GTLs (e.g. NGLs used directly in the petrochemical industry), which surpass refinery processing. This section covers balances from the perspective of distillation capacity, crude runs and total demand without considering specific refined products.

In the final step, the potential incremental crude runs are compared with the cumulative incremental refined product demand on an annual basis. The analysis is done at the global and regional levels. The resulting balances show the oversupply of refining capacity relative to incremental refined product demand and are a good indicator of the state of the downstream sector, globally and regionally.

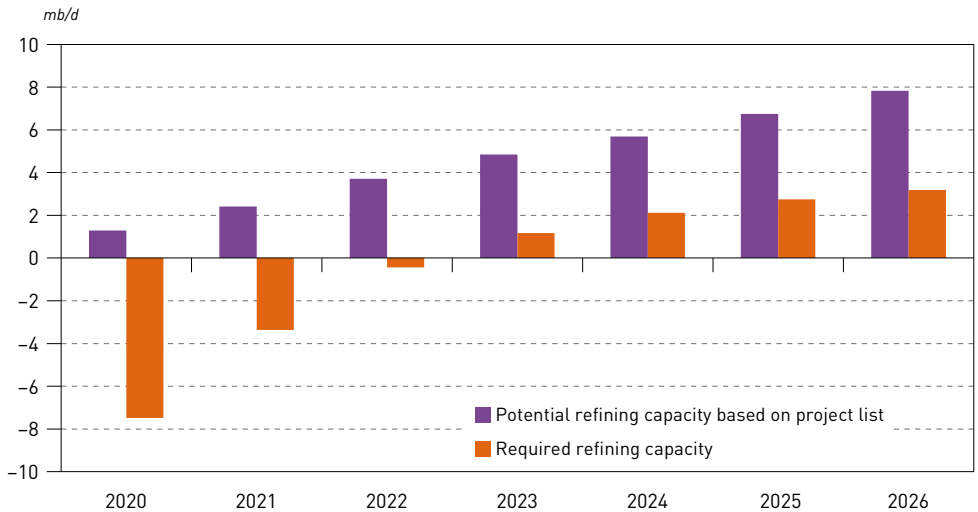
Finally, it should be noted that the analysis throughout this sub-section also includes assumptions on the product stock change throughout the period 2020–2026. Given the large imbalance of the market in 2020, a large product stock build for 2020 was assumed, with gradual stock draws from 2021 onwards. This somewhat alters the picture, *versus* one based solely on oil demand patterns and changes in non-refinery fuel supply as already described.

Figure 5.7 provides a summary assessment of the cumulative medium-term potential for additional crude runs compared to the required incremental product supply from refineries based on global product demand growth. As mentioned earlier, this figure includes capacity expansions for the period 2020–2026 and demand growth relative to 2019. Potential refining capacity is set to increase throughout the period, cumulatively reaching almost 5 mb/d by 2023 and 7.8 mb/d by 2026.

At the same time, the severe drop in the required refining capacity in 2020 due to the plunge in demand is estimated at around –7.5 mb/d in 2020, relative to 2019. The recovery in required refinery capacity is projected to be gradual, reaching 2019 levels only in 2023. By 2026, the incremental call on refining is expected to be around 3.2 mb/d, relative to 2019.

The resulting difference between the potential and required refining capacity in 2020 was almost 9 mb/d, which led to a drop in refinery margins and temporary shut-ins in all major refining hubs. However, in line with recovering demand, the gap is likely to decline to around 3.5 mb/d

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.

in 2023/2024. By 2026, the projected overhang is expected to widen to around 4.6 mb/d. This is considerably higher compared to the WOO 2020, mostly due to a more optimistic medium-term outlook for increasing new build capacity.

However, this significant capacity overhang will be offset by firm and planned refinery closures over the medium-term, which is projected to reach levels of 4.5 mb/d. In 2023/2024, the level of closures could be even higher than the projected gap. This is why, if all projected closures materialize, the global refining sector could be more balanced and relatively close to 2019 conditions already by 2023. The standard caveat applies – the cumulative overhang would be lower if refinery projects slip and higher should demand growth prove to be less than expected.

The regional picture looks different. The widening gap between potential and required refining capacity is the result of declining demand in developed regions (the US & Canada and Europe) and of strong refining capacity expansion in the medium-term in developing regions. The downstream market outlook for major regions is discussed below.

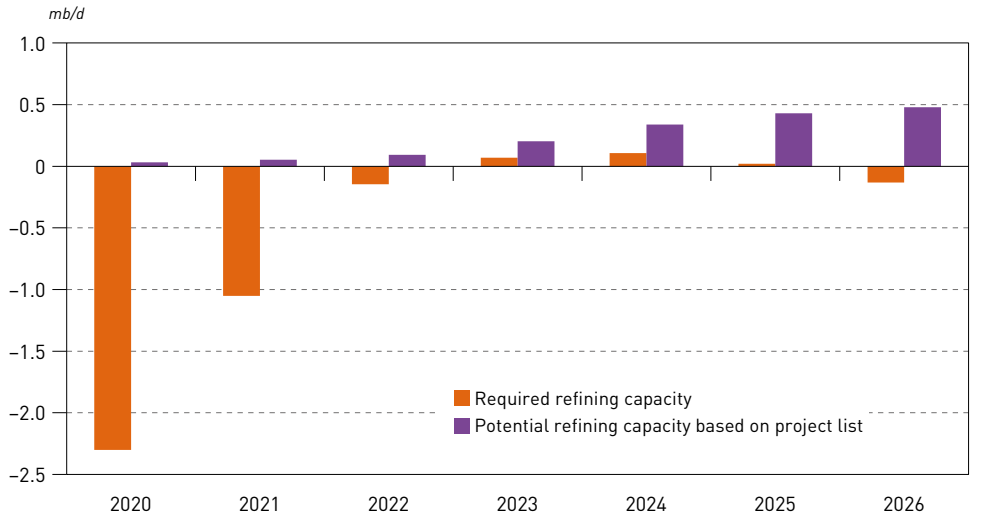
Medium-term regional balances

At the regional level, contrasts in the refining supply/demand balances remain stark. Figures 5.8 to 5.15 present a comparison of data drawn for all major regions in the period 2020–2026.

Figure 5.8 illustrates the medium-term outlook for the US & Canada. After the strong drop in 2020 of 2.3 mb/d, relative to 2019, and partial recovery in 2021 (–1 mb/d relative to 2019), the required refining capacity is set to switch to positive territory in 2023 and 2024. However, as the region's oil demand starts declining towards the end of the medium-term, the required refining capacity is projected to reach –0.1 mb/d in 2026. At the same time, limited refinery expansions, with only one major project, will push the potential incremental refining capacity to 0.5 mb/d in 2026. The gap between potential and required refining capacity is expected to narrow to just 0.1 mb/d in 2023, in line with the aforementioned recovery, but widen to 0.6 mb/d in 2026.

Source: OPEC.

Figure 5.8
Additional cumulative crude runs in US & Canada, potential and required

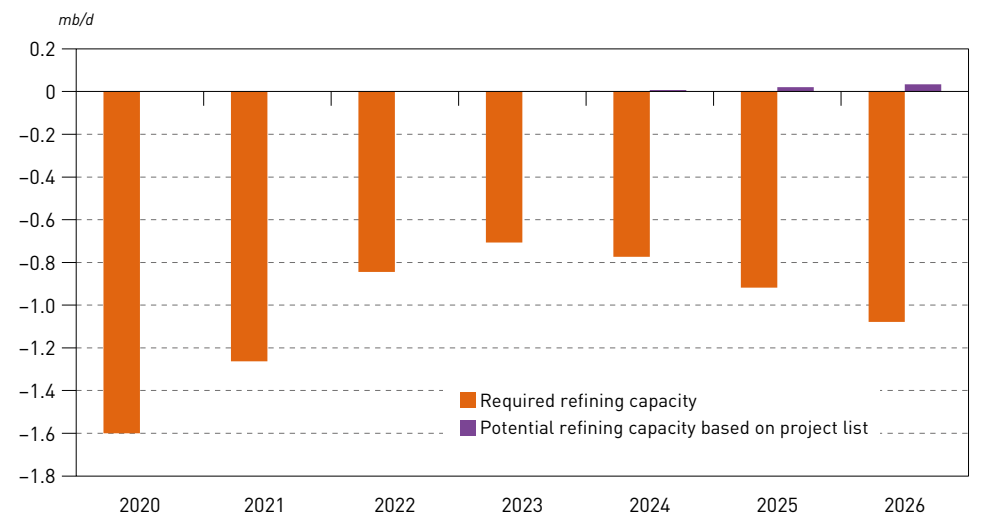


Source: OPEC.

Europe shows a bleak picture for the refining sector in the medium-term (Figure 5.9). The potential refining capacity in Europe remains virtually zero throughout the medium-term, with only minor creep capacity additions. At the same time, required refining capacity in this region recovers from around –1.6 mb/d in 2020 to –0.7 mb/d in 2023, but drops again to around –1.1 mb/d in 2026. This is in line with the region's oil demand trajectory, with demand not expected to recover to pre-COVID levels. Consequently, refinery closures will be necessary to offset negative oil demand trends.

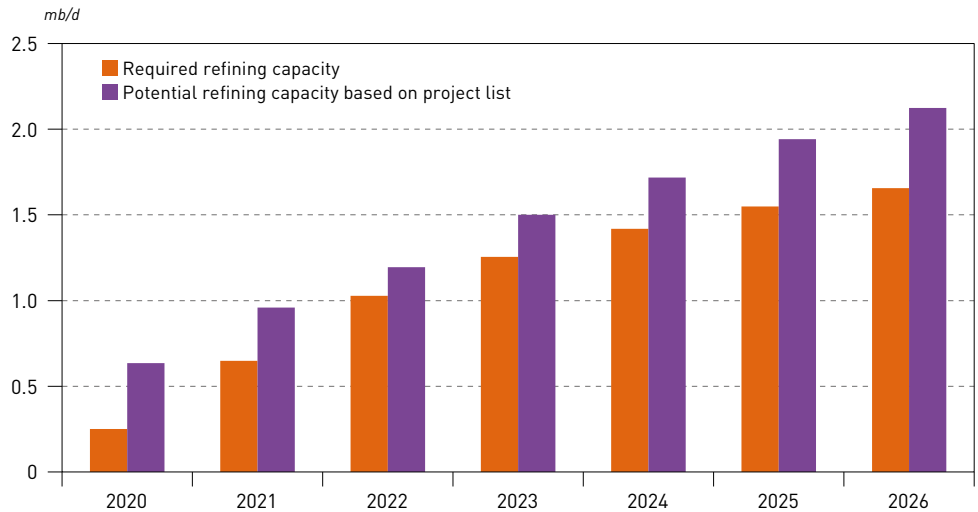
In China, strong growth in both potential and required refinery runs is projected (Figure 5.10). The call on refining increases to almost 1.7 mb/d by 2026. This, however, includes the rise in refinery runs during 2020, which increased despite negative demand growth across the year. China, which

Figure 5.9
Additional cumulative crude runs in Europe, potential and required



Source: OPEC.

Figure 5.10
Additional cumulative crude runs in China, potential and required



Source: OPEC.

was the first country affected by the outbreak of COVID-19, was able to relax lockdown measures relatively quickly compared to other countries. This was reflected in the downstream market too.

Potential refining capacity is also projected to increase strongly, including significant additions during 2020, reaching levels just above 2 mb/d in 2026. There is a continuous gap between the potential and required refining capacities, amounting to around 0.4 mb/d. However, the caveat to this outlook is that some of the new additions, for example, the 400 tb/d at the Yulong petrochemical complex, are set to replace the closure of several smaller teapot refineries, some of which have already occurred, or will likely occur in the near future. Taking the closures into account, the medium-term outlook would be more balanced with minimal gaps between potential and required refining capacities in 2026.

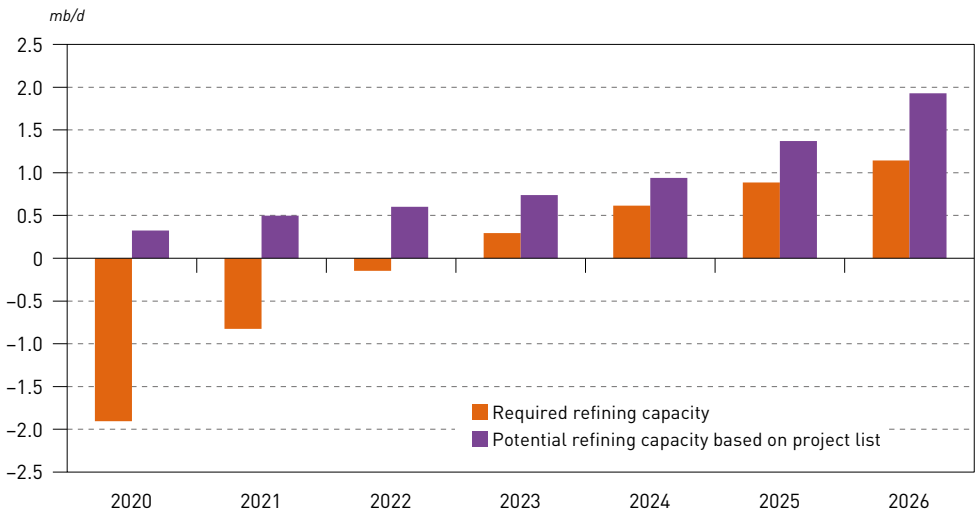
In the Asia-Pacific (excl. China), the required refinery capacity dropped significantly by 1.9 mb/d during 2020 (Figure 5.11), in line with the drop in refinery runs. Refinery runs dropped in both developed and developing countries of this region due to the extended lockdown measures. However, required refining capacity is projected to recover, reaching positive territory in 2023, and then climbing further to around 1.2 mb/d in 2026. Meanwhile, significant capacity expansion is expected in this region, especially in the second part of the medium-term outlook.

Consequently, potential refining capacity is likely to rise to around 0.7 mb/d in 2023 and 1.9 mb/d in 2026. Thus, the gap between potential and required refining capacity is expected to narrow from more than 2 mb/d in 2020 to just 0.3 mb/b in 2024, in line with the forecasted demand recovery. However, the significant increase in potential refining capacity towards the end of the medium-term period results in a widening gap, which is expected to reach 0.8 mb/d. This gap, however, could be offset by announced closures, mostly in developed countries of this region, such as Australia, Japan and New Zealand.

In the Middle East (Figure 5.12), potential refining capacity is projected to increase strongly, reaching 1.7 mb/d in 2026. This includes two large projects (Jizan in Saudi Arabia and Al-Zour in Kuwait) and a number of smaller projects. The required refining capacity based on demand growth, relative to 2019, in the Middle East increases from –0.8 mb/d in 2020 to

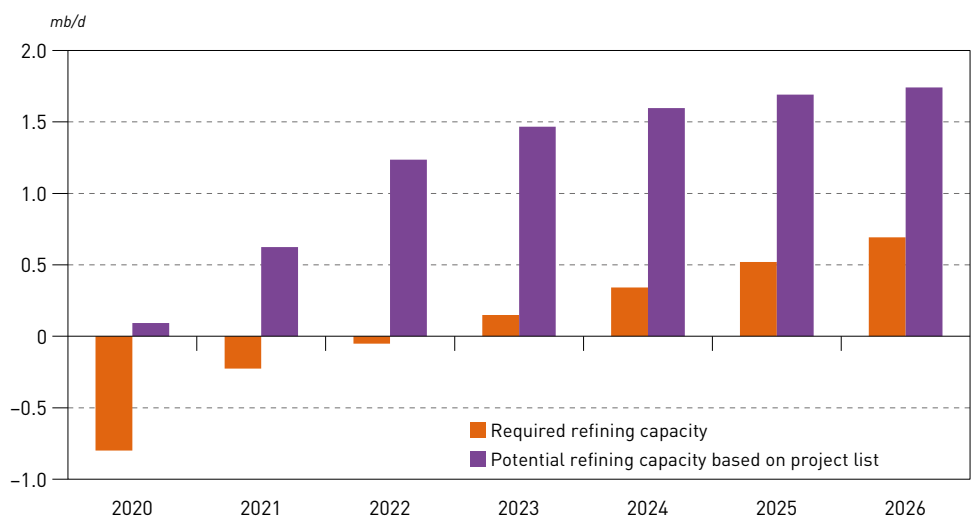
0.7 mb/d in 2026. The gap between potential and required refining capacity remains between 0.8 mb/d and 1.3 mb/d throughout the medium-term. This surplus will possibly lead to rising product exports from the Middle East, given that some of the new refineries are state-of-the-art plants with access to locally produced feedstock and with capabilities to compete in the international downstream market.

Figure 5.11
Additional cumulative crude runs in Asia-Pacific (excl. China), potential and required



Source: OPEC.

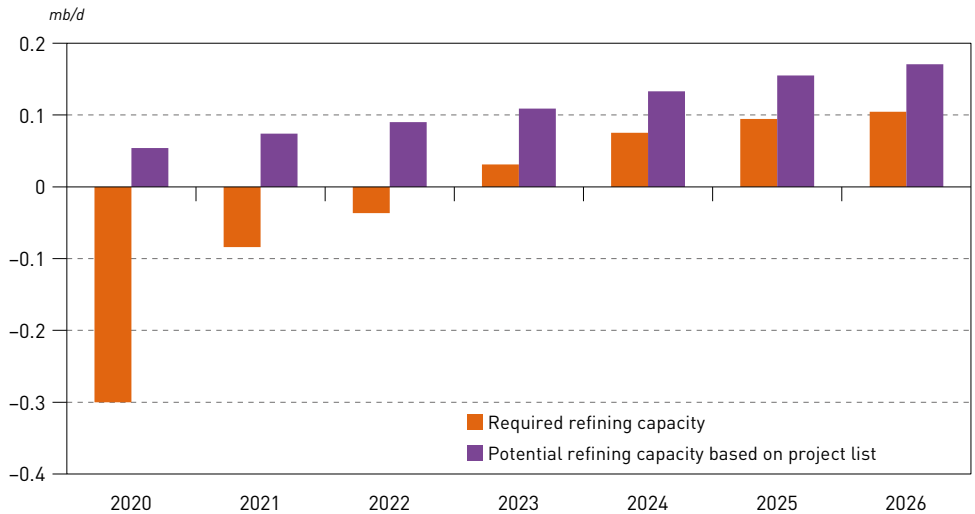
Figure 5.12
Additional cumulative crude runs in the Middle East, potential and required



Source: OPEC.

In the Russia & Caspian (Figure 5.13) region, the magnitude of changes is significantly less compared to other regions. The potential refining capacity is expected to increase marginally, reaching some 170 tb/d by 2026. Primary capacity additions in this region are limited to expansions of existing plants. Required refining capacity is set to recover from the COVID-19 related shock

Figure 5.13
Additional cumulative crude runs in the Russia & Caspian, potential and required

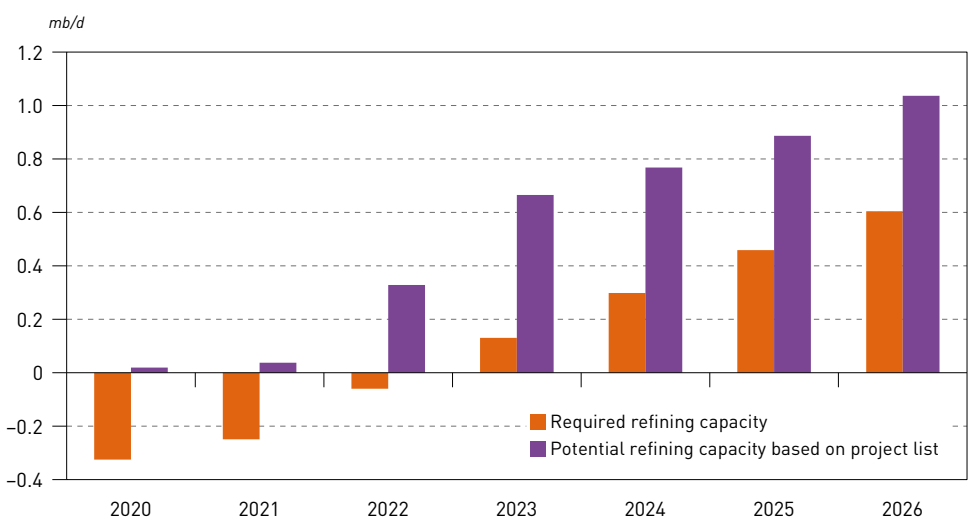


Source: OPEC.

by 2023, and then increase further to 0.1 mb/d by 2026. The market is forecast to come close to balance towards the end of the outlook period. However, some pressure may come from declining demand in Europe, which is the main export outlet for refiners from the Russia & Caspian region.

In Africa (Figure 5.14), this year's outlook is more optimistic concerning refining capacity new builds, especially in West Africa. The potential refining capacity is expected to start increasing in 2022 at just below 0.4 mb/d, before reaching just above 1 mb/d in 2026. Required refining capacity is estimated at around –0.3 mb/d in 2020, but increases to 0.6 mb/d in 2026. This means that the gap between potential and required refining capacity flips from negative territory in 2020 and 2021,

Figure 5.14
Additional cumulative crude runs in Africa, potential and required

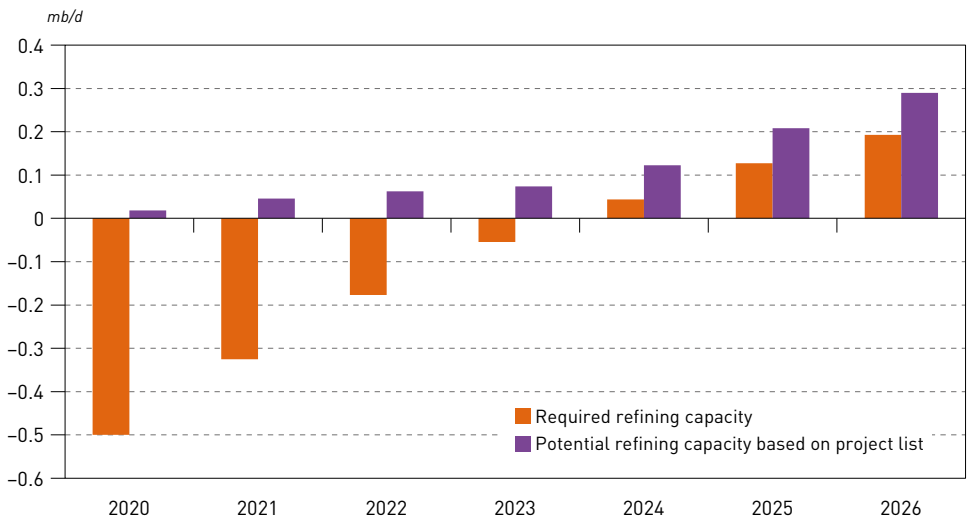


Source: OPEC.

and reaches 0.4 mb/d by 2026. However, this gap will not necessarily lead to pressure on the local downstream market given the region's current large volumes of product imports. Rather, it will help increase local refined product output and thus, reduce product imports from other regions.

In Latin America (Figure 5.15), cumulative potential refining capacity is expected to rise gradually, reaching 0.3 mb/d in 2026 as only minor medium-term capacity additions are expected. Cumulative required refining capacity is projected to recover from around –0.5 mb/d in 2020 to 0.2 mb/d in 2026. This means that there will be an overhang of refining capacity in the first part of the medium-term, which will gradually disappear by 2026 due to rising demand. In other words, the downstream market is expected to be close to the 2019 market balance at the end of the medium-term.

Figure 5.15
Additional cumulative crude runs in Latin America, potential and required



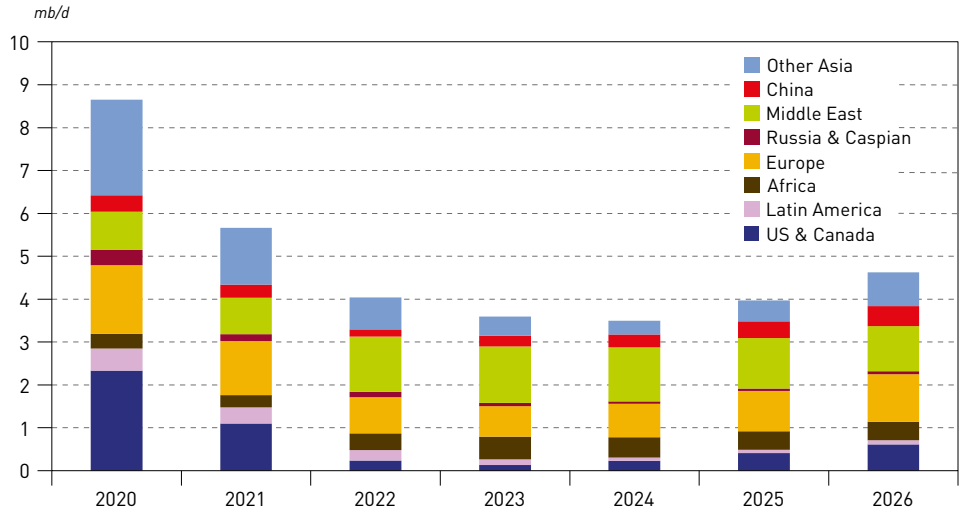
Source: OPEC.

Figure 5.16 shows the cumulative medium-term gap between the incremental potential and required refining capacity for all regions. This overhang is estimated at levels of around 8.7 mb/d in 2020 and is due to a combination of falling demand and rising refinery capacity, as previously discussed. This gap narrows by 2023/2024 to around 3.5 mb/d, but then widens again and reaches 4.6 mb/d by 2026, a level that is significantly higher when compared to last year's outlook. The major reason for this development is declining demand in some regions and significant refining capacity additions at the end of the medium-term, which was not the case in the WOO 2020 Reference Case.

Many regions are expected to see drops in their overhang as demand recovers, especially in the US & Canada, Other Asia-Pacific and Europe in 2023 and 2024. However, as demand starts declining in developed regions, the overhang may widen, especially in the US & Canada and Europe. In developing regions, it is due to refining capacity additions towards the end of the outlook period that the surplus of potential refining capacity increases.

It is important to note that, in the medium-term period, this overhang does not include any assumed closures, which are estimated at around 4.5 mb/d between 2020 and 2026. The majority of the closures are expected to occur by 2024, which should help to more than balance out the overhang shown in Figure 5.16.

Figure 5.16
Net cumulative regional refining potential surplus/deficits *versus* requirements



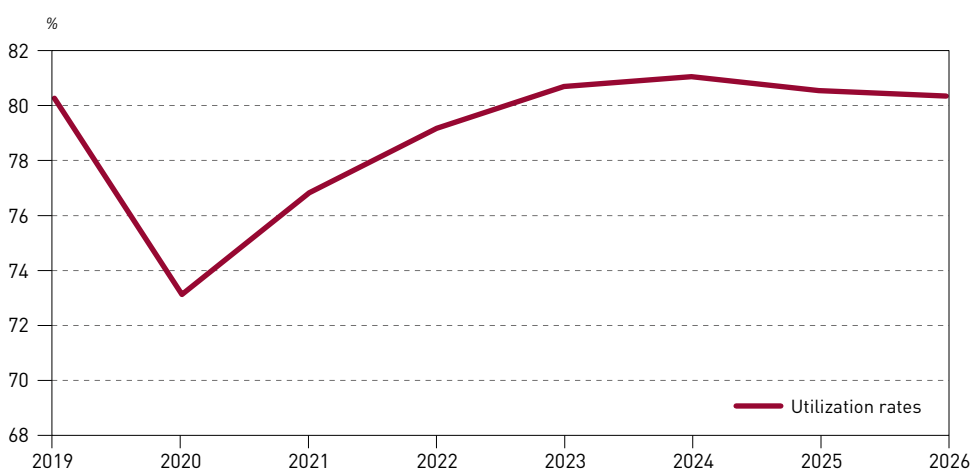
Source: OPEC.

Medium-term refinery utilization and throughputs outlook

This section focuses on projected global refinery utilization rates based on assumed demand growth, refinery capacity expansions and includes the assumption for medium-term refinery closures. Furthermore, it shows the estimated crude runs, the effects of the assumed closures and so-called spare refining capacity for the medium-term.

In line with the medium-term outlook, Figure 5.17 shows the development of global refinery utilization, including assumed refinery closures to 2026. In 2019, the average global utilization rate was estimated at around 80%. This rate was lower relative to previous years due to the rising shift of oil demand towards non-refinery fuels and continuous refinery expansions. The impact of the demand shock in 2020 led to a drop in utilization rates of almost 7 pp to just above 73%. This

Figure 5.17
Historical and projected global refinery utilization, 2019–2026



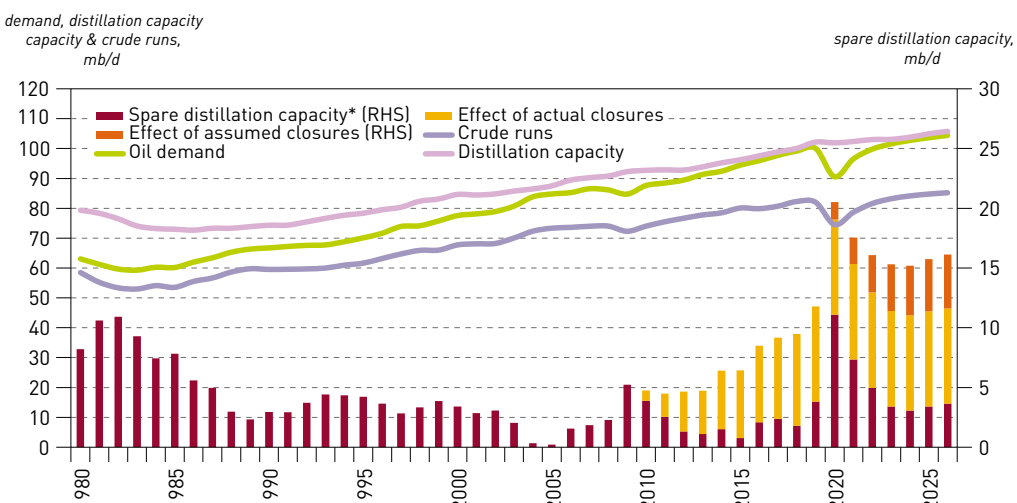
Source: OPEC.

includes increased downtime and extended shutdowns for many refineries during 2020, which in some cases were prolonged to 2021.

In line with the demand recovery during 2021 and 2022, utilization rates are expected to reach levels of 77% and 79%, respectively. In 2023 and 2024, refinery utilization is forecast to increase further based on demand growth and additional closures, reaching 81% in 2024. However, based on a slowdown in refinery run growth, yet with strong refinery capacity additions, utilization rates are estimated to decline to around 80.5% in 2025 and 2026. Nevertheless, without the assumed closures from 2021 onwards (see Section 5.2.5), the utilization rate would not climb above 80% in the medium-term and would only reach levels just above 78% in 2026.

Figure 5.18 shows the evolution of oil demand, crude throughputs and distillation capacity at the global level (shown by the lines in Figure 5.18). There is the obvious convergence of total oil demand and refining capacity since 1980, which is due to several reasons. The level of refining capacity has historically been significantly higher relative to oil demand given the larger share of refined products in total oil demand and, to some extent, due to a significant number of active, but inefficient plants in the downstream sector. However, as the share of non-refinery fuels in total oil demand increased, such as NGLs and biofuels, and some inefficient older refinery units were retired, the gap between total distillation capacity and oil demand almost disappeared, as can be viewed in recent years, the exception being 2020. This is also illustrated by the refinery run/oil demand ratio. In the early 1980s, this ratio was above 90% and has consistently declined since, reaching 82% in 2019.

Figure 5.18
Global oil demand, refining capacity and crude runs, 1980–2026



* *Effective 'spare' capacity estimate based on assumed 84% utilization rate, accounting for already-closed capacity.*

Source: OPEC.

In the medium-term, global refinery runs will likely reach pre-COVID levels at around 82 mb/d in 2023, and will then continue increasing to around 85 mb/d in 2026. After the widening in 2020 due to the oil demand drop, the gap between oil demand and distillation capacity will narrow again to marginal levels by the end of the medium-term.

Figure 5.18 also shows the effect of actual and assumed closures with an estimate for spare refining capacity. Refinery spare capacity peaked in 2020 at levels above 11 mb/d, but this is

expected to decline to levels from 3–3.5 mb/d by the end of the medium-term period. This is somewhat lower relative to the last year's outlook, which can be explained by the higher level of assumed medium-term closures.

5.2.4 Long-term balance for the refining sector

In this section, the long-term outlook for the downstream market is presented, with a focus on global and regional refinery throughputs and utilization in line with demand (Chapter 3) and supply (Chapter 4) projections.

Table 5.4 shows refinery throughputs and utilization at the global level and for major regions. Refinery utilization projections include assumptions on refinery closures in the medium-term, but do not assume any closures beyond 2026. It also includes data for 2019 as an ease of reference for long-term trends. Global refinery throughputs fell to around 74.5 mb/d in 2020 due to the drop in global demand. The recovery of throughputs is expected to be gradual in the medium-term, reaching 84.7 mb/d in 2025 and above 85 mb/d in 2026.

Table 5.4
Crude unit throughputs and utilization rates, 2019–2045

Total crude unit throughputs *mb/d*									
	US & Canada	Latin America	Africa	Europe	Russia & Caspian	Middle East	China	Other Asia-Pacific	Global
2019	18.3	4.3	2.4	12.6	7.0	7.4	13.1	17.0	81.9
2020	16.0	3.8	2.1	11.0	6.7	6.6	13.5	14.9	74.5
2025	17.9	5.1	2.9	11.9	6.8	8.5	14.4	17.3	84.7
2030	17.1	5.6	3.6	11.6	6.6	9.0	14.5	17.3	85.3
2035	16.4	5.9	4.1	11.2	6.4	9.2	14.8	18.1	86.2
2040	16.0	6.2	4.5	9.8	6.1	9.9	14.6	19.0	86.2
2045	15.7	6.4	4.9	9.1	6.1	10.3	14.6	19.0	86.1

Crude unit utilizations *% of calendar day capacity*									
	US & Canada	Latin America	Africa	Europe	Russia & Caspian	Middle East	China	Other Asia-Pacific	Global
2019	88.7	55.4	62.2	77.8	91.1	76.0	76.7	87.8	80.3
2020	79.4	48.8	53.3	69.8	88.1	66.8	77.9	76.2	73.1
2025	88.9	64.3	59.7	80.9	88.9	72.7	78.1	86.7	80.5
2030	84.6	68.2	62.1	79.1	86.3	75.5	77.4	81.5	78.7
2035	81.0	71.4	64.7	76.6	83.4	74.1	78.1	82.3	77.9
2040	79.3	73.1	67.9	67.2	79.0	78.5	76.1	83.5	76.8
2045	77.9	74.0	72.1	62.6	78.4	80.8	76.1	82.7	76.3

Source: OPEC.

However, in the long-term, refinery throughputs are expected to reach levels of just above 86 mb/d in 2035 and remain stable until 2045 at the global level. This limited increase of throughputs after 2025 is in line with the oil demand slowdown and the rising supply of non-refinery fuels, such as biofuels, NGLs, CTLs and GTLs. This means that refinery throughputs increase by only around 4 mb/d from pre-pandemic levels in 2019 and reach a plateau after 2035.

Refinery utilization rates are useful indicators for the state of the refining sector in a given region, as well as globally. At the global level, utilization rates are set to recover by 2025, reaching 80.5%. This includes significant medium-term refinery closures in the (4.5 mb/d in the period 2020–2026). After 2025, refinery utilization rates are projected to decline gradually to 76.3%, which could imply that further refinery closures will be needed in the long-term.

At the regional level, however, there are significant differences. Refinery throughputs in developed countries are projected to decline strongly as demand starts dropping. This is especially the case in Europe, where refinery throughputs are expected to decline by almost 2 mb/d between 2020 and 2045, never again reaching 2019 levels of around 12.5 mb/d. In the US & Canada, the return of robust demand is expected to boost refinery throughputs to almost 18 mb/d, which is close to pre-COVID levels. However, the long-term demand decline will lead to a significant drop in runs, reaching 15.5 mb/d in 2045. This is almost 3 mb/d below 2019 levels.

Relative to the demand decline, refinery runs in the US & Canada are forecast to decline less compared to Europe, due to the local availability of feedstock and highly complex and competitive refinery systems that are capable of replacing a part of the local demand losses by increasing product exports to other regions, such as the Asia-Pacific. Furthermore, utilization rates in Europe and US & Canada are expected to decline significantly in the long-term, by 15 and 11 pp respectively, between 2019 and 2045. This will probably lead to further refinery closures if utilization rates are to be kept at sustainable levels.

Refinery throughputs in the Russia & Caspian are estimated at around 0.6 mb/d between 2020 and 2045. This is mostly due to demand declines in export markets, such as Europe, and a demand peak in Russia. Refinery utilization rates are expected to decline to 78.5%, down from strong levels of above 90% in 2019.

Other regions are anticipated to see significant increases in refinery runs in the long-term, although with a significant deceleration towards the end of the outlook period. This development is led by the Middle East, where refinery runs increase to 10.3 mb/d in 2045, up from 6.6 mb/d in 2020 (7.4 mb/d in 2019). Utilization rates are expected to increase gradually from around 73% in 2019 to almost 81% in 2045. The growth in local demand, as well rising product exports, are the main reasons for this development.

Other Asia-Pacific refineries are also anticipated to see rising runs based on the demand increase and refinery expansion in the long-term. Runs are expected to increase to 19 mb/d in 2040 and 2045, up by 2 mb/d from 2019 levels. A large share of this increase is accounted for by India, where strong demand growth will lead to significant refinery expansions (see Chapter 9). It is important to note that the growth of 2 mb/d between 2019 and 2045 also includes losses in developed countries in the Asia-Pacific region, such as Japan, South Korea, Australia and New Zealand. Refinery utilization rates in this region are expected to drop from somewhat above 85% levels in 2019 and 2025, and reach around 82%–83% from 2030 onwards.

At the same time, refinery run increases in China are expected to see a slowdown after 2020. China managed to increase refinery runs in 2020, relative to 2019, which was based on the country's strong recovery in 2H20, as well as the start-up of some projects. However, further growth will be limited due to the expected deceleration of oil demand growth and the rising share of petrochemical demand. After reaching levels of 13.5 mb/d in 2020, Chinese refinery runs are projected

to climb to 14.8 mb/d in 2035, with marginal declines in the years thereafter. Utilization rates are projected to remain at around 77% throughout the outlook period.

In Africa, long-term demand growth will lead to an increase in refinery throughputs of almost 5 mb/d in 2045, up from 2.4 mb/d in 2019. A strong expansion in refining capacities is expected to support this growth trend. Similarly, runs in Latin America will increase by more than 2 mb/d between 2019 and 2045, which should not only be supported by an expansion of the refining system, but also by the higher utilization of existing capacity. Consequently, utilization rates are set to increase strongly in both regions, but still remain at levels below 75% in 2045. It is important to note that higher refinery runs in Africa and Latin America should help to curb product imports from other regions. This also means that any failure in refinery run increases, such as through possible project delays, would necessarily lead to higher product imports from other regions.

5.2.5 Refinery closures

This section reviews refinery closures in the medium- and long-term with two different approaches. Refinery closure projections in the medium-term include firm and probable closures, largely based on announcements and analysis on refinery closures. In the long-term (beyond 2026), the outlook is much more uncertain. Analysis is based on projections for regional utilization rates, and a conclusion is drawn on how many closures are needed to keep regional utilization rates at technically and financially sustainable levels.

Refinery closures in the medium-term

Table 5.5 and Figure 5.19 show actual closures from 2012 and projected closures to 2026. This year's Reference Case sees around 4.5 mb/d of refinery closures between 2020 and 2026. Following the 2020 demand shock, a wave of closures started, predominantly in three regions – US & Canada, Europe and parts of the Asia-Pacific. The downstream market in these regions were showing overcapacity even before COVID-19, with the pandemic accelerating the rationalization process.

In the US & Canada, total closures are estimated at 1.1 mb/d between 2020 and 2026. This includes several mid-sized plants, such as the 160 tb/d Martinez plant owned by Marathon, the 120 tb/d San

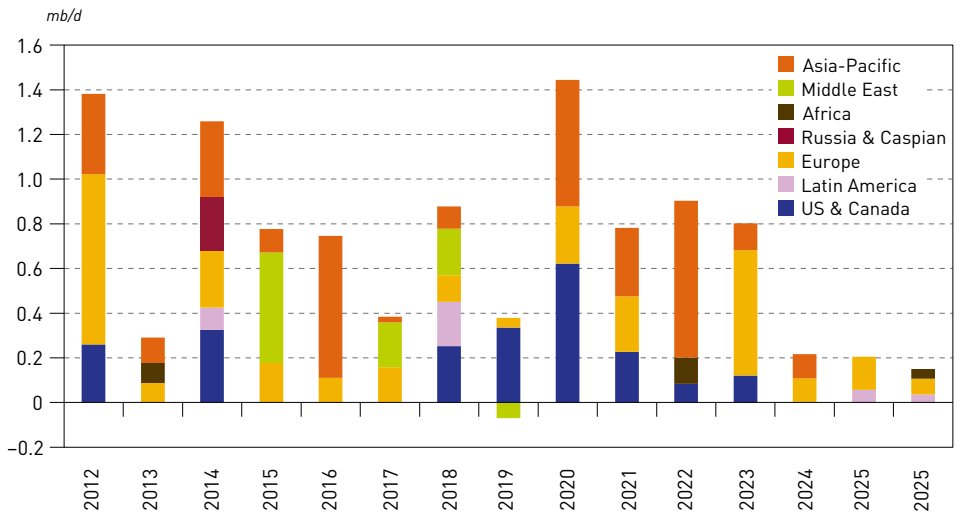
Table 5.5
Refinery closures by region, recent and projected

mb/d

	Total 2012–2019	2020	2021	2022	2023	2024	2025	2026	Total 2020–2026
US & Canada	1.2	0.6	0.2	0.1	0.1	0.0	0.0	0.0	1.1
Latin America	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Europe	1.7	0.3	0.2	0.0	0.6	0.1	0.1	0.1	1.4
Russia & Caspian	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Africa	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2
Middle East	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Asia-Pacific	1.7	0.6	0.3	0.7	0.1	0.1	0.0	0.0	1.8
Total	**6.0**	**1.4**	**0.8**	**0.9**	**0.8**	**0.2**	**0.2**	**0.1**	**4.5**

Source: OPEC.

Figure 5.19
Refinery closures by region, recent and projected



Source: OPEC.

Francisco refinery (Philips 66) and the 130 tb/d refinery in Come by Chance, Canada. All other projected closures in this region are below 100 tb/d, some of which could be converted into biofuel plants.

In Europe, refinery closures by large oil majors, smaller oil companies and trading companies, for example, Gunvor, are projected at 1.4 mb/d between 2020 and 2026. Several of these plants have capacities above 100 tb/d, such as refineries in Antwerp (Belgium) and Grandpuits (France). In addition, a significant number of smaller plants are set to be closed, including Matosinhos (Portugal), Naantali (Finland), Grangemouth (UK) and Rotterdam (Netherlands). On top of firm closures, there is a large potential for further medium-term closures, thus reflecting the changes in business strategies of some European oil and gas companies.

In the Asia-Pacific, closures are concentrated mostly in developed countries, including Australia, New Zealand and Japan. Similar to Europe, these closures are partly based on weak demand prospects and the strategy shifts of some oil majors. In Australia, two firm closures have been announced, Altona and Kwinana, totalling 230 tb/d. Two other refiners in Australia could potentially be closed too, which is why the Australian government has offered subsidies to keep them open in order to ensure security of fuel supply. In New Zealand, the 127 tb/d Marsden Point refinery is set to close in the coming years. In Japan, two Eneos plants, with around 240 tb/d of capacity, are scheduled for closure. Furthermore, Shell decided to close two plants in the Asia-Pacific (Philippines and Singapore) with a total capacity of nearly 350 tb/d.

In addition, this outlook assumes a number of closures in China, affecting smaller, less complex, teapot plants, some of which have already been closed in 2020. In total, around 700 tb/d of refining capacity is expected to be shut down in China and to some extent replaced by new large and integrated refinery projects with a focus on petrochemicals (notably the 400 tb/d Yulong Petrochemical project.

As shown in Figure 5.19, the majority of projected closures will occur in the coming years with only modest shut-ins from 2024 onwards. However, the pace of closures largely depends on the demand recovery and medium-term prospects. It is possible that some of the projected closures between 2021 and 2023 could be delayed and slip into the second half of the medium-term, or even beyond, if demand recovers strongly.

Refinery closures in the long-term

Results for modelling cases in the long-term provide a means to estimate the implied closures required within a region. The target for this back calculation is the sustainable average utilization rate. It is important to note that modelling cases already include assumptions on medium-term refinery closures (4.5 mb/d for the period 2020–2026). The parameter for estimating closures in the long-term is set at around 80%, representing the lowest utilization rate considered viable. Thus, model results will indicate some level of implied closures for any region with projected average annual utilization levels below 80%.

The global average utilization by 2025 is projected at 80.5% (Table 5.4). At the regional level, all major regions seem to have sufficient average utilization rates, which would not require additional closures in this period. This also means that assumed closures in the medium-term seem appropriate to keep utilization rates at a reasonable level.

However, beyond 2026 and until 2045, the Reference Case projects the need for further closures as global utilization rates drop to around 76% in 2045. Based on regional demand patterns, closures will be required mostly in developed regions. This affects predominantly Europe, the US & Canada, the developed regions of the Asia-Pacific and, to some extent, Russia & Caspian.

At the global level, around 6–7 mb/d of refinery closures will be required beyond 2026 and to 2045. The largest share of this is accounted for by Europe, where further closures of more than 4 mb/d will be needed to keep refinery utilization rates at levels around 80%. The US & Canada could see around 1 mb/d of closures in the long-term. As already mentioned, even though oil demand in the US & Canada is set to decline strongly, the region's refining sector is expected to remain competitive in the international downstream market.

In the Russia & Caspian region, some closures, up to 0.5 mb/d, are also possible given the decline in product exports (Chapter 6). Further closures are likely in developed countries in the Asia-Pacific (Japan and South Korea) due to declining demand. Some shut-ins are also possible in other countries of this region, where some old units are still in operation and these will potentially face competition from new refineries that are projected to come online.

In Latin America and Africa, utilization rates in 2045 are projected at levels below 80%. However, as demand increases and many refineries are strategically important for the countries in which they operate, only limited closures are considered in these regions.

Box 5.1

The future of oil refining: adaptation

Many of the current trends in the global oil and energy sector will not leave the downstream sector unaffected. There are several challenges, as well as opportunities, in the years ahead, such as the deceleration in global oil demand growth and shifts within the product mix. Furthermore, in line with environmental concerns and rising climate ambitions from many countries, refineries are likely to come under increasing pressure to lower their carbon footprint. Finally, there is an observable policy shift to support demand for alternative fuels, such as biofuels, synthetic fuels and hydrogen, where the refining sector could play an important role.

As already highlighted in Chapter 3, global demand growth in OPEC's Reference Case is set to decelerate significantly after an initial period of strong growth during the medium-term. Consequently, global oil demand sees a relatively lengthy period of plateauing in the long-term, albeit with significant regional differences. At the product level, petrochemical feedstocks will likely play an increasingly important role in the product mix, accounting for a large part of the demand growth to 2045. However, even though there is an expected strong slowdown in demand growth for transportation fuels, they will continue to play a dominant role in the long-term product slate.

This begs the question for refiners: how to maintain the refinery product slate given these evolving trends?

It is clear that demand growth for petrochemical feedstock will require novel approaches in terms of the design of future refineries, and potentially revamping existing ones. This has been a clear trend in recent years, with the commissioning of large new refineries with petrochemical integration, especially in Asia and the Middle East, including OPEC Member Countries. Some of these plants can reportedly yield over 50% of petrochemical feedstocks.

Many existing refineries are also expanding in this direction, adding petrochemical units and adopting their product slates. Additionally, some Middle East oil companies are interested in strengthening their petrochemical position abroad, mostly in Asia. OTC processes, which have been around for some time, could also increasingly be employed in the future.

In moving towards the maximization of chemicals production, refiners appear to be targeting naphtha and primary chemical intermediates, notably aromatics and olefins. While naphtha production entails only light processing, olefins and aromatics require extensive processing steps. These can include the cracking of heavy streams, notably via FCC, hydro-cracking and catalytic reforming as the most important building blocks from the perspective of a petrochemicals-integrated refinery, with steam cracking a critical process for converting naphtha and other light hydrocarbon feedstocks. OTC arguably represents the most extreme form of such processing.

At the same time, the push for electrification in the transportation sector could potentially lead to strong drops in gasoline and/or diesel demand in some regions, mostly developed countries. However, it is important to remember that transportation fuels will remain the baseload for refiners in most developing regions.

Given the demand trends, it is obvious that complex refiners with petrochemical integration will have greater flexibility and an increasingly better overall market position, relative to simple refineries. This is why simple refineries in developed countries might be the first ones to be affected by further downstream rationalization waves (more details in Section 5.2.5).

At the same time, climate-related ambitions and environmental concerns will lead to more pressure on refineries to improve energy efficiencies and reduce carbon intensity. It should be noted that highly-complex and integrated refining plants will not be unaffected by these trends. This is due to their high energy intensity when it comes to processing.

This refining sector challenge can be addressed through a number of measures, which could help realize huge potential for energy savings. Energy efficiency starts with the refinery design and the conceptual framework for future, as well as existing refineries. Rising levels of digitalization and the implementation of big data could help to better optimize refinery

operations and thus, reduce energy consumption. In addition, fuel switching, for refinery operations, has been advocated as a pathway to more efficient refineries with a lower carbon footprint. The integration of renewables, such as wind or solar, could help reduce fossil fuel consumption in power generation.

Another central pillar for advancing refining systems is improving the performance of catalysts, with enhancements in this area a perpetual work in progress. In many instances and production stages, oxidative processes may also be required, thus oxygen could play a greater future role. Moreover, when considering a refinery's immediate site specific environment, the implementation of district heating can help the refinery recover and utilize excess heat.

CCUS is another technology that should be employed in order to reduce the carbon footprint. Some refinery processes could profit from CCUS, such as OTC or synthetic fuel production, which use CO_2 as raw materials.

In combination with CCUS and renewables, refineries are also well-positioned to produce low carbon hydrogen (blue and/or green). Hydrogen production from gasification and partial oxidation in refineries will also increase a refinery's hydrogen potential and open up possibilities to introduce more versatility into the feedstock intake, such as solid bio-products and various low-value waste streams. Consequently, low carbon hydrogen could be used within the refinery itself, but also supply hydrogen to the market. In 2021, there have been several announcements related to the possible expansion of low carbon hydrogen production and trade, including the establishment of the MENA Hydrogen Alliance.

Furthermore, rising demand for alternative fuels, such as hydrogen, biofuels or synthetic fuels could lead to the increasing hybridization of the refining business. This will create opportunities for new business models, which can already be seen.

Several refiners are integrating plastics recycling (mechanical and chemical), biofuels or synthetic fuel production at their existing sites, with several projects in Europe. In addition, some refineries after closure, could be fully converted into biofuel plants. For instance, TotalEnergies announced in 2020 that it would convert its Grandpuits refinery (France) into a plant for biofuels and bioplastics and Eni is considering a comparable strategy for its Livorno refinery (Italy). There are other similar projects focused in this direction, mostly in Europe and the US, where long-term oil demand is likely to decline significantly. While focusing on traditional fuels, refineries in developing countries are also set to play an important role in biofuels and low carbon hydrogen production, in line with rising policy support.

Finally, even though these trends will somewhat modify refining business models, it is clear that the production of traditional fuels, such as gasoline and diesel, will continue to dominate the refining business in most regions in the years to come. At the same time, however, the refinery of the future will be increasingly technology-focused, more energy efficient and more integrated relative to the conventional refinery set-up.

Nonetheless, in such a diverse landscape, and with significant regional differences, no one-solution-fits-all approach can address all possible site-specific issues. Rather, refinery configuration will be dependent on local/regional demand patterns, available crude slates and various local market conditions, including energy policies. Given their technological capabilities, modern oil refining systems are in an ideal position to adapt and evolve, and provide solutions for the future of the energy sector.

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 and which deliver most of a refinery's 'value-added'. Hence, secondary processes constitute a key gauge of the refining sector's capability to meet final product demand.

This section looks into secondary capacity additions in the medium- and long-term by major categories of secondary units. The development of the secondary capacity goes hand-in-hand with evolving refined product demand and product specifications, such as sulphur content or octane.

5.3.1 Medium-term secondary capacity additions

The 6.9 mb/d of new distillation capacity from medium-term projects (Table 5.2) is expected to be accompanied by an additional 3.7 mb/d of conversion units, 5.9 mb/d of desulphurization capacity and 1.8 mb/d of octane units (Table 5.6). These additions have relatively high complexity levels, relative to the global average, as they include several world-class refineries, especially in the Middle East and Asia-Pacific. It also reflects demand patterns, which show demand shifting to light products, and more stringent sulphur levels, such as the IMO Sulphur Rule introduced in early 2020.

Table 5.6 *mb/d*

Secondary capacity additions from existing projects, 2021–2026

	By year		
	Conversion	Desulphurization*	Octane units
2021	0.7	1.7	0.5
2022	1.1	1.3	0.4
2023	0.4	0.8	0.2
2024	0.4	0.6	0.2
2025	0.6	0.8	0.3
2026	0.5	0.6	0.2
	By region		
	Conversion	Desulphurization*	Octane units
US & Canada	0.0	0.2	0.0
Latin America	0.2	0.3	0.1
Africa	0.5	0.8	0.3
Europe	0.1	0.1	0.0
Russia & Caspian	0.6	0.4	0.1
Middle East	0.5	2.2	0.5
China	1.0	0.9	0.5
Other Asia	0.8	1.0	0.3
World	**3.7**	**5.9**	**1.8**

* *Desulphurization capacity in this table includes naphtha desulphurization.*

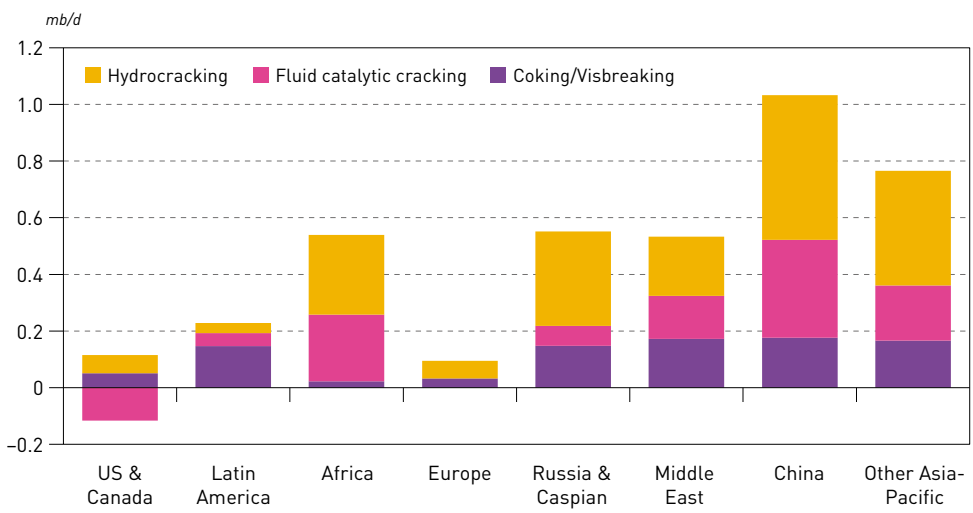
Source: OPEC.

Conversion units

Figure 5.20 highlights the geographic distribution of conversion capacity additions by major unit category. The 3.7 mb/d in new global conversion units for the period 2021–2026 are spread across each of the three main unit categories: 51%, or 1.9 mb/d, for hydrocracking, 25%, or 0.9 mb/d, for coking/visbreaking (essentially all coking), and 25%, or 0.9 mb/d, for FCC/residue fluid catalytic cracking (RFCC) capacity.

In line with distillation additions, the majority of incremental conversion capacity is located in the Middle East and Asia-Pacific, with more than 60% of the total. The Middle East is expected to add around 0.5 m/d of new conversion capacity, almost equally distributed among the three categories. In China (+1 mb/d) and Other Asia-Pacific (+0.8 mb/d), there is a clear trend toward hydrocracking, with its inherent flexibility between light and middle distillates. Africa is set to add around 0.5 mb/d of new conversion capacity. Additions in developed countries remain minimal, except for Russia & Caspian where around 0.5 mb/d of new conversion capacity is expected by 2026. These projects are in line with efforts to upgrade Russia's refining system.

Figure 5.20
Conversion projects by region, 2021–2026



Source: OPEC.

Desulphurization units

Global medium-term desulphurization additions are estimated at around 5.9 mb/d. This means that the ratio of desulphurization relative to distillation capacity is projected at around 85%, which is considerably higher than the current level of 67%.

Almost 70% is set to be located in the Middle East (2.2 mb/d) and Asia-Pacific (1.9 mb/d). Africa is also expected to add significant desulphurization capacity volumes of around 0.75 mb/d in the medium-term. All this reflects not only rising oil demand, but tightening product specifications, such as shifting to Euro 4–6 equivalent standards and AFRI fuel standards. At the same time, other regions are expected to add less due to lower distillation capacity additions, as well as peaking oil demand.

In the Middle East, the ratio between desulphurization and distillation capacity is at around 130%, which is in line with the region's high-sulphur crude slate. In the Asia-Pacific region and Africa, this ratio is significantly lower, at between 55% and 65%.

Looking at the different product categories, the majority (more than 50%) of desulphurization capacity is set to come from middle distillates, around 3 mb/d, which reflects the trend towards low and ULS standards for diesel. Of the rest, 1.3 mb/d is for naphtha processing, 0.9 mb/d for heavy streams (VGO/residue) and 0.6 mb/d for gasoline.

Octane units

Octane unit increments are estimated at 1.8 mb/d between 2021 and 2026, driven by rising gasoline demand in developing regions, rising octane levels and increasingly growing demand for BTX aromatics. Similar to other secondary units, the majority are expected to be installed in the Middle East, Asia-Pacific and Africa (around 85%). In other regions where prospects for gasoline demand are relatively weak, there are only minor medium-term investments.

The majority are set to be for catalytic reforming (1.3 mb/d) and the remainder (0.5 mb/d) attributed to isomerization, alkylation and MTBE/ETBE. The latter projects are predominantly in Asia, notably China, where there continues to be interest in expanding MTBE use to meet rising gasoline pool octane requirements.

5.3.2 Long-term secondary capacity additions

Today, essentially all major projects for new refineries and large expansions comprise complex facilities with high levels of upgrading, desulphurization and related secondary processing. Especially for large projects in the Middle East and Asia-Pacific, the production of high levels of petrochemical feedstocks is a key objective, which is increasingly driving the secondary capacity installations.

Smaller projects at existing refineries are generally directed towards the upgrading goals of reducing residual fuel output and achieving quality improvements for clean products. Again, the driver is that most incremental fuel demand is for light, clean products, including petrochemical feedstocks.

Condensate splitters, which are currently primarily being built in the Middle East are one exception to the overall trend towards increased complexity. Condensate splitter capacity tends to bring with it only limited secondary processing, often centred on catalytic reforming, isomerization and hydrotreating of lighter fractions.

In setting out to capture outlooks for refining, and especially future processing needs by type of unit, the WOO modelling has to manage a number of challenges. One is the evolution of refinery process technology. This tends to be stable, with only gradual changes, mainly as catalysts slowly improve. That said, significant process improvements and novel technologies warrant close monitoring.

Over the next few years, these developments, and others, could start to materially impact installed refinery configurations. The current refinery modelling represents proven processes and allows for gradual efficiency improvements. Novel processes are incorporated only once these are commercially proven, and sufficient to have some level of meaningful volume impact.

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. It is now possible for a new complex to be designed to produce 40% or more of petrochemical feedstocks.

With regard to petrochemicals, the modelling undertaken to project the refining outlook is designed to match demand for 'liquids' as projected by the WOO and other statistical sources.

The more common roles that refineries play in producing petrochemical feedstocks are, however, included, notably: the use of the FCC unit as a source of propylene; and the use of catalytic reformers to feed aromatics (BTX) extraction units and for production of naphtha and LPG. These are then used as a feedstock to steam crackers and other units, in turn, leading to by-products returning to the refinery as fuel blend stocks.

As in recent outlooks, this year's projections for future required secondary processing through to 2045 (Table 5.7 and Figure 5.21), cover the conventional refinery process technologies that comprise the vast majority of new units added. Similar to those for crude distillation units, these projections for secondary process units take into account the 4.5 mb/d of net refinery closures assumed for the period 2020–2026. These remove not only distillation, but in many cases, associated secondary unit capacity. As a result, projected additions, over and above firm projects are somewhat higher than they would have been had no closures been assumed.

At the global level, projections indicate the need to add some 7.1 mb/d of conversion units, 16.7 mb/d of desulphurization capacity and 4.7 mb/d of octane units in the period 2021–2045, to go with the 14 mb/d of new distillation capacity. It is important to bear in mind that these projections will be influenced, up or down, by several factors, including: the overall level of global liquids demand; the extent to which this embodies growth or a decline in such streams as gasoline, jet and diesel fuel; and the evolution of the global crude slate between lighter, less sour and heavier, more sour grades.

Table 5.7
Global capacity requirements by process, 2021–2045

mb/d

	Existing projects	Additional requirements		Total additions
	to 2026*	2026–2035	2035–2045	to 2045
Crude distillation	**6.9**	**4.9**	**2.2**	**14.0**
Conversion	**3.7**	**1.9**	**1.4**	**7.1**
Coking/visbreaking	0.9	0.2	0.4	1.5
Catalytic cracking	0.9	1.0	0.7	2.6
Hydrocracking	1.9	0.8	0.3	3.0
Desulphurization**	**4.5**	**9.1**	**3.1**	**16.7**
Gasoline	0.6	0.5	0.3	1.4
Distillate	3.1	8.0	1.3	12.3
VGO/residue	0.9	0.6	1.5	3.0
Octane units***	**1.8**	**1.8**	**1.1**	**4.7**
Catalytic reforming	1.3	0.9	0.7	2.8
Alkylation	0.2	0.5	0.3	1.0
Isomerization	0.3	0.2	0.1	0.5
MTBE	0.0	0.3	0.1	0.4

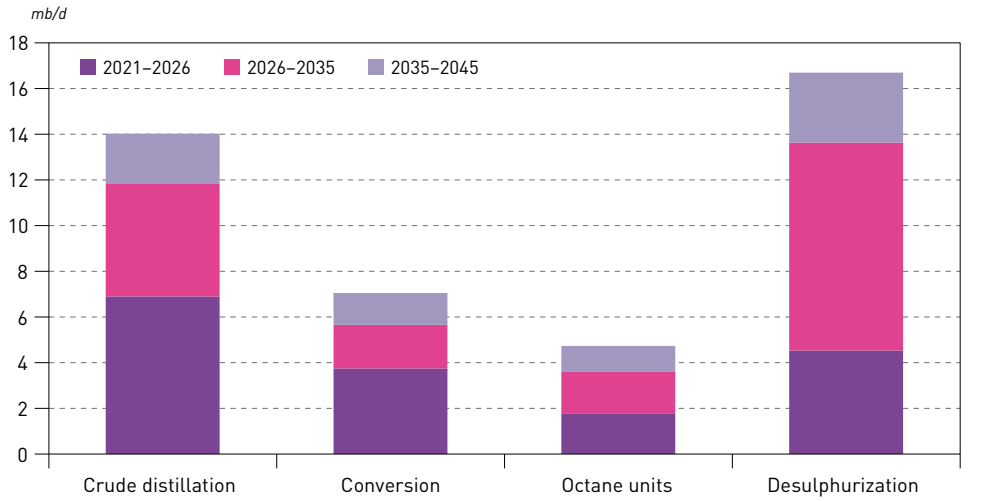
* *Existing projects exclude additions resulting from 'capacity creep'.*

** *Naphtha desulphurization not included.*

*** *New units only (excludes any revamping).*

Source: OPEC.

Figure 5.21
Conversion capacity requirements by process type, 2021–2045



Source: OPEC.

The pace of change in product quality will also be critical, most notably the speed with which developing regions complete the move to Euro 4/5/6 standards for gasoline and diesel, and whether jet fuel sulphur levels are lowered. Moreover, needed conversion and desulphurization additions will be sensitive to the extent to which the IMO 2020 Sulphur Rule is met by the use of on-board scrubbers, which would allow the continued use of HSFO instead of 0.5% sulphur fuels.

Future scrubber use and penetration has been, and remains, the subject of a number of uncertainties, including whether the use of scrubbed HSFO can survive given the IMO's target of reducing GHG emissions by 40% from shipping by 2030 *(versus* 2008 levels) and by 50% by 2050. In the short-term, however, scrubber sales and installations are buoyant, and HSFO bunker sales have been much higher at some bunkering ports than was anticipated. The call on the refining industry to add vacuum gasoil (VGO)/residue desulphurization and/or upgrading capacity will partly depend on marine bunker sector developments in the long-term.

Conversion units

As shown in Table 5.7, existing projects to 2026 have conversion additions at over 54% of new distillation capacity. Along with Figure 5.21, it is indicated that this level is likely to drop to around 42% in the period 2026– 2035, and then recover to the 54% level during the period 2035–2045. This is as distillation additions slow in the long-term and as the world's crude slate trends heavier.

The 0.9 mb/d of coking/visbreaking capacity – predominantly coking – added via existing projects to 2026 is followed by lower projected additions of 0.2 mb/d from 2026–2035, then 0.4 mb/d from 2035–2045. The slowdown in additions between 2026 and 2035 reflects the large project additions to 2026, combined with a relatively stable global crude slate quality during the period and a modest projected recovery in residual fuel demand. The latter is driven by a gradual increase and then a plateau in the use of on-board scrubbers.

From 2035–2045, the picture changes. Coking additions continue, as noted, and utilization is expected to recover appreciably. The key drivers are a projected 'heavying up' of the global crude slate between 2035 and 2045, as highlighted in Chapter 4, together with a reduction in residual fuel demand.

A third of total coking/visbreaking additions (again predominantly coking) are expected to take place in Latin America and the US & Canada. A recovery in heavy crude production in Latin America and a gradual, but sustained growth in western Canadian oil sands are projected to be the primary drivers behind this. (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 market, i.e. downstream of upgraders and blending.) The remaining additions are spread across the other world regions.

Future coking additions and utilization levels will be sensitive to heavy crude developments in the Middle East, and in countries such as Canada, Venezuela, Brazil, Colombia and Mexico, as well as to how residual fuel demand evolves.

This outlook includes the presumption that the Trans Mountain pipeline expansion will go ahead around 2023, increasing western Canadian heavy crude exports to Asia and temporarily reducing them to the US. Over the longer-term, however, the ongoing oil sands expansion leads to continued growth in imports to the US. Likewise, the projected recovery in Latin America's heavy crude production leads to a gradual rise in such crudes being exported to the US, their historical primary export market. As a result, coker utilizations are expected to be high in the US – in the 85–90% range – over the long-term, while those in other regions are projected to be somewhat lower.

Fluid catalytic cracking (FCC) additions are driven primarily by gasoline demand. Globally, this is projected to rise from around 26 mb/d in 2019 to just above 27 mb/d in 2030, after which it essentially plateaus until there is a small drop after 2040. This seemingly static picture, however, masks major differences in the evolution of demand between industrialized and developing regions.

In the former (US & Canada, Europe, Japan and Australasia), gasoline demand enters a sustained decline after 2021, which then accelerates post-2030. In contrast, in developing regions (Latin America, Africa, the Middle East and developing Asia-Pacific) demand grows significantly. The net effect is that the loss in gasoline demand of nearly 5 mb/d from 2019–2045 in industrialized regions is more than offset by demand gains in developing regions. This has major implications for FCC and other gasoline unit utilizations, capacity additions and closures, and for the gasoline trade.

The continued growth in developing regions helps sustain the need for new FCC and other gasoline units, despite the parallel demand declines in the industrialized regions. On top of 0.9 mb/d of medium-term projects, FCC additions of 1 mb/d are seen as needed for the period 2026–2035, then a further 0.7 mb/d for 2035–2045. This is in line with the decelerating pace of gasoline demand growth in developing regions.

Driven by the disparity in demand trajectories, a mere 2% of the FCC additions between 2026 and 2045 are projected to be in industrialized and the Russia & Caspian regions. The bulk of the additions are spread across Latin America, Africa, the Middle East, China and Other Asia-Pacific. Correspondingly, FCC utilizations are projected to decline steadily to 2045 in the US & Canada, Europe and other industrialized regions. This implies needed FCC closures at refineries in industrialized regions that could total at least 0.5 mb/d over the long-term. These could comprise single unit closures, as has been witnessed in the US, and/or components of total refinery shutdowns (Section 5.2.5.).

Conversely, the utilization of FCC units in developing regions is expected to rise gradually over the long-term. It also needs to be borne in mind that Asia, in particular, has a high proportion of RFCC units and a growing tendency to utilize FCCs to produce propylene for petrochemical feedstock. These factors, plus the ability to at least partially swing FCC yields away from gasoline and toward distillates, are included in the modelling and tend to add a degree of resiliency to the FCC as a core upgrading 'engine'.

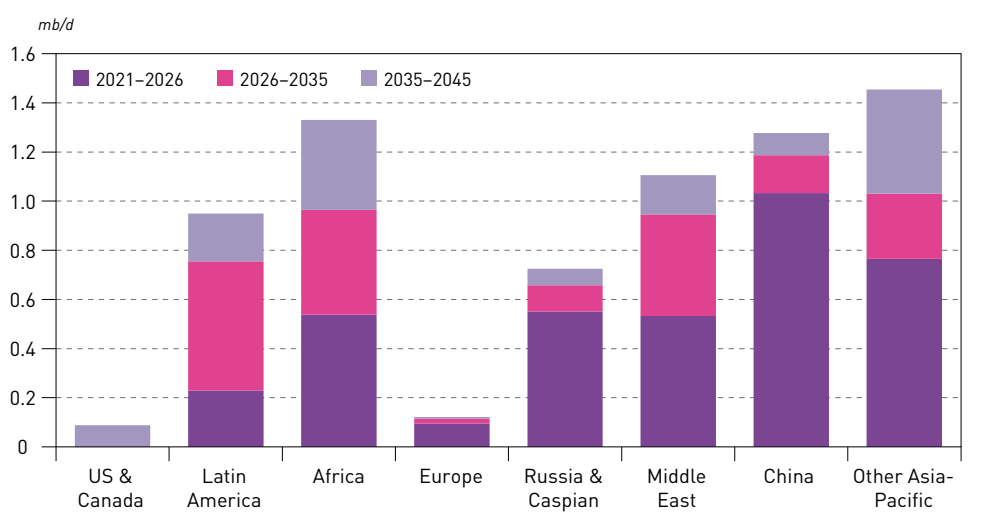
Hydrocracking units have inherent flexibility to alter yields to emphasize either naphtha/gasoline or distillates. Today, their use is mainly associated with increasing production of the latter (jet/ kerosene and gasoil/diesel). However, it is worth noting that a few projects in Asia are using hydrocrackers to produce heavy naphtha as feedstock to catalytic reformers for aromatics (BTX) production. Global project additions of 1.9 mb/d from 2021–2026 are projected to be followed by a further 0.8 mb/d from 2026–2035, but then much reduced additions of 0.3 mb/d are expected for the period 2035–2045. This slowing pace for additions is consistent with the projection for a deceleration in distillate demand growth over the longer-term.

As is the case with gasoline, there are marked differences in demand growth patterns between industrialized and developing regions. Using the same regional groupings as were applied for gasoline, demand for jet/kerosene plus gasoil/diesel in industrialized regions drops by around 5 mb/d from 2019–2045, while that for developing regions rises by around 8 mb/d.

Consistent with the regional differences in demand growth, hydrocracking additions, beyond projects, are forecast to be minor in the US & Canada and Europe. Combined, they are only around 1% of the global total. The Russia & Caspian region is expected to see around 6% of total additions, while the remaining 90%-plus are again spread across Latin America, Africa, the Middle East and Other Asia-Pacific. Unlike FCC units, hydrocrackers in industrialized region refineries are not expected to suffer the same risk of low utilization and closure. Globally, hydrocracker utilizations are expected to rise gradually over the long-term and generally be in the range of 75–88%.

The regional distribution of total future conversion capacity additions is presented in Figure 5.22. Requirements are expected to be led by the Asia-Pacific, at around 39%, or 2.7 mb/d, of total additions to 2045; and the Middle East, with 16%, or 1.1 mb/d. As percentages of the global total, these levels are substantial, but lower for the two regions than those for distillation capacity additions, at 46% and 20% of global totals to 2045. This indicates relatively higher proportions of conversion additions, relative to distillation, in other world regions, in part as existing refineries in nearly all regions raise their processing complexity.

Figure 5.22
Conversion capacity requirements by region, 2021–2045



Source: OPEC.

Significant additions are projected for Latin America and Africa, at around 0.95 mb/d and 1.3 mb/d, respectively. These are driven by sustained regional product demand growth, with the bulk of additions in the longer-term. Additions in the Russia & Caspian region to 2045 are estimated at 0.7 mb/d, occurring predominantly in the period to 2035. Overall, it is the non-OECD regions that sustain conversion capacity growth over the period to 2045. Only 3% of total conversion capacity growth to 2045 is expected in the US & Canada and Europe.

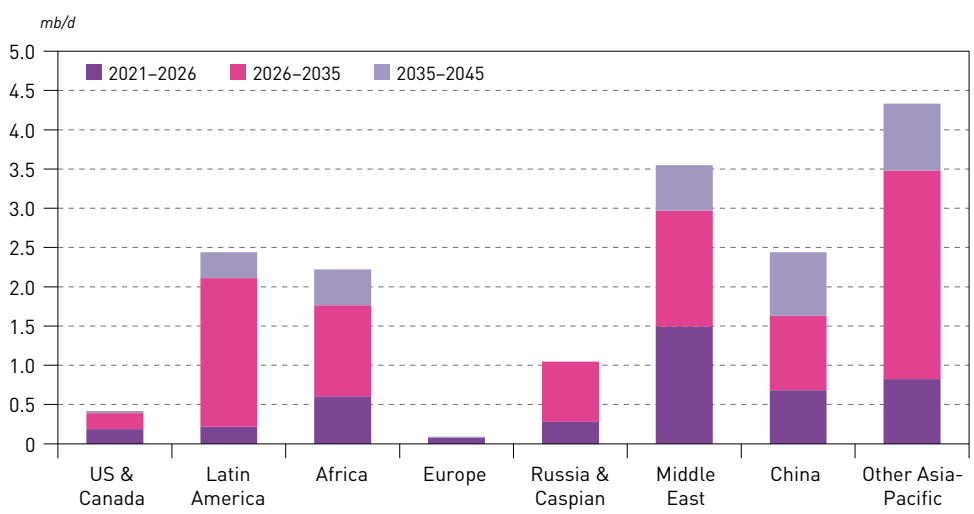
Desulphurization units

Desulphurization unit additions are projected to continue throughout the outlook period to 2045, but with the largest additions expected in the period 2026–2035. As illustrated in Table 5.7, and also shown in Figures 5.23 and 5.24, 4.5 mb/d of global projects for 2021–2026 are expected to be followed by some 9.1 mb/d of additions for 2026–2035, then 3.1 mb/d for 2035–2045.

A critical component of secondary capacity, desulphurization additions represent the largest capacity increases among all process units over the forecast period. The total of 16.7 mb/d of desulphurization additions by 2045, which excludes over 3 mb/d for naphtha desulphurization, exceeds the 14 mb/d for added distillation capacity. It is evident that while major new refinery projects are designed with significant built-in desulphurization capacity, the high-level of total desulphurization additions, relative to distillation, points to substantial desulphurization occurring at existing refineries. This is due to their processing complexity being raised in order to increase yields of predominantly light, clean products, and as sulphur standards for those products are progressively tightened.

Specifically, the continued move towards near-universal ULS gasoline and diesel standards is a key factor driving the high level of desulphurization additions. Further drivers are expected reductions in sulphur content for jet fuel and heating oils, as well as marine fuels with the impact of the IMO 2020 Sulphur Rule and the possibility of additional Emission Control Areas (ECAs) in the future. The bulk of these changes is expected to be completed by around 2030–2035, hence, the pattern of extensive additions occurring for the period to 2035, followed by much lesser additions for 2035–2045.

Figure 5.23
Desulphurization capacity requirements by region*, 2021–2045



* *Projects and additions exclude naphtha desulphurization.*

Source: OPEC.

With the tightening of sulphur standards projected to be essentially complete by 2035, and with a slowing in global liquids demand growth post-2035, desulphurization additions in the long-term are driven largely by a steady increase in global crude slate sulphur levels, from approximately 1.2% around 2025, to roughly 1.35% in 2045.

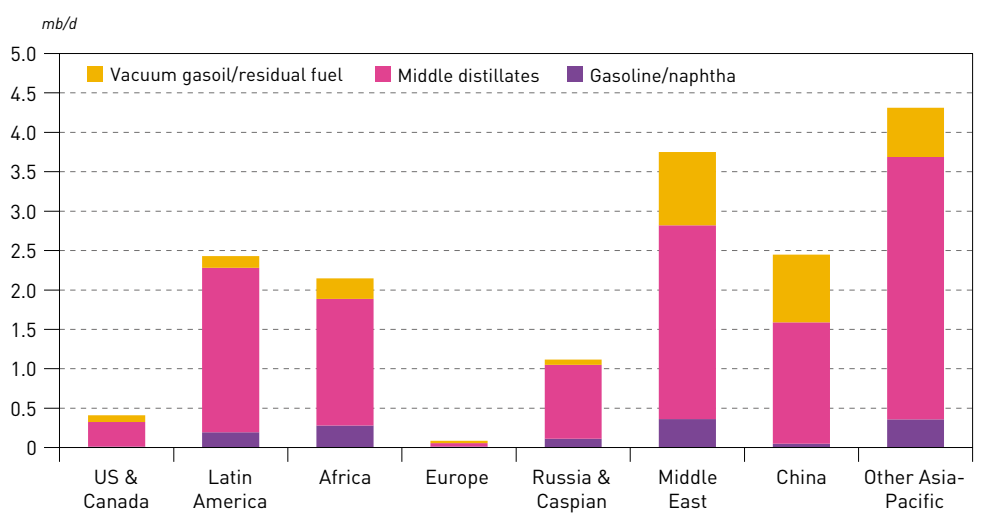
The industrialized regions are already largely at ULS standards for gasoline and diesel. In the period to 2026, project additions are thus focused mainly on those regions that are undertaking, or completing, steps toward ULS gasoline and diesel standards, notably a series of countries across Africa, the Middle East and developing Asia, as well as Latin America and the Caspian. The same applies in regions where there is heavy construction of new export refineries geared towards the production of Euro 5/6 fuels, notably the Middle East (Figure 5.23).

Thereafter, to 2035, desulphurization additions are predominantly in developing regions where, as already discussed, gasoline, jet fuel and diesel demand growth is expected to continue. The near universality of ULS fuels by 2035 calls for all such incremental demand to be desulphurized.

Driven by demand growth and goals to reach ULS standards, the developing regions of Latin America, Africa, the Middle East and developing Asia account for over 90% of total desulphurization additions (excluding naphtha desulphurization) to 2045, with the US & Canada plus Europe accounting for only 3%. The remaining 6% are projected to occur in the Russia & Caspian region, driven by tax incentives to upgrade away from residual fuel and with the intention to produce diesel and gasoline to ULS standards for both domestic use and export.

Gasoline desulphurization additions, at a total of 1.4 mb/d by 2045, are focused on developing regions where, as noted, gasoline demand continues to grow and where the shift to ULS standards is still ongoing. Middle distillate additions comprise the bulk (74%) of total desulphurization additions, excluding naphtha, to 2045. They are anticipated across all regions but, again, with the primary concentration in developing countries led by the Middle East and the Asia-Pacific, with a combined 7.3 mb/d, out of a global total of 12.3 mb/d to 2045.

Figure 5.24
Desulphurization capacity requirements by product and region*, 2021–2045



* *Projects and additions exclude naphtha desulphurization.*

Source: OPEC.

VGO/residue desulphurization is the one category where additions are projected to increase rather than decline later in the period. Projects to 2026 (Table 5.7) total 0.9 mb/d, in part associated with meeting increased demand for 0.5% VLSFO, as a result of the IMO 2020 Sulphur Rule. Further additions are projected at 0.6 mb/d for the 2026–2035 period, but are then expected to more than double to 1.5 mb/d for 2035–2045. Total additions to 2045 are concentrated in the Middle East (31%) and Asia (over 49%), a result of these regions processing large quantities of sour Middle East and Latin American crudes in the long-term. This is consistent with the anticipated rising share of heavy crudes in the global crude slate over the projection period.

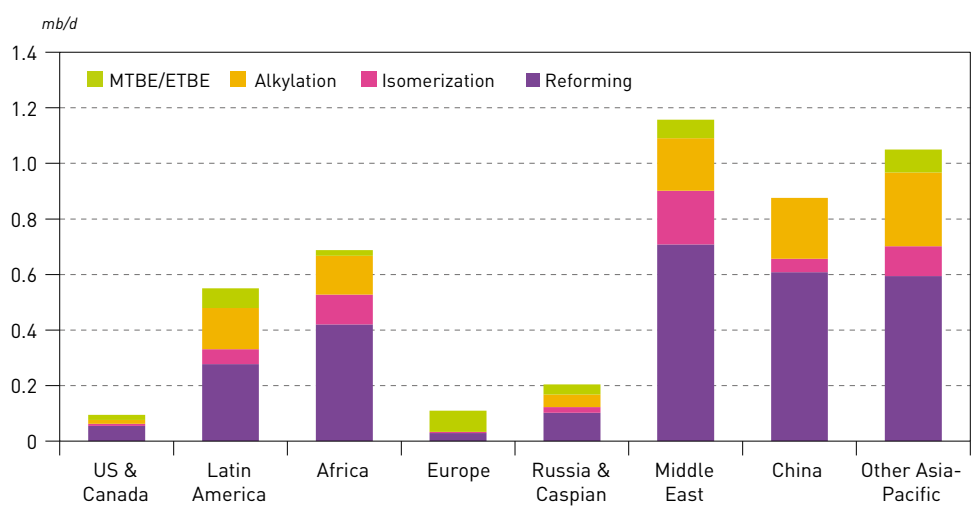
Octane units

As shown in Table 5.7, additions for octane units are expected in the period to 2045, with a sustained pace through 2035, but slowing thereafter. By 2026, 1.8 mb/d of project additions are expected to be followed by another 1.8 mb/d for 2026–2035, dropping to 1.1 mb/d for 2035–2045. As discussed in relation to FCC units, one primary driver of octane unit additions is the projected continued growth in gasoline demand in developing regions through 2045, albeit slowing towards the end of the period.

A second key driver is the presumed gradual increase in gasoline octane levels built into the modelling. Levels are projected to slowly increase in the developing world towards those currently seen in industrialized countries as a series of countries seek to raise their minimum octane standards. Levels in industrialized countries also have the potential to rise in order to improve engine efficiencies. This progressive increase in octane needs is projected to have largely played out by the longer-term, reinforcing the tendency for octane unit additions to eventually weaken, notably post-2035.

Maintaining the pattern visible in the projects, the majority of octane units are expected to be required in the form of catalytic reforming, with a total of 2.8 mb/d to 2045, alkylation at 1 mb/d, isomerization at 0.5 mb/d and MTBE/ETBE units at 0.4 mb/d. Reforming and isomerization raise naphtha's octane content and thus enables additional naphtha – including that from condensates – to be blended into gasoline. MTBE and associated ethers are used (outside the US & Canada) either to meet oxygen content requirements in gasoline, and/or to boost octane levels.

Figure 5.25
Octane capacity requirements by process and region, 2021–2045



Source: OPEC.

In line with other secondary processes, the vast majority (91%) of these additions are projected for developing regions, led by the Asia-Pacific and the Middle East (at 65% combined), and driven by large gasoline demand increases and expanding petrochemical industries. (The latter increases the need for catalytic reforming to produce BTX aromatics.) Latin America and Africa are also projected to have significant octane unit additions as their gasoline standards rise, accounting for 12% and 15% of the total additions, respectively. In contrast, the US & Canada, Europe and the Russia & Caspian region together garner the remaining 9% of octane unit additions to 2045.

5.3.3 Implications for refined products supply and demand balances

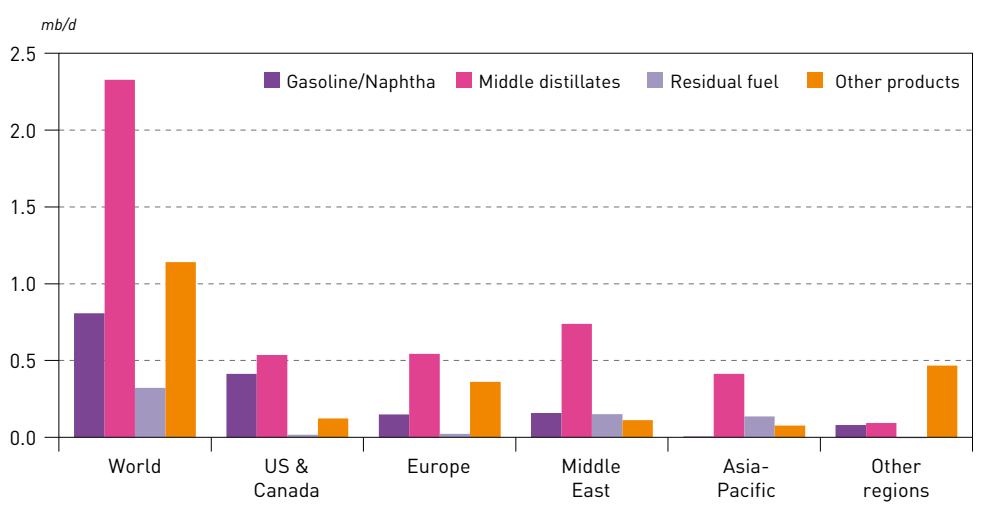
In assessing the effects of capacity additions on regional product balances, it needs to be emphasized that refiners have some limited flexibility to optimize their product slates, depending on changing market circumstances and seasonal patterns. This can be done by changing feedstock composition (crude slate) and by adjusting process unit operating modes. Table 5.8 below presents an estimation of the cumulative potential incremental output of refined products resulting from existing projects by major product category in the period 2020–2026. It also corresponds with the potential incremental output shown in Section 5.2.3.

Total potential refining capacity in the period 2020–2026 is around 7.8 mb/d, assuming utilization of 90%. As already noted, the analysis shows a balance relative to 2019 and does not include refinery closures.

The majority of incremental capacity is related to middle distillates, at 3.5 mb/d, or 44%, in line with strong diesel demand growth in developing regions. Gasoline/naphtha output accounts for around 2.1 mb/d, while potential output of other products is estimated at 2.2 mb/d. Fuel oil, understandably, has only minor additional capacity from refinery projects in the medium-term.

Figure 5.26 shows the balances for the main product classes at the regional level. It is calculated based on the incremental refining potential by product (Table 5.8) and the regional incremental demand by product. Non-refinery streams are deducted in order to get only demand for refined products.

Figure 5.26
Expected surplus/deficit* of incremental product output from existing refining projects, 2021–2026



* *Declining product demand in some regions contributes to the surplus.*

Source: OPEC.

Table 5.8
Global cumulative potential for incremental product output*, 2020–2026

	Gasoline/ Naphtha	Middle distillates	Fuel oil	Other products	Total
2020	0.4	0.7	–0.1	0.4	1.3
2021	0.7	1.2	0.0	0.6	2.5
2022	1.0	1.8	0.1	1.0	3.8
2023	1.2	2.2	0.1	1.4	5.0
2024	1.5	2.6	0.1	1.7	5.8
2025	1.8	3.1	0.1	1.9	6.9
2026	2.1	3.5	0.1	2.2	7.8
	27%	*44%*	*1%*	*28%*	*100%*

* *Based on assumed 90% utilization rates for the new units.*

Source: OPEC.

The estimated cumulative surplus by 2026 is around 4.6 mb/d, as previously explained (Section 5.2.3). Figure 5.26 shows the most significant overhang for middle distillates estimated at 2.3 mb/d cumulative by 2026. Demand growth for middle distillates remains weak in the medium-term, due to switching away from diesel in the road transportation sector and only moderate recovery in the aviation sector. The largest overhang of middle distillates is expected in the Middle East, followed by the US & Canada and Europe. In the Middle East, the overhang is the result of expanding refining capacity, while in the US & Canada and Europe, the surplus comes from declining demand for this product.

Gasoline/naphtha show an overhang of 0.8 mb/d for the period 2020–2026. The largest part of this overhang is located in the US & Canada at 0.4 mb/d, mostly due to declining demand. Other regions show moderate gasoline/naphtha overhangs, such as Europe and the Middle East. The balance for fuel oil shows surpluses in the Middle East and Asia-Pacific, at around 0.15 mb/d each, while other regions are balanced. In the category 'Other products', the global cumulative overhang to 2026 is estimated at around 1.15 mb/d, with the largest surpluses in Europe.

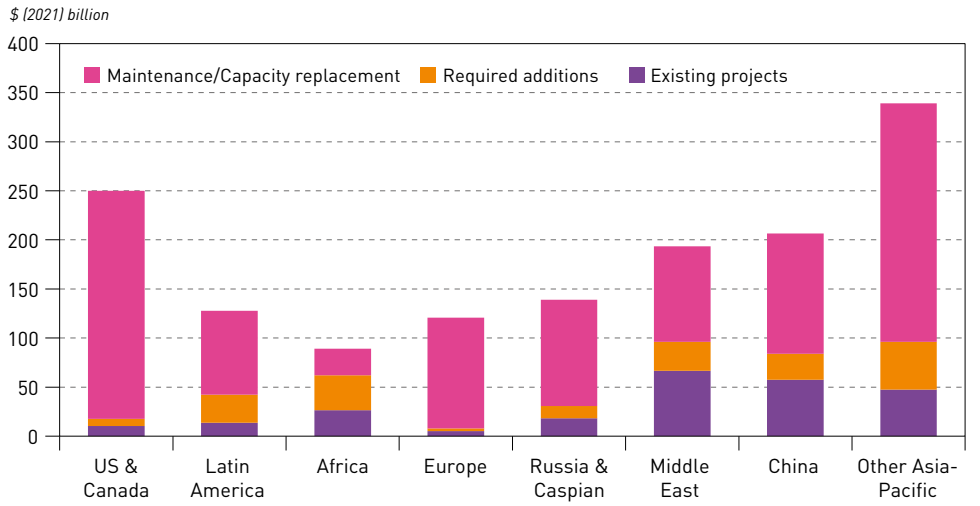
As already noted, it is important to state that this balance does not include projected closures to 2026, which are estimated at around 4.5 mb/d (Section 5.2.5). If they all materialize, the market would be more balanced with some products possibly in deficit for the period 2020–2026.

5.4 Investment requirements

Downstream sector investment requirements are shown in three separate categories (Figure 5.27). The first category relates to existing (identified) projects, which are expected to come online in the medium-term (2021–2026) and as described in Section 5.1. This category includes the real investment costs to the extent possible, and if reported. The second category is related to investments beyond 2026 and generally represents still generic projects in the long-term. The third category focuses on the continuous maintenance of the global refining system and covers necessary capital replacements throughout the projection period (2021–2045).

For the first category, the total investment requirement is estimated at just below $250 billion, which is significantly higher relative to WOO 2020 projections. It is in line with expected medium-term capacity expansions of 6.9 mb/d in the current Outlook. Investments of almost $172 billion,

Figure 5.27
Refinery investments by region, 2021–2045



Source: OPEC.

or 77%, are accounted for by the Middle East and Asia-Pacific (including China), as most new projects come from these regions. Africa is projected to also have significant investments of $27 billion, an increase of more than $10 billion from the WOO 2020, given the more optimistic prospects for new refining capacity. Investments in other regions are moderate, led by the Russia & Caspian ($19 billion), Latin America ($14 billion) and the US & Canada ($10 billion), mostly dedicated to expansion projects at existing plants. Finally, Europe is likely to see only $5 billion of medium-term investments into the downstream sector.

Beyond 2026 and to 2045, total investments into new refining projects are expected at $192 billion. In line with the capacity outlook, there is a significant slowdown in the rate of downstream investments. Similar to the medium-term, major investments will be located in developing regions. More than half of the investments are accounted for by the Middle East and Asia-Pacific (including China). However, in the long-term, investments in other regions, such as Africa and Latin America, are considerably higher relative to the medium-term at $36 billion and $29 billion, respectively, as more capacity is projected to come online. New refining capacities are required in both regions in order to reduce product imports in the midst of expanding oil demand. Developed regions (the US & Canada, Europe and Russia & Caspian) see only minor investment levels, totalling $22.5 billion.

Finally, for maintenance and replacement costs the required investments are estimated at around $1 trillion between 2021 and 2045. These investments are needed in all regions led by the Other Asia-Pacific and the US & Canada.

5.5 Refining industry implications

Even before the COVID-19 pandemic outbreak, the global downstream market was exhibiting capacity surpluses, and previous editions of the WOO pointed to the need for medium-term refinery closures. The demand shock of 2020, and the uncertainty related to future demand developments, led to a wave of refinery closures, and more are expected in the coming years. A total of 4.5 mb/d of refining capacity is set to be closed between 2020 and 2026, mostly in developed

regions. Many of the plants scheduled for closure are less efficient, smaller in size and with no petrochemical integration. Closures should help to stabilize the downstream sector and return refining utilization rates to sustainable levels in the medium-term.

Nevertheless, the uncertainty related to oil demand growth remains, and could possibly lead to further closure announcements in the medium-term. At the regional level, the downstream sectors in developing countries are likely to be more resilient thanks to expanding demand. At the same time, as demand starts declining in developed countries, refiners in the US & Canada, developed Asia-Pacific and Europe will continue to see pressure, even after the current wave of closures.

In the long-term, slowdowns in demand growth over the long-term will mirror the dynamics in the global and regional downstream market. Global refinery throughputs are set to start plateauing from 2035 onwards, and the need for additional capacity will begin to decline. In the last five years of the outlook, only minimal additions will be required at the global level. That means that construction of large refining projects towards the end of the outlook period becomes increasingly unlikely.

At the regional level, the migration of refining capacity to developing countries is expected to continue, with most of the new capacity being commissioned in the Middle East, Asia-Pacific, Africa and Latin America. A large number of new plants are anticipated to have petrochemical integration, thus providing a 'hedge' against demand decline for traditional fuels.

Furthermore, refineries in developed countries are likely to build biofuel capacities and possibly integrate CCUS as a result of more stringent energy policies. In line with this, the closure of some facilities will mean the start of a new life cycle. Some plants are likely to be converted into biofuel or hydrogen production plants, as strategies shift among oil and gas companies. Nevertheless, new plant capacities are likely to be smaller in size. In order to ensure business sustainability, supportive energy policies seem decisive for these conversions, at least for the foreseeable future.

Finally, the uncertainty over energy policies and related implications on oil demand remain significant (see Chapter 8). Lower-than-expected oil demand in the long-term would most probably mean more pressure on utilization rates, and, in turn, lead to fewer project additions and/or more closures. Nevertheless, even though the downstream sector is projected to face numerous challenges as it approaches maturity, it will remain a large and important part of the global oil and gas industry.

Oil movements

Key takeaways

- The COVID-19 pandemic had a severe impact on global oil trade in 2020. Global interregional movements, including crude, condensate and refined products, fell from 57 mb/d in 2019 to just below 50 mb/d in 2020, due to the oil demand drop and related supply adjustments. In the medium-term, global oil trade is expected to recover to pre-COVID levels, before gradually reaching 61.5 mb/d in 2045.

- After the 2020 drop, global crude and condensate trade is projected to reach levels above 38 mb/d in 2025 and 2030 and then 40 mb/d and above from 2035 onwards, supported by increased oil demand in the Asia-Pacific and rising crude and condensate supply in the Middle East.

- Middle East crude and condensate exports are projected to return to pre-COVID levels of around 18 mb/d in 2025, with levels to some extent limited by rising local crude use and increasing exports from other regions. In the longer-term, exports are set to rise to almost 23 mb/d in 2045, in line with rising OPEC liquids demand.

- The main destination for Middle East crude and condensate barrels will be the Asia-Pacific region, with volumes increasing from around 15 mb/d in 2019 to just above 19.5 mb/d in 2045. However, Europe, along with the US & Canada, remain important export outlets for the Middle East.

- Based on rising oil supply, Latin American crude and condensate exports are set to increase and reach almost 5 mb/d by 2025, remaining above 4 mb/d throughout the outlook period. The main destinations for Latin American barrels include the US & Canada, the Asia-Pacific, and moderate volumes to Europe.

- Crude and condensate exports from the Russia & Caspian are mostly stable at levels just below 7 mb/d throughout the outlook period, with a rising focus on the Asia-Pacific and decreasing shipments to Europe.

- African crude and condensate exports are expected to decline from almost 6 mb/d in 2019 to around 4.7 mb/d in 2045, as local crude use increases significantly. Most of the African volumes are projected to leave for Europe and the Asia-Pacific.

- Based on supply patterns, crude and condensate flows from the US & Canada are seen rising to 4 mb/d in 2025, but start declining thereafter, dropping to 1.7 mb/d by 2045. At the same time, crude and condensate imports to the US & Canada (mostly heavier barrels), are expected to reach almost 3.5 mb/d in 2025 and then decline to around 2.5 mb/d for the rest of the period.

- Europe's crude and condensate imports are set to drop by 3 mb/d between 2019 and 2045, in line with declining demand and despite an expected drop in local production.

- The Asia-Pacific region is the main outlet for crude and condensate flows, with total imports increasing from 23.5 mb/d in 2019 to almost 30 mb/d in 2045. Latin America and the US & Canada are set to increase their exports in the medium-term, while shipments from the Russia & Caspian, along with the Middle East, increase significantly after 2030.

Oil trade movements are an indispensable part of the global oil market and enable the integration of different regions into the overall global system. They help balance out the market, while taking into account oil supply and demand trends. 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 regions. Projections are based on the assumptions and modelling results discussed throughout this Outlook, including oil demand, supply and refining. Projections on trade movements also include assumptions regarding logistics developments.

6.1 Logistics developments

The development of logistics infrastructure is crucial for maintaining oil trading and exporting capacity and the availability of products for markets. For this reason, significant interregional 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 altered by the infrastructure that is developed. 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 moving crude oil, 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, the Russia & Caspian, along with the US & Canada.

6.1.1 The US & Canada

The upending of US and Canadian crude oil supply and logistics that occurred in 2020 due to the COVID-19 pandemic continued into 2021 and will likely reverberate for years to come. COVID-induced financial difficulties and production declines for US shale producers, combined with new pipelines to the Gulf Coast, have dramatically altered the logistics capacity balance. Logistic constraints shifted into a logistics surplus for most movements.

In parallel, political and legal challenges continue to delay some pipelines, and in some cases cancellations have occurred. The most notable was the recent denial by the Biden Administration of permits for Keystone XL, arguably ending the project. As a result, the logistics outlook remains uncertain, which has been the case for the past few years.

US

US crude oil and condensate exports (excluding NGLs), which had reached 3 mb/d by mid-2019, broadly stayed at that level through 2020 and into the first half of 2021. While at first glance this may seem somewhat surprising, it must be recognized that exports are predominantly very light streams not readily suited to US refineries. Additionally, during COVID-19, US production dropped, as did US refinery runs. The vast majority of US exports, some 2.75 mb/d, were and are from the US Gulf Coast, highlighting the reality that infrastructure developments in that region are critical to the overall US logistics picture.

The COVID-19 pandemic has had a significant impact; while some projects have continued to move ahead, others have been delayed or cancelled. The Wink-to-Webster project was delayed from

early 2020 to late 2020, but has since started service. This provides 1 mb/d of takeaway capacity from the Permian Basin to destinations in the Houston area. The 400 tb/d EPIC pipeline was commissioned in April 2020. Yet, several other large projects have been put on hold or cancelled outright, including the 1 mb/d Jupiter project and the 450 tb/d ECHO 4 project.

Despite the cancellation of several projects, and given the setbacks to US production, the rapid build-out of pipeline capacity over the past few years has left the US with ample takeaway capacity, especially from the Permian/Eagle Ford Basins and Cushing. Even allowing for the 3.2 mb/d recovery in US tight oil production expected in this Outlook by 2026, *versus* 2021, 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 reversal of the Capline and expansion of the Dakota Access pipeline, both designed to bring crude from the US interior to the Gulf Coast, have been delayed, but plans are still in place to complete them in late 2021. While, like the Permian, the US interior has sufficient takeaway capacity with planned and existing pipelines, there are regulatory uncertainties that could impact this, as discussed later. However, the Bakken region, in particular, has a large amount of rail capacity that can act as a buffer to mitigate potential pipeline problems, notably if Dakota Access were to end up being shut down rather than expanded.

Much of the crude oil moved on new pipelines to the Gulf Coast is destined for export markets, requiring upgrades to export facilities. Like pipeline projects, what was once a bevy of port expansions has also faced delays or cancellations as a result of the impacts of COVID-19.

There are two leading offshore very large crude carrier (VLCC) loading projects – the Enterprise SPOT terminal offshore Houston and the Phillips 66 Trafigura Bluewater project offshore Corpus Christi – that remain active, but both continue to face delays and are unlikely to be completed before 2023, if at all. This leaves the Louisiana Offshore Oil Port (LOOP) and Ingleside as the only VLCC-capable US crude export terminals. Originally designed to take imports, and to work with Capline to take mainly imported crudes into the US interior, LOOP has also been exporting local Gulf of Mexico medium sour crudes and light sweet grades since 2019. It should also be noted that Ingleside, just purchased by Enbridge, sited adjacent to the Port of Corpus Christi, can accept crude and condensates from several pipelines out of the Permian and Eagle Ford and is being expanded to enable dual VLCC loading.

Amplifying the upheaval to projects as a result of the dramatic supply and demand changes due to COVID-19, resistance continues to new pipeline developments and existing pipeline infrastructure. Most projects today are the subject of lawsuits, including at the state level. In addition, state regulatory authorities more frequently require lengthy reworking and extensions of environmental reviews. Several recent rulings in federal courts regarding the inadequacy of environmental reviews have resulted in project delays and higher costs.

The current US Administration has placed renewed emphasis on reducing GHG emissions. In this context, new projects to move hydrocarbons are frequently seen as undesirable. One of the first actions of the Biden Administration was to revoke the cross-border permit for the Keystone XL pipeline. Operator TC Energy subsequently cancelled the project, ending a 13-year attempt to build the pipeline.

Furthermore, in July 2020, a federal court ordered that the 570 tb/d Dakota Access pipeline out of the Bakken be shut down pending further environmental review. This marked the first time an existing pipeline has been ordered shut. Subsequent rulings have allowed the pipeline to remain operating until an environmental review is completed, potentially in March 2022, but its future is not certain.

In mid-2020, a second operating pipeline, the 200 tb/d High Plains line out of the Bakken, was also ordered shut while its owners negotiated a renewal of their right-of-way with landowners. While the

pipeline is currently operating, the legal dispute is ongoing, highlighting a new reality of uncertainty that hangs over the continued operation of existing pipelines, let alone new or unfinished projects.

As discussed below, Enbridge's Line 5 renewal project continues to meet resistance. The bottom line is that it is becoming increasingly difficult for US operators to build major new pipelines and that a number of currently operating pipelines face costly lawsuits and the risk of closure.

Canada

Cross-border pipelines and projects from Canada into the US impact both countries. As noted earlier, the current outlook is for Canadian crude and condensate production to see minor increases in the medium- to long-term of 0.25 mb/d from 2021–2030 and the same again from 2030–2040. On this basis, few additions to takeaway capacity are needed for the next few years. Minor debottlenecking projects and system optimization on both 'mainline' (Enbridge and TC Energy) and secondary cross-border pipelines could add up to an additional 225 tb/d by 2022.

In principle, these upgrades should be more than enough to cover medium-term Western Canadian Sedimentary Basin (WCSB) production increases, but unless all are implemented pipeline takeaway capacity from Western Canada could once again become tight. The takeaway system also includes significant crude-by-rail capacity, a 'nameplate' of 850 tb/d. Although more costly than movement via pipeline, exports by rail have averaged close to 150 tb/d for each of 2019 and 2020 and have previously demonstrated the ability to reach over 400 tb/d.

Future takeaway capacity could be impacted by new processes and technologies. So-called diluent recovery units are being constructed, which improve the economics of crude-by-rail by reducing the amount of diluent needed.

Likewise, there is an interest in new processes that would partially upgrade bitumen, reducing or even eliminating the associated diluent needed for shipment via pipeline and thereby freeing up pipeline capacity. One such process, which centres on removing heavy asphaltenes, has seven units installed or planned (some in China) with a capacity of up to 20 tb/d.

Finally, CN Rail has developed a technology (CanaPux™) to safely move undiluted bitumen by rail as solid 'pucks' (the shape of small bricks), which will not contaminate if spilled. Unlike current means of crude-by-rail, CanaPux™ are moved in regular coal-type rail cars, reducing freight costs. CN Rail is reported to have a 10,000 b/d demonstration facility starting in 2021. Should this process prove commercially successful, it would alleviate pressure on both takeaway pipelines and conventional crude-by-rail. Asia is seen as a primary market for this product.

In terms of major pipeline developments, Western Canada continues to be beset by delays and cancellations involving long-planned projects and faces issues in terms of restoring and maintaining capacity on existing exit pipelines.

The largest such cross-border project, Keystone XL, would have transported 830 tb/d of mainly heavy Canadian crude to the US Gulf Coast, supplying additional barrels to regional refiners. The line would have also opened up the possibility for WCSB crude oil exports via the Gulf Coast. However, as already described, TC Energy formally terminated the project in June after the new US Administration revoked a presidential cross-border permit.

Another significant cross-border project is the Enbridge Line 3 Replacement. This project is slated to restore the line's original capacity by replacing the ageing existing pipeline. In doing so, it would add an effective 370 tb/d to cross-border capacity. While construction is still subject to resistance and litigation, shipments on the renewed and expanded system are projected to start in October 2021.

Enbridge is also locked in a dispute with the State of Michigan over how and when to replace an underwater section of Line 5, which has a capacity of 540 tb/d and carries crude oil and NGLs from Western Canada to the US Midwest and to Ontario. The state has sued to close the line permanently over fear of leaks, while Enbridge is seeking state and federal permits for a new 8 km tunnel to replace the existing exposed section of the ageing underwater line. The State of Michigan has ordered the pipeline shut as of May 2021, however, it continues to operate while Enbridge appeals the decision.

The Keystone XL cancellation and the issues surrounding Line 3 and Line 5 arguably render even more critical a project to expand the Trans Mountain pipeline from 300 tb/d to 890 tb/d for the WCSB. Crucially, this project would enable Canada to open up export markets other than the US, since it would lead to most, or all, of the additional crude volumes being shipped by tanker from the pipeline's Westridge terminal near Vancouver.

In 2018, the Canadian government undertook what some deemed to be the extreme move of purchasing the pipeline project from Kinder Morgan. A series of subsequent court actions culminated in early July 2020 when the Supreme Court of Canada dismissed an appeal by British Columbia's First Nations, thereby authorizing the project to go ahead. Resistance is still active in British Columbia, however, and various permits are outstanding. Construction began in 2020, but it has faced several COVID-related delays. The line is now expected to be in service by the end of 2022.

Should the two remaining major expansion projects – namely Trans Mountain Expansion and Line 3 Replacement – go ahead, they will add nearly 1 mb/d of new exit capacity from Western Canada. Combined with other minor debottlenecking that could add another 225 tb/d, the total new takeaway capacity could be well above the latest projection for WCSB supply growth through 2030. In contrast to periods in the recent past, infrastructure would no longer constrain WCSB supply from reaching markets. However, should the Line 5 project – or some other pipeline – be ordered shut, a constrained situation would likely recur.

In terms of the effects on international oil trade, the Trans Mountain expansion is likely to have the largest impact, since it is the one project that would move WCSB crudes to the US West Coast and Asia rather than to the US Gulf Coast.

What does appear certain is that the high-paced build-out of pipelines and related infrastructure in the US (and Canada) in recent years is now over. The likelihood that any major new pipeline projects will be announced over the next several years appears low. It seems that it will be some time, if ever, before logistics capacity once again becomes a constraint to supplying US and Canadian crudes to market.

Additionally, the demand collapse in 2020 and heightened environmental concerns have reinforced arguments against allowing new capacity. The difficulties and costs of getting projects built are now accompanied by a new element, namely uncertainty over the continuing operation of existing pipelines. Should the latter trend begin to have material impacts, such as forced pipeline closures, then a difficult and constrained situation could emerge.

6.1.2 Other regions

As for other regions, there are no major updates relative to last year's WOO. Russia expanded the capacity of its ESPO pipeline to China and the Pacific coast to 1.6 mb/d in late 2019. Currently, there are no further projects on this route, but in the longer-term, expansions are possible, given the rising focus of Russia on the Asian oil market.

Furthermore, the CPC pipeline, which brings Kazakh crude to the Black Sea, has started a debottlenecking project, which should help to further increase pipeline capacity. According to official

announcements, pipeline capacity should increase to 1.6 mb/d by 2023, which is in line with the expected increase in Kazakh oil production (see Chapter 4).

6.2 Crude oil and product movements

The integrated global downstream sector relies on the ability to move crude oil, condensates, refined products and various intermediate streams between countries and regions, driven by economics. The infrastructure (pipelines and shipping capacity) enable market participants to move large amounts of oil liquids (crude or products) between almost any two regions of the world, over short and long distances, via a variety of transport modes.

These interregional movements enable physical supply, as well as trade and competition, as they respond to price signals between regions. The ability to move crude oil and products also helps avoid short-term shortages of fuel in specific regions at a 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 proven in the past.

Various factors affect the direction and volume of crude and condensate, as well as product trade movements. These include demand levels; the production and quality of crude and non-crude streams; product quality specifications and related changes; refining sector configurations; 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; price levels and differentials; freight rates; and, at times, geopolitics. In fact, there is never only one factor influencing the flow of petroleum, rather a combination of several influences 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 also play a role. Recent trends in the downstream sector clearly confirm this – the majority of refining capacity additions in recent years have materialized in developing regions with strong oil demand growth, led by the Asia-Pacific. As a result, crude and condensate account for the majority of 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 not only cover domestic demand, but also to benefit from the export of value-added products beyond crude oil. As an extension of this strategy, in their efforts to secure future outlets for crude production, some producing countries may choose to participate jointly in refining projects in consuming countries, especially where long-term contracts for feedstock supply can be arranged. For instance, various companies from the Middle East, building upon existing capacity, seek to participate in downstream projects in the Asia-Pacific region.

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 predict what 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 modelling approach that looks at the longer-term, with few restrictions on movement and that operates by minimizing 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. Historical volatility in tanker freight rates and the difficulties in predicting where they may be in two, five or ten years, add to the uncertainties in projecting future oil movements.

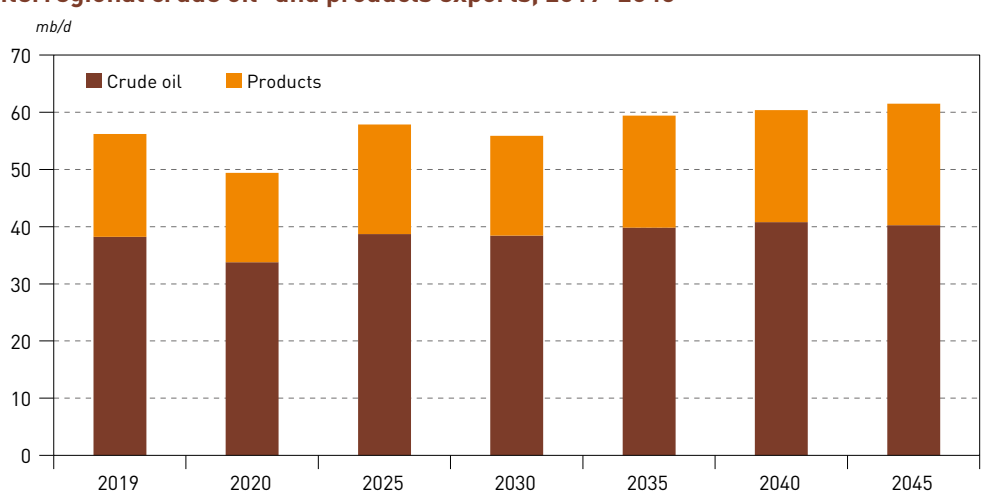
Nevertheless, the model-based results presented in this section provide a useful indication of future crude oil movement trends, which necessarily function to resolve regional supply and demand imbalances for both crude and products. These projections are, of course, dependent on a number of assumptions in this Outlook, which, if altered, could materially impact 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 products. There is also an interplay between freight and refining costs. Broadly, 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 serve to provide more opportunity to regions with spare refining capacity to export products.

Figure 6.1 shows global oil (crude oil, condensates and refined products) between seven major regions, excluding intratrade between countries within regions. Projections are made for anchor years only (2025, 2030, 2035, 2040 and 2045), to illustrate the main long-term trends. As already mentioned, these projections are in line with demand projections (Chapter 3), supply projections (Chapter 4) and the outlook for the refining sector (Chapter 5).

As shown in Figure 6.1., global oil trade was estimated at around 56.2 mb/d in 2019, before dropping to around 49.5 mb/d in 2020 due to the oil demand drop caused by the outbreak of the

Figure 6.1
Interregional crude oil* and products exports, 2019–2045



* *Including condensates.*
Source: OPEC.

COVID-19 pandemic. However, recovering oil demand in OPEC's Reference Case is expected to lead to an oil trade rebound in the medium- and long-term.

In 2025, global oil trade is projected at around 58 mb/d, followed by a drop in 2030 to 56 mb/d, as more oil is consumed in large producing regions such as Africa and Latin America. This is also in line with new refining capacity additions in these regions, which reduces crude and condensate exports and refined product imports. However, beyond 2030, oil imports are expected to increase gradually and reach levels of 61.5 mb/d in 2045. This is slightly lower relative to last year's WOO and in line with downward long-term oil demand revisions (see Chapter 3).

After the strong decline in 2020 to around 34 mb/d, crude and condensate trade is expected to reach levels of around 39 mb/d in 2025 and 2030. By 2040, crude and condensate movements reach 41 mb/d, in line with rising oil demand and declining supply in some consuming regions, such as the Asia-Pacific. Crude and condensate trade is then expected to decline slightly in the period to 2045, but remain above the 40 mb/d threshold.

Looking at the refined product side, trade levels declined by more than 2 mb/d between 2019 and 2020, reaching almost 15.5 mb/d in 2020. However, rising oil demand in consuming regions, such as Africa and the Asia-Pacific, is expected to lead to higher product trade flows in the medium- and long-term. Consequently, total product flows are estimated at above 19 mb/d by 2025. In 2030, there is a temporary drop in overall product flows to 17.5 mb/d (similar to 2019 levels), in line with lower import needs in Africa, along with the US & Canada.

Beyond 2030, total product flows increase gradually again to levels above 21 mb/d by 2045. This is supported by increasing product exports from developed regions, such as US & Canada, where oil demand declines and thus some refining capacity would increasingly turn to export markets, such as Latin America, Africa and the Asia-Pacific.

6.3 Crude oil and condensate movements

In order to provide background, this section first discusses changes in crude and condensate supplies by major region in the medium- and long-term. It then turns to the main trends in crude oil and condensate movements at the regional level, showing trade flows from the perspective of the main exporting and importing regions.

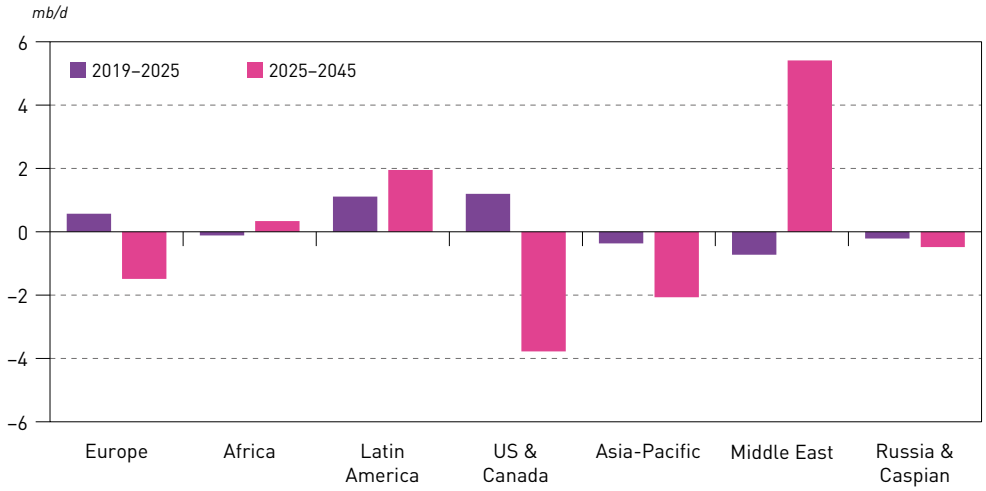
Crude and condensate supply

While global crude and condensate supply (excluding NGLs) increases only modestly throughout the outlook period, there are significant regional differences in supply patterns. Similar to previous outlooks, the medium-term perspective sees a supply increase in Europe, the US & Canada, as well as Latin America, while other regions are either stable or decline slightly. In the long-term, supply developments see increments coming from the Middle East and Latin America, while most other regions witness a significant oil output decline. This is one of the major drivers of long-term crude and condensate trade flows, which will be discussed in more detail.

As shown in Figure 6.2, between 2019 and 2025 the largest supply increments come from the US & Canada, along with Latin America. In the US & Canada, supply is expected to recover after the 2020 drop. The increment between 2019 and 2025 is around 1.2 mb/d, mostly attributed to US tight oil. However, as the 2020 drop was more pronounced in the US & Canada, the increase between 2020 and 2025 is even more impressive – around 2.3 mb/d.

Latin America is expected to increase its crude and condensate supply by 1.1 mb/d between 2019 and 2025, similar to the US & Canada. This includes new supply projects, primarily in Brazil and

Figure 6.2
Change in crude and condensate supply* between 2019 and 2045



* *Includes condensate and synthetic crudes.*
Source: OPEC.

Guyana. Europe is another region where oil supply growth is expected in the years to come. Rising crude and condensate output in Norway is the major reason for the increase in Europe's supply of around 0.6 mb/d for the period 2019–2025.

At the same time, other regions are either stable, such as Africa and Russia & Caspian, between 2019 and 2025, or have lower supply in 2025, relative to 2019, such as the Asia-Pacific and Middle East. While a drop of some 0.5 mb/d (2019–2025) in the Asia-Pacific region is the result of natural decline, a similar drop in the Middle East is mostly the consequence of lower demand for OPEC crude in 2025, relative to 2019. Nevertheless, it needs to be emphasized that the Middle East is set to increase its crude and condensate supply by around 1.5 mb/d between 2020 and 2025, following strong supply output reductions during 2020.

In the long-term the situation changes fundamentally. Several regions show significant output declines, including the US & Canada, along with Europe and the Asia-Pacific, mostly due to ageing production and natural decline. At the same time, these declines are expected to be offset by supply increases in the Middle East and Latin America.

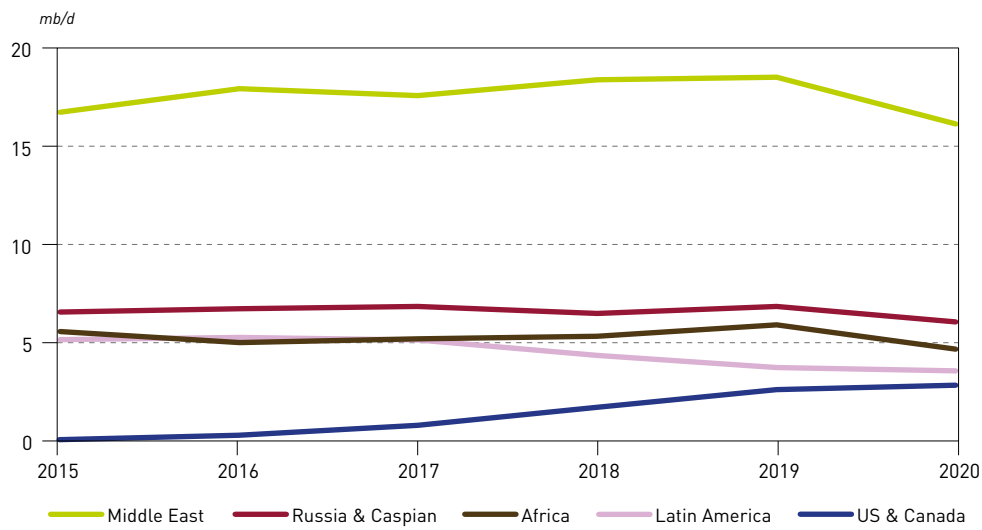
In more detail, the crude and condensate supply from the US & Canada is expected to decline by around 3.8 mb/d between 2025 and 2045. This is accounted for by a decline in US supply after it reaches a peak around 2027. Europe's crude and condensate supply is projected to decline by some 1.5 mb/d from 2025–2045, in line with the natural decline from ageing fields in the UK and Norway. In the Asia-Pacific region, crude and condensate supply continues its natural decline, mostly in Indonesia, Malaysia and China. Overall supply from this is estimated to be around 2 mb/d lower in 2045, relative to 2025. Moderate declines are also seen in the Russia & Caspian region, with output dropping by around 0.5 mb/d between 2025 and 2045. This is mostly due to declines in Russia and Azerbaijan, which are not fully balanced by expected moderate supply increases in Kazakhstan over this period.

The declines discussed above will be offset by rising production in the Middle East, mostly OPEC Member Countries, where output is expected to rise by almost 5.5 mb/d in the 2025–2045 period. Additional volumes in the 2025–2045 timeframe will also come from Latin America (2 mb/d) and Africa (0.3 mb/d).

Crude and condensate oil movements

The impacts of COVID-19 severely affected global oil demand and supply, as already described in Chapters 3 and 4. Consequently, distortions in the global oil market massively impacted the global crude and condensate trade (Figure 6.3). Total crude and condensate exports fell from around 38.2 mb/d in 2019 to below 34 mb/d in 2020. The largest reductions in exports were observed in the Middle East, Africa and the Russia & Caspian region, declining by around 2.4 mb/d, 1.2 mb/d and 0.8 mb/d, respectively. This was in line with OPEC and non-OPEC voluntary production adjustments in the DoC. Exports from Latin America dropped only marginally over the same time frame, by around 0.2 mb/d. For the same period, exports from the US & Canada increased by around 0.2 mb/d, due to a strong demand decline and related supply overhang in the US market.

Figure 6.3
Global crude and condensate exports, 2015–2020*



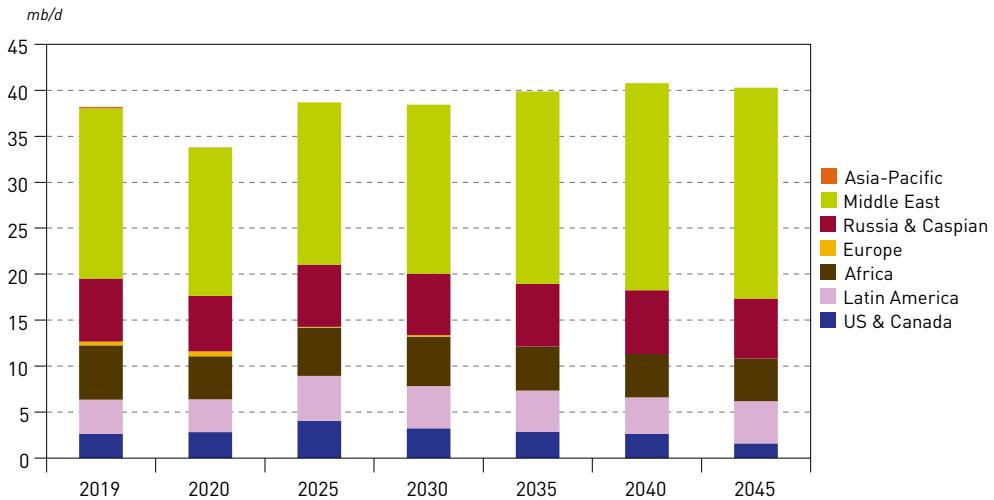
* *Includes exports from major exporting regions.*
Source: OPEC.

Figure 6.4 shows global crude oil and condensate trade by major region and for anchor years, in line with assumptions on oil demand and supply trends, as well as refining capacity development. After the drop in 2020, crude and condensate trade is expected to recover by 2025, in line with growing demand, and reach levels of just below 39 mb/d. Even though global demand continues to increase and several consuming regions see strong supply declines, global trade is set to stabilize by 2030. The main reason for this is rising local crude and condensate consumption by large exporting regions, such as the Middle East, Africa and Latin America, which limits exports to some extent.

Total crude and condensate exports are expected to reach almost 41 mb/d in 2040, in line with aforementioned supply trends, after which they are projected to settle at 40.3 mb/d by the end of the outlook period.

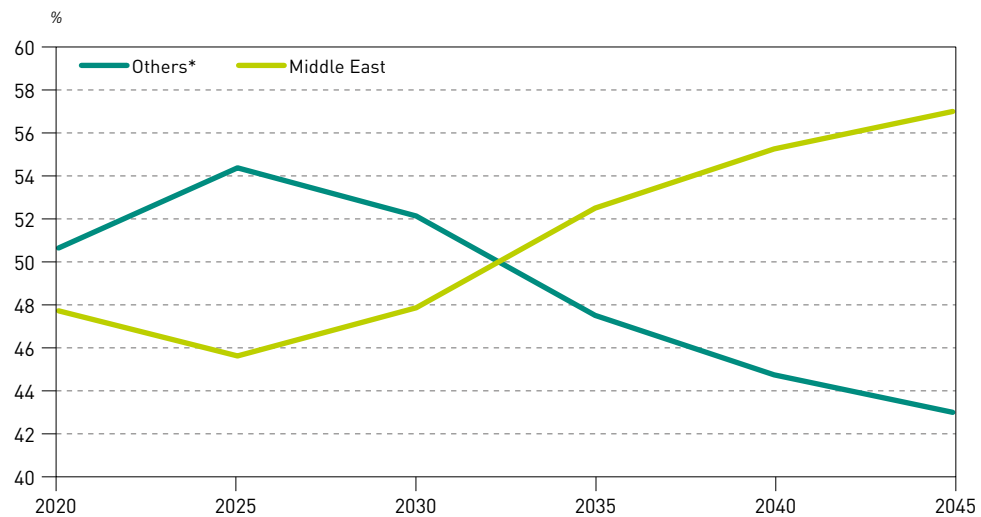
As illustrated in Figure 6.5, the Middle East's share of the global crude and condensate trade is expected to modestly decline from around 48% in 2019 to below 46% by 2025, as exports from other regions rise and the Middle East increases local crude use. However, the share of Middle East crude and condensate in the average export barrel increases strongly beyond 2025 and reaches 57% in 2045.

Figure 6.4
Global crude and condensate exports by origin*, 2019–2045



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

Figure 6.5
Share in crude and condensate exports, 2020–2045

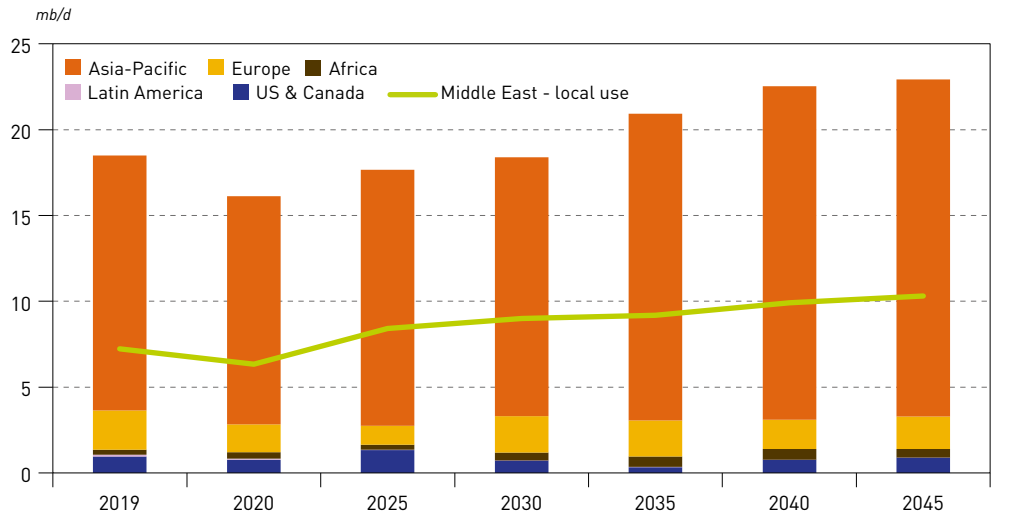


* *Others include Latin America, Africa, Russia & Caspian and the US & Canada.*
Source: OPEC.

At the same time, the share from other exporting regions, including Latin America, Africa, Russia & Caspian, and the US & Canada, are set to decline or remain stable over the forecast period, partly due to declining supply, but also due to rising local crude use in some regions. This consequently limits the availability of crude and condensate from these areas for export markets.

Figures 6.6 to 6.10 show the main trends related to crude and condensate exports from the main exporting regions – the Middle East, Russia & Caspian, Latin America, Africa and the US & Canada.

Figure 6.6
Crude and condensate exports from the Middle East by major destination, 2019–2045



Source: OPEC.

Figure 6.6 shows crude and condensate exports from the Middle East. Total exports were seen at around 18.5 mb/d in 2019, after which they declined to just above 16 mb/d in 2020. By 2025, crude and condensate exports from the Middle East are likely to recover to 17.7 mb/d, which is slightly lower compared with 2019. The major reason for this is that several other exporting regions increase their exports, such as. Latin America, as well as the US & Canada. Another reason is an expected rise in local crude use in the Middle East between 2019 and 2025, due to refining expansions.

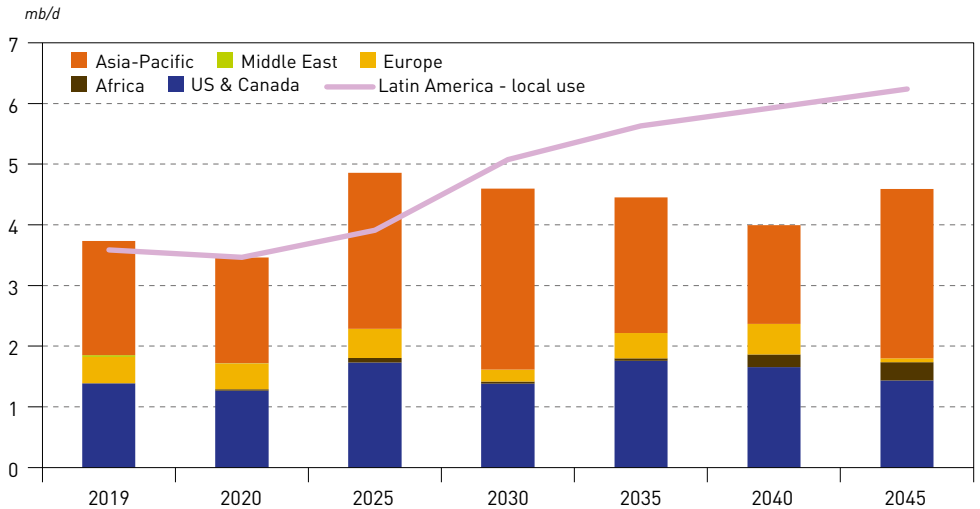
Beyond 2025, Middle East crude and condensate exports are set to increase gradually, reaching almost 23 mb/d in 2045. The main export outlet for Middle East barrels is the Asia-Pacific, in line with rising demand and declining supply in the region. Export volumes to the Asia-Pacific are forecast to increase from 15 mb/d in 2019 to above 19.5 mb/d in 2045, or around 85% of total Middle East exports in 2045.

Other regions remain important outlets for Middle East crude and condensate. The US & Canada is expected to continue importing Middle East cargoes, around 1 mb/d in most of the anchor years, in line with US refining sector requirements for heavier barrels. Europe will also continue importing considerable volumes of Middle East crude, in line with declining European supply and despite the continent's declining oil demand. After dropping to around 1 mb/d in 2025, exports to Europe are estimated to recover to around 2 mb/d for the rest of the outlook period.

Local crude use in the Middle East is set to rise continuously throughout the outlook period, from around 7.2 mb/d in 2019 to above 10 mb/d in 2045. This is in line with rising domestic demand in the Middle East, along with rising product exports from the region.

Crude and condensate exports from Latin America are shown in Figure 6.7. After a marginal decline in 2020, they are set to increase strongly in the medium-term to almost 5 mb/d in 2025, from 3.7 mb/d in 2019. Rising oil supply in several countries, such as Brazil and Guyana, combined with a limited increase in local crude use, is the main reason for this.

Figure 6.7
Crude and condensate exports from Latin America by major destination, 2019–2045



Source: OPEC.

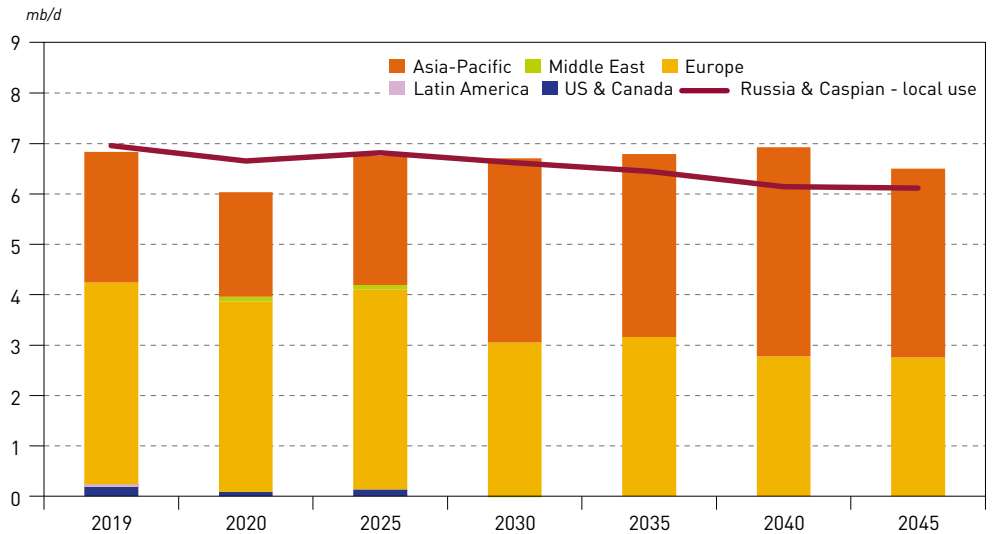
This year's outlook for 2025 is somewhat lower compared with the WOO 2020 Reference Case, as oil supply growth in Latin America has been revised down due to a number of project postponements. In the long-term, crude and condensate exports are forecast to decline to levels of between 4 mb/d and 4.6 mb/d, as local crude use increases faster than crude and condensate supply.

Asia-Pacific and the US & Canada are the main destinations for Latin American barrels. US refiners (mostly Gulf Coast) are the traditional buyers of heavy oil from Latin America, which is also favoured due to the relatively short distance between the two regions. Latin American exports to the US & Canada are projected to increase to around 1.7 mb/d by 2025, from 1.4 mb/d in 2019, and remain at that level to 2040. Towards the end of the outlook period, these volumes drop to around 1.4 mb/d once again, in line with lower demand and less refinery throughput in the US & Canada.

Latin American crude and condensate movements to the Asia-Pacific region are projected to increase to 3 mb/d in 2030, up from just below 2 mb/d in 2019, in line with rising output. However, flows to the Asia-Pacific are forecast to start declining beyond 2030, reaching only 1.6 mb/d in 2040, due to higher local crude use in Latin America that limits export volumes. Finally in 2045, volumes increase again to around 2.8 mb/d as Latin American flows to other regions drops, such as the US & Canada to the Asia-Pacific, as well as Europe. Although not the main destination, Latin America is also expected to ship volumes to Europe throughout the outlook period. This is estimated to be around 0.5 mb/d in most of the years modelled, dropping off at the end of the outlook period as European refinery throughput declines.

Latin American local crude use is projected to increase from 3.6 mb/d in 2019 to 6.2 mb/d in 2045, as local oil demand increases. This is also in line with expected refinery new builds in Latin America of nearly 1 mb/d between 2021 and 2045 and the rising utilization of existing capacities. However, should an expected increase in local refinery throughputs not materialize for various reasons, such as delays in refining new builds or lack of modernization of existing facilities,

Figure 6.8
Crude and condensate exports from Russia & Caspian by major destination, 2019–2045



Source: OPEC.

Latin America could see overall crude and condensate exports at higher levels. Consequently, this could increase product imports from other regions, such as the US & Canada, along with Europe.

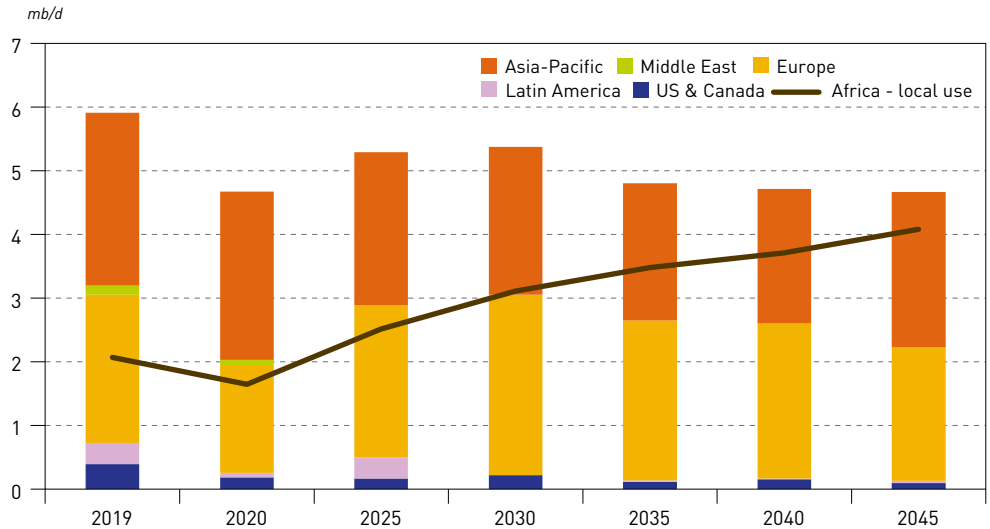
Crude and condensate flows from the Russia & Caspian region (Figure 6.8) are expected to recover in the medium-term to levels around 6.8 mb/d, after experiencing a temporary drop to almost 6 mb/d in 2020. In the longer-term, total crude and condensate exports are forecast at stable levels just below 7 mb/d, before dropping to around 6.5 mb/d in 2045. The relative stability of crude and condensate exports is the result of declining crude and condensate output after 2030, which is offset by lower local crude use, especially in Russia.

Europe and the Asia-Pacific are the two major destinations for supplies from the Russia & Caspian. Europe, which is a traditional market for barrels from the region, is projected to see imports decline from around 4 mb/d in 2019 to below 3 mb/d in 2045. This is a consequence of declining oil demand in Europe and lower refinery throughput, especially after 2035. The decline in European exports is set to be compensated by rising movements of crude and condensate to the Asia-Pacific. From around 2.6 mb/d in 2019, crude and condensate exports from Russia & Caspian region to the Asia-Pacific are expected to increase to more than 4 mb/d in 2040. This will lead to high utilization of existing pipeline infrastructure, such as the ESPO pipeline with a total capacity of 1.6 mb/d, as well as seaborne shipments. The OPEC Reference Case also assumes the possibility of further expansion of pipeline capacity to the Asia-Pacific in the long-term, which would help accommodate the increase in exports.

At the same time, local crude use is expected to decline gradually by almost 1 mb/d between 2019 and 2045. This is mostly due to a demand decline in traditional export markets for refined products, such as Europe, in combination with rising competitive pressure from other refining centres, such as the US and the Middle East.

African crude and condensate exports dropped from almost 6 mb/d in 2019 to 4.7 mb/d in 2020 due to the COVID-19 demand decline and related supply adjustments. Shipments to Europe were especially affected during 2020. However, African crude and condensate exports (Figure 6.9) are

Figure 6.9
Crude and condensate exports from Africa by major destination, 2019–2045



Source: OPEC.

expected to recover to around 5.3 mb/d in 2025, which will be followed by a gradual decline to the end of the outlook period when levels are projected to reach 4.7 mb/d in 2045. This is mostly due to the rising local use of crude in the long-term, which more than offsets the moderate increase in African crude and condensate in the same period.

African producers are expected to remain focused on two major export markets in the long-term – Europe and the Asia-Pacific. Volumes heading to Europe are expected to increase to 2.8 mb/d by 2030, thus replacing some of the losses in Europe's domestic supply. Nevertheless, flows to Europe are expected to decline to just above 2 mb/d by 2045, as European oil demand declines.

At the same time, African crude and condensate exports to the Asia-Pacific see a gradual drop from 2.6 mb/d in 2020 to 2.1 mb/d in 2040, in line with the lower availability of export barrels and a greater interest in trade with Europe due to lower transportation costs. In 2045, flows to the Asia-Pacific recover to almost 2.5 mb/d, offsetting lower African exports to Europe. Africa continues exporting crude and condensate to the US & Canada, but these volumes remain minimal at 0.2 mb/d throughout the outlook period. This is far away from the annual average levels of close to 2 mb/d observed in 2010 before US tight oil supply surged.

Growing local oil demand in Africa and an expected expansion of refining capacity in the medium- and long-term is projected to lead to the higher local use of crude, which is set to rise from 2.1 mb/d in 2019 to above 4 mb/d in 2045. However, any delays in the expansion of local refining capacity would result in higher crude and condensate availability for export and rising product imports from other regions, such as the US & Canada, Europe, as well as the Middle East.

Crude and condensate exports from the US & Canada increased by around 0.2 mb/d in 2020, relative to 2019. The drop in supply was more than offset by the demand decline in 2020, which led to a somewhat higher availability of crude and condensate for export.

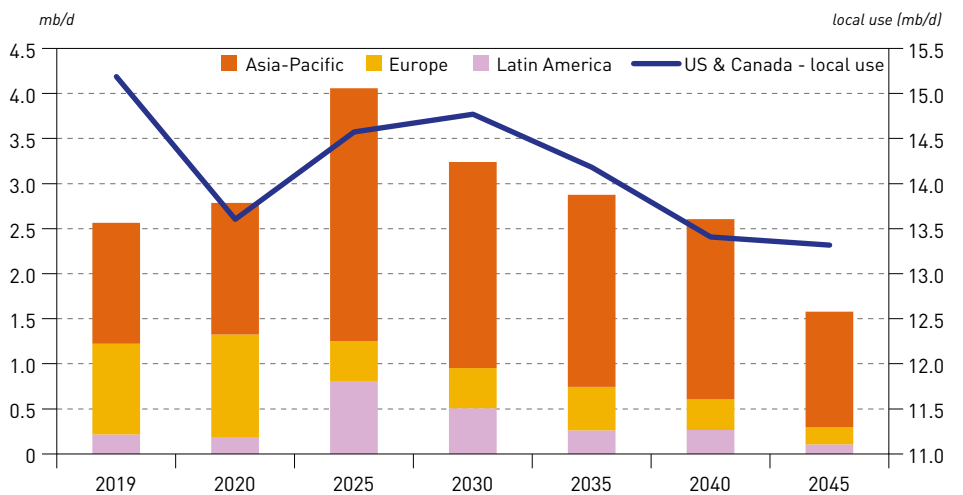
In the medium-term, exports are set to increase, reaching 4 mb/d in 2025. This is in line with rising production, especially of US tight oil (see Chapter 4). However, as US oil supply peaks between

2025 and 2030 and starts declining thereafter, crude and condensate exports from the US & Canada are anticipated to drop, reaching around 3 mb/d in 2035 and then only 1.6 mb/d in 2045.

The majority of exports from the US & Canada is accounted for by US light-sweet barrels, with minor volumes of other qualities from the Gulf of Mexico and Canada. Most of the barrels are seen heading to the Asia-Pacific, peaking at around 2.8 mb/d in 2025, before gradually declining to 1.3 mb/d by 2045.

Exports to Europe are already expected to decline to around 0.5 mb/d in 2025, partly due to rising supply and declining demand in Europe. In the longer-term, US & Canada exports to Europe are set to decline even further, hitting 0.2 mb/d in 2045. This is in line with weakening demand and lower refinery throughput in Europe. US & Canada exports to Latin America are forecast to increase to 0.8 mb/d in 2025, from 0.2 mb/d in 2020, due to the higher availability of export barrels and the preference of some Latin American customers for light-sweet cargoes. However, shipments to Latin America are expected to decline gradually to just 0.1 mb/d in 2045, partly due to rising oil supply in Latin America, including the supply of relatively lighter grades with low sulphur content.

Figure 6.10
Crude and condensate exports from US & Canada by major destination, 2019–2045

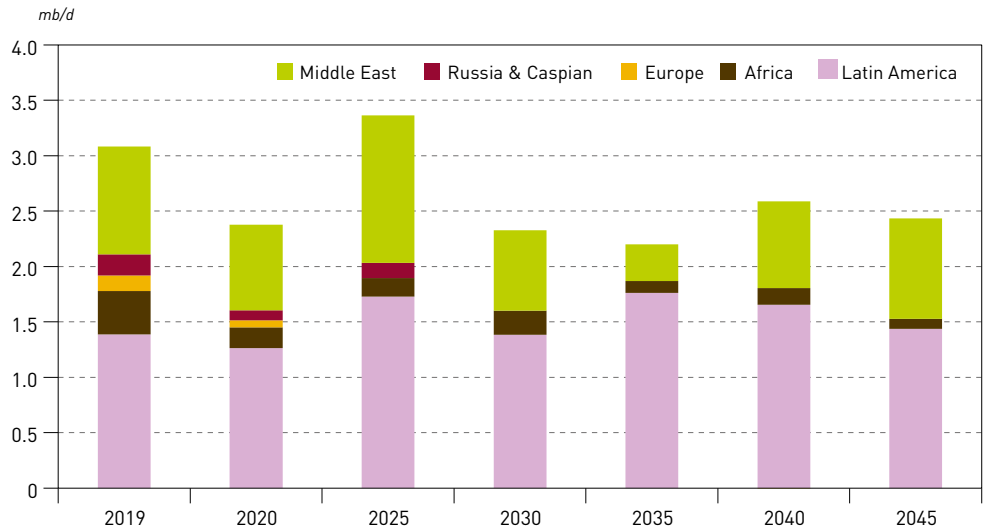


Source: OPEC.

Local crude use in the US & Canada is expected to recover after the drop in 2020 to some 13.6 mb/d, and reach levels close to 15 mb/d by 2030. However, declining oil demand in the region will result in lower local crude use, which is seen dropping to almost 13 mb/d by 2045.

At the same time, the US & Canada is projected to continue importing crude (mostly the US), including predominantly heavier grades from Latin America and the Middle East, which are well-suited for complex US refiners (Figure 6.11). Looking back, while US supply increased from 2010 onwards, total crude and condensate imports dropped strongly. However, this decline affected mostly light and medium grades, such as from Africa and the Middle East. At the same time, the share of heavy grades (below 25° API) in total US imports increased from around 40% in 2010 to more than 60% in 2020 as imported volumes were more stable.

Figure 6.11
Crude and condensate imports to the US & Canada by origin, 2019–2045



Source: OPEC.

This trend is expected to continue in the future, with crude and condensate imports to the US & Canada recovering after the drop in 2020, reaching almost 3.5 mb/d in 2025. However, with the rising supply of Canadian heavy grades and declining US & Canada refinery throughput, crude and condensate imports are expected to decline to between 2.2 mb/d and 2.6 mb/d for the rest of the outlook period.

Imports into the US & Canada are dominated by Latin American barrels, hovering between 1.3 mb/d and 1.8 mb/d throughout the outlook period. At the same time, imports from the Middle East are projected to peak in 2025 at around 1.3 mb/d. Post-2025, imports from the Middle East remain below 1 mb/d. Some minor crude and condensate imports from Africa are projected throughout the outlook period, albeit not rising above 0.2 mb/d.

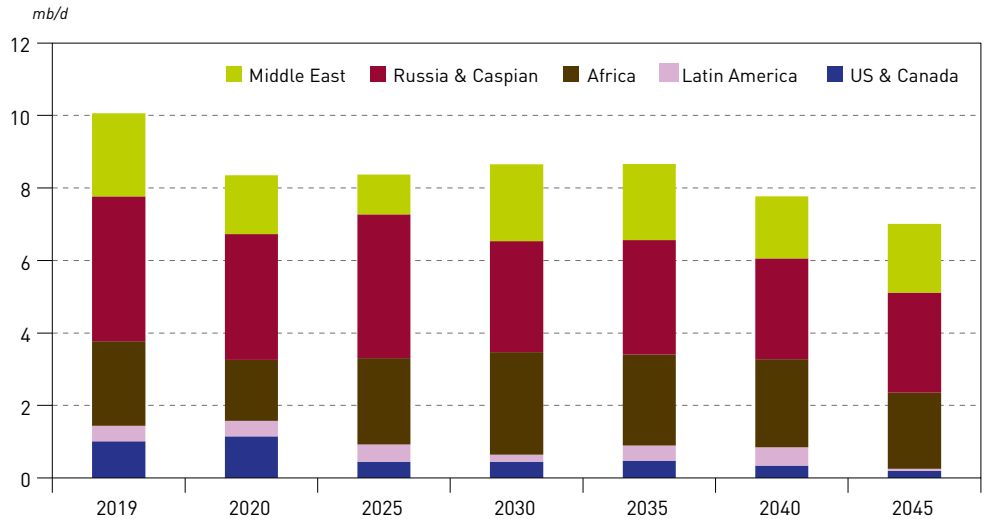
After the drop of 1.5 mb/d in 2020 to around 8.5 mb/d, crude and condensate imports in Europe (Figure 6.12) are expected to remain stable until 2035. On one hand, this is the result of declining demand and on the other, trends in European supply with an increase of 0.6 mb/d between 2019 and 2025 and then a gradual decline in the long-term. Long-term crude and condensate imports decline towards 7 mb/d in 2045 as demand drop more than offsets domestic supply declines.

Europe receives crude imports from all major exporting regions, dominated by the Russia & Caspian, Africa and the Middle East. Minor imports from the US & Canada, as well as Latin America are also part of the import mix. Imports from Russia & Caspian are expected to decline from around 4 mb/d in 2025 to below 3 mb/d in 2045, due to Europe's declining demand and the increasing focus of the Russia & Caspian region on the Asia-Pacific.

African volumes increase in the first half of the outlook period, reaching 2.8 mb/d in 2030, up from 2.4 mb/d in 2019. This is followed by a gradual decline to 2.1 mb/d, as they become increasingly limited due to local crude use. Middle East exports to Europe are expected to drop in the medium-term, reaching 1.1 mb/d in 2025, but are then projected to recover to between 1.7 mb/d and 2.1 mb/d in the long-term, as exports from other regions decline.

At the same time, US & Canada is expected to maintain exports to Europe at levels of around 0.5 mb/d between 2025 and 2035, partly due to the balancing impact of Europe's rising supply

Figure 6.12
Crude and condensate imports to Europe by origin, 2019–2045



Source: OPEC.

and declining demand in the medium-term. Europe's imports of volumes from the US & Canada drop to around 0.2 mb/d by 2045, in line with the lower availability of exports and falling European demand. Latin American volumes are also seen occasionally going to Europe, however, they are not expected to break the 0.5 mb/d level in any of the projected anchor years. Towards the end of the outlook period, imports drop to almost zero, as demand in Europe declines.

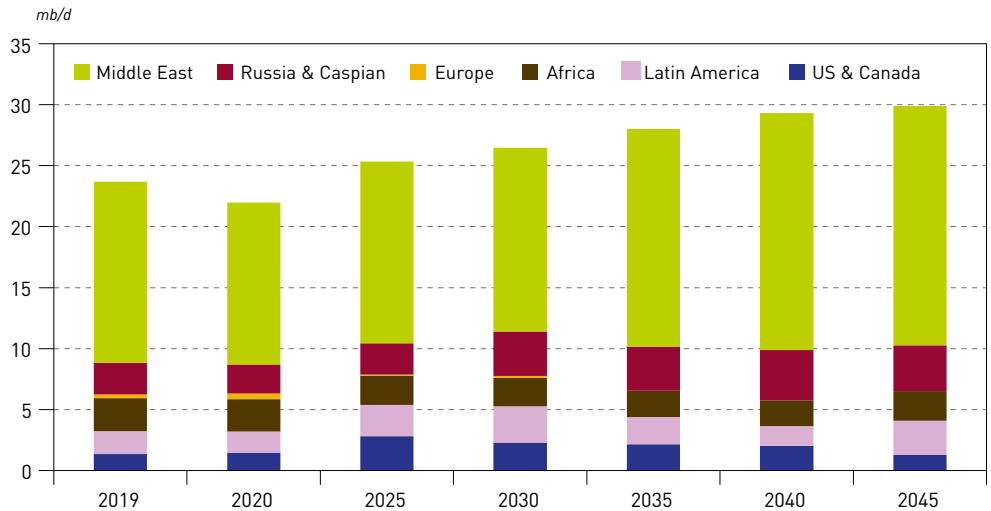
Finally, the Asia-Pacific is set to remain the most important region in terms of crude and condensate imports in the long-term. Overall import volumes are expected to increase from around 23.5 mb/d in 2019 (and 22 mb/d in 2020) to almost 30 mb/d by 2045. The Middle East remains the main supplier for the Asia-Pacific region. However, imports in the medium-term are stable at around 15 mb/d in 2025 and 2030. This is due to rising imports from other regions such as the US & Canada, Latin America, as well as Russia and the Caspian, along with the higher local use of crude in the Middle East.

In the long-term, Middle Eastern flows to the Asia-Pacific region are set to increase to above 19.5 mb/d by 2045, which is around 4.8 mb/d higher relative to levels seen in 2019. This is why the share of Middle Eastern imports to Asia-Pacific declines by 2030 to levels below 60%, before rising again to 66% in 2045.

Due to rising oil production, Latin American imports become more important in the overall import mix for the Asia-Pacific region. Crude and condensate flows are expected to increase from around 1.8 mb/d in 2019 and 2020 to almost 3 mb/d in 2030. Post-2030, these flows are set to decline temporarily to 1.6 mb/d in 2040, but increase again in 2045, reaching 2.8 mb/d. The US & Canada also increase flows to the Asia-Pacific thanks to rising supplies, reaching 2.8 mb/d in 2025.

In the longer-term, these volumes are expected to decline gradually, reaching 1.4 mb/d by 2045, as US supply drops. With the increasing focus of the Russia & Caspian on the Asia-Pacific, flows are set to increase from around 2.7 mb/d in 2019 and 2020 to above 4.1 mb/d in 2040. This is partly compensated by lower movements of crude and condensate to Europe. Flows from the Russia & Caspian are projected to drop to around 3.7 mb/d in 2045, in line with the region's declining supply. Finally, imports of African barrels to the Asia-Pacific remain strong and are estimated to be in the range of 2.1 mb/d to 2.4 mb/d throughout the outlook period.

Figure 6.13
Crude and condensate imports to Asia-Pacific by origin, 2019–2045

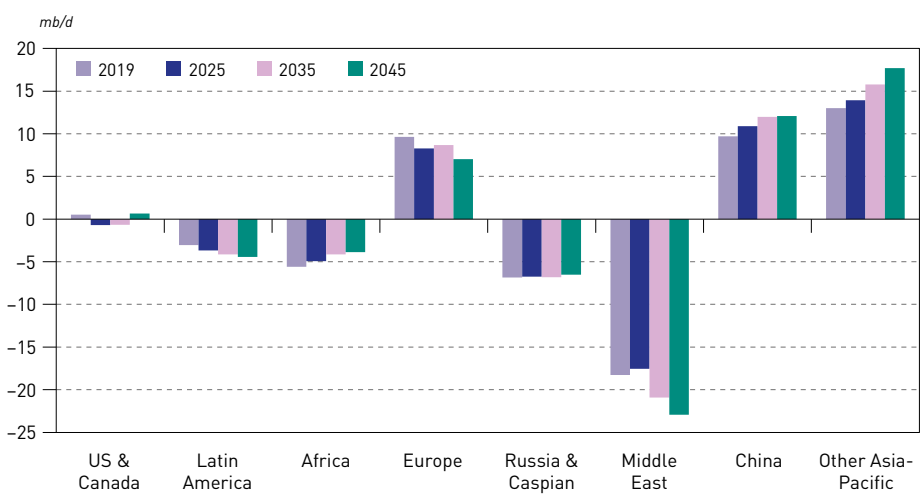


Source: OPEC.

Figure 6.14 shows crude and condensate imports from all major regions for anchor years. Clear trends can be observed. The Middle East and Latin America have rising net crude and condensate exports throughout the period, based on rising supply, especially in the Middle East in the latter part of the outlook period. Middle East net exports increase from 18.3 mb/d to almost 23 mb/d in 2045.

Other export regions, such as Africa, are projected to see declining net exports, from 5.6 mb/d in 2019 to below 4 mb/d in 2045, mostly due to the higher local use of crude as new refining

Figure 6.14
Regional net crude and condensate imports, 2019, 2025, 2035 and 2045



Source: OPEC.

capacities are built and refining throughput increases (Chapter 5). Net exports from Russia & Caspian are broadly stable for most of the outlook period at around 6.8 mb/d, but drop slightly by 2045 in line with declining supply. The US & Canada become net crude and condensate exporters in 2025 and 2035, with net crude exports of 0.7 mb/d), in line with higher exports relative to required imports. However, this region becomes a net importer again by 2045 as oil supply and, consequently, exports decline below import levels.

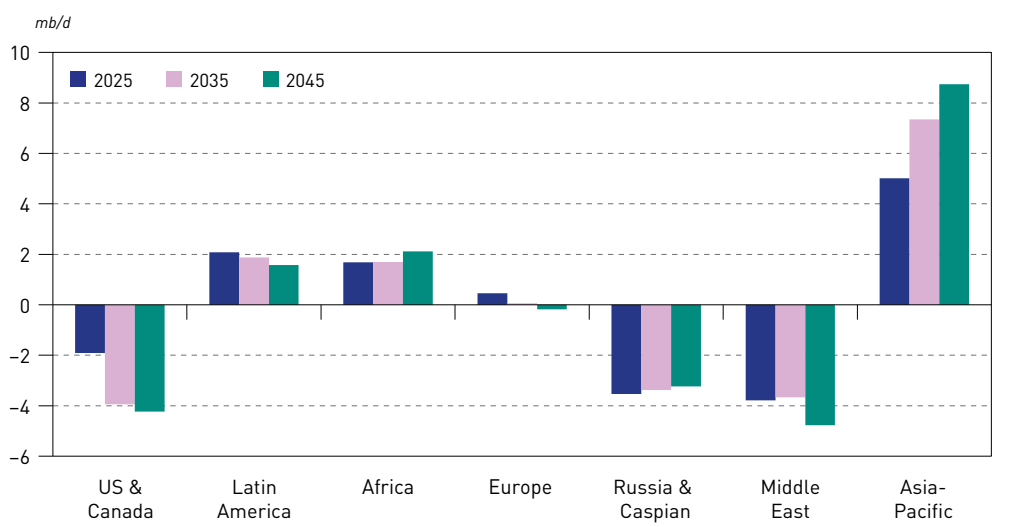
Europe sees a gradual decline in net imports, which is primarily based on declining demand and partly on rising domestic supply in the medium-term. Net crude and condensate imports to Europe are sat to decline from 9.6 mb/d in 2019 to 7 mb/d in 2045. However, in the Other Asia-Pacific and China, there is a clear trend to rising net crude and condensate imports in line with rising demand and declining domestic supplies. Overall, net crude and condensate imports into the region are projected to increase by more than 7 mb/d between 2019 and 2045, reaching 30 mb/d in 2045.

6.4 Product movements

Refined product movements between the seven major regions are significantly lower relative to crude and condensate flows. This is due to the preference of consuming countries to increase domestic refining and import crude and condensates, and benefit from lower transportation costs for crude relative to refined products. The majority of refined products are produced and consumed within the respective regions. In other words, a large part of refined product trade remains an intratrade issue (trade within the region itself). However, there are still significant refined product flows from regions with sufficient refining capacity to others where local product demand is higher compared with local refinery production. Consequently, future trends depend on local demand growth, as well as available and new refining capacity (see Chapter 5).

Three regions are important net product exporters (Figure 6.15) – Russia & Caspian, the US & Canada and the Middle East. Product net exports from Russia & Caspian are projected to

Figure 6.15
Regional net product imports, 2025, 2035 and 2045



Source: OPEC.

decline moderately due to falling demand in Europe as the main export outlet, as well as rising competition from other regions (the US & Canada and the Middle East). The Middle East is projected to increase its net product exports by around 1 mb/d between 2025 and 2045, climbing to almost 5 mb/d in 2045. This is the result of ongoing refining capacity expansion and efforts to replace crude and condensate exports by refined product flows.

In the US & Canada, an expected decline in domestic demand will lead to a rising focus by US refiners on export markets. At the same time, the local availability of crude and condensate provides additional support for refined product exports. This Outlook assumes that US refiners, predominantly highly complex, world-class refineries, will be competitive in the international refined product market in the long-term. Consequently, net product exports from the US & Canada are projected to increase from just below 2 mb/d in 2025 to 4.2 mb/d in 2045.

On the net import side, the Asia-Pacific sees a significant increase from around 5 mb/d in 2025 to 8.7 mb/d by 2045. This is due to an increase in demand, which is higher than the expansion of the region's refining capacity. Latin America is projected to reduce its product imports from around 2.1 mb/d in 2025 to 1.6 mb/d in 2045, as local refinery capacity expands and local refinery throughput increases. In Africa, a marginal increase in product net imports is projected as expanding refining capacity will not be sufficient to offset the increase in demand. For both Latin America and Africa, any delay in the expansion of refining capacity would necessarily lead to increasing product imports, predominantly from the US & Canada, the Middle East and possibly Europe.

Finally, Europe seems largely balanced between 2025 and 2045, although marginal changes are projected. From being a marginal net importer in 2025, Europe becomes a net exporter towards the end of the outlook period, mostly due to declining oil demand and a decreasing need for product imports.

Energy policy, climate change and sustainable development

Key takeaways

- There is growing awareness among policymakers in many countries that there is a need to accelerate actions addressing climate change, resulting in ambitious new policy targets. At the same time, there is increased public acceptance of products and services with a lower environmental footprint, and a state of technology development that offers solutions, albeit at a cost.

- In 2020, Parties to the Paris Agreement were expected to announce their new or updated NDCs aimed at achieving the agreement's long-term goals. Due to COVID-19, not all countries have done so.

- An assessment of the collective efforts in already submitted NDCs shows that the estimated emission reductions from their implementation fall short of what is required to achieve a temperature target of well below 2°C above pre-industrial levels.

- To enable enhanced global efforts to tackle climate change, decision making should be made in a manner that is both inclusive and fair. It should facilitate consensus-based decisions, providing space to both developed and developing countries, and take into account the principles of the Convention and the Paris Agreement.

- The fulfilment of developed countries' commitments on critical issues such as climate finance, technology transfer and capacity-building in developing countries is required for all countries to be able to enhance their mitigation action and reduce vulnerability to the harmful effects of climate change. As there is a vast gap between the support required and support provided, climate finance, in particular, should be scaled up and take into account funding requirements for both mitigation and adaptation.

- The eradication of energy poverty could enable the achievement of many other SDGs, including those related to climate action. The rate of advancement remains below the levels required to achieve universal energy access by 2030.

- Over the period 2010–2019, important progress has been made in South Asia, yet population growth has resulted in an increased number of people without access to electricity and clean cooking in Sub-Saharan Africa.

- Hydrogen could play an important role in efforts to reduce future emissions. Hence, many countries increasingly focus on hydrogen as an integral part of their energy policies.

- The EU, Japan, South Korea, the US and India have specific programmes for hydrogen development. China is one the few large countries that has so far not announced a separate hydrogen strategy.

- The Middle East region and Africa are also moving towards putting in place hydrogen enabling policies.

Change takes time, especially when it is a fundamental and global change. This is evidently true of the energy sector, which has undergone various structural changes in the past. One of these large transitions obviously lies ahead and there are several factors that will likely make this energy transition different from those of the past.

At the highest level, there is growing awareness among policymakers in many countries that there is a need to accelerate actions addressing climate change, which have recently resulted in ambitious new policy targets. At the same time, there is increased public acceptance of products and services with a lower environmental footprint, and a state of technology development that offers solutions, albeit at a cost. These trends are also being observed at a time when COVID-19 recovery plans in some major economies provide significant sources of funding that aim to support the building of more resilient and sustainable economies.

At the forefront is an evolution of energy policies that move towards achieving the goals of the Paris Agreement. Several economic powerhouses – including the EU, the US, Japan, UK, Canada and Brazil – have recently announced their intention to reach net-zero emissions by 2050, with China targeting carbon-neutral growth by 2060. At the same time, negotiations at the international level are intensifying in order to achieve the overarching global goals.

It is the pace of change that is critical in the impending energy transition. For targets to be met by the middle of this century, the rate of climate mitigation action needs to accelerate and many countries have put in place new policy measures and strengthened existing ones to do just that.

This chapter explores the key energy policies of major economies that will have an impact on the energy sector and, therefore, the future energy mix. The use of hydrogen, which could play an important role in the energy mix in the long-term, is also highlighted.

In addition, the chapter includes a standalone section on the latest developments in regard to UN processes on climate change and the implementation of the Paris Agreement in the context of sustainable development. This analysis focuses on the impact of COVID-19 on formal climate negotiations, briefly presenting the key findings in assessing countries' commitments for tackling climate change. Moreover, the analysis provides insights on progress made towards eradicating energy poverty and efforts to build inclusive, resilient and sustainable societies through universal energy access.

7.1 Climate change action and sustainable development

The Paris Agreement, under the auspices of the UNFCCC, as well as the UN 2030 Agenda for Sustainable Development, are the two landmark global action plans adopted in 2015 to enhance collective efforts aimed at reducing global GHG emissions, increasing adaptation capacity and advancing progress towards economic, social and environmental sustainability.

The year 2020 was considered critical for the implementation of both the Paris Agreement and the 2030 Agenda. It was seen as key to addressing the global challenge of climate change in the post-2020 period and in pursuing progress toward achieving the SDGs. In regard to the UN climate process specifically:

- UNFCCC Parties were expected to fulfil and deliver their pre-2020 climate mitigation, adaptation and support commitments, in accordance with the principles and provisions of the Convention;
- Parties to the Paris Agreement were expected to submit their new or updated NDCs prior to the UN Climate Change Conference (COP26), communicating ambitious efforts in line with the long-term temperature target of the agreement, and demonstrating a successive progression within this five-year NDC cycle; and

- Parties were also expected to make critical decisions at COP26 and resolve outstanding negotiation issues related to the Paris Agreement Work Programme (PAWP), including substantive matters on finance, transparency and cooperative approaches.

Moreover, the 2020 UN High-level Political Forum (HLPF) on Sustainable Development, which is the core platform for reviewing the 2030 Agenda and its SDGs, was originally intended to initiate a new four-year cycle to review the implementation of the SDGs and assess progress towards achieving the 2030 Agenda.

Yet since early 2020, the world has been confronted with the COVID-19 pandemic, which has brought widespread human and socio-economic ramifications. The pandemic has affected the UN processes on climate change and sustainable development too, with implications on the implementation of the Paris Agreement and the 2030 Agenda, as further elaborated on below.

7.1.1 UN climate process and the Paris Agreement implementation

Due to the pandemic, it was noted that formal negotiation sessions on climate change would only resume when in-person sessions reconvene. As a result, both COP26 and the sessions of the UNFCCC subsidiary bodies (SB52) in 2020 were postponed.

It led to climate diplomacy moving to informal discussions and they have been held in virtual mode ever since. Instead of the UNFCCC formal meetings, two web-based climate dialogues were held in June and November 2020, and in May and June 2021, the first part of the SB sessions were convened in an informal virtual setting, aimed at addressing mandated work from 2020 and 2021, yet without making any decisions.

Official negotiations are, therefore, on hold until in-person sessions are possible. In-person deliberations would allow full, effective and inclusive engagement of both developed and developing countries, leaving no issue and no one behind. Following a decision to start a day earlier than originally planned, COP26 is currently scheduled to take place from 31 October to 12 November 2021, in Glasgow, UK. However, travel restrictions and guidelines, including having to quarantine, raise uncertainties on the format of the climate change conference and whether standard procedures of the UNFCCC can be observed.

It should also be noted that climate diplomacy is a multifaceted and dynamic issue. UN climate change negotiations require a significant amount of Parties' engagement on a wide range of complex technical issues that could lead to the full operationalization of the Paris Agreement and an effective global response to the challenge of climate change in the context of sustainable development and poverty eradication. Thus, intense negotiations are expected, which will likely ensure that the time lost is made up in advancing work, leading to a successful COP26 outcome.

Besides advancing technical work, leadership and political decisions would be required that would allow outstanding issues related to the Paris Agreement rulebook to be resolved. A significant amount of work remains to be done, and the COP26 Presidency (the UK) continues to reach out to Parties, creating space that could lead to potential compromises. For instance, the COP26 President hosted a ministerial meeting with Parties from key negotiation groups in July 2021, focusing on issues related to market and non-market approaches, adaptation and finance, among others.

The May-June SB sessions, held for the first time virtually, aimed to allow Parties to make progress on the high volume of work accumulated in the absence of negotiation sessions in 2020. Consultations were informal and convened for the purpose of discussion. Despite a number of technical challenges for both developed and developing countries, particularly holding the sessions in three different time zones, Parties remained committed to discuss critical issues. The

progress achieved during these sessions was captured in informal papers, with some countries stressing the need for additional informal consultations prior to COP26.

Regardless of the impact of COVID-19 on UNFCCC processes, the outstanding negotiation issues should be resolved with all Parties agreeing upon a comprehensive, balanced, Party-driven and consensus-based outcome. This includes adopting decisions that are guided by the objectives of the Convention and the Paris Agreement, taking into account the principles of equity, common but differentiated responsibilities and respective capabilities, and in light of national circumstances.

Moreover, the pre-2020 implementation gap that has been assessed, including support provided by developed countries to developing countries with the provision of finance, technology transfer and capacity-building, should be addressed. The fulfilment of developed countries' commitments on critical issues such as climate finance would be required for all countries to be able to enhance their mitigation action and reduce vulnerability to the harmful effects of climate change.

A number of developed countries have reiterated their commitment to the goal of mobilizing jointly $100 billion p.a. from different sources by 2020. Some have referred to the crucial role of public finance in meeting the climate investment needs and priorities of developing countries, while also unlocking finance at the scale required for achieving the Paris Agreement goals. Yet pre-2020 commitments were inadequate. Climate finance has increased, reaching an annual average of $48.7 billion in 2017–2018, but it remains far lower than developed countries' commitment to mobilize $100 billion annually by 2020.

For developing countries, implementing a low-emission, climate-resilient development strategy means attracting and securing financial and technological support to help increase capacity-building. COVID-19 has impacted developing countries' access to funding for climate action. The majority of climate-related financial support is also targeted to mitigation action. There is, therefore, a need to enhance adaptation support. Climate finance should be new, additional, adequate and predictable, ensuring a balance between support for mitigation and for adaptation in developing countries.

Technology transfer and capacity-building are needed too. It is estimated that about 85% of the population in Europe and North America uses the Internet, but only 20% are connected in the least developed countries. Developing countries face several challenges when engaging in virtual UN sessions, including those on matters related to climate change and sustainable development. Poor quality Internet connections, inadequate equipment and a lack of IT infrastructure, compounded by different time zones, impede their effective participation. It is, therefore, necessary to address the technical and organizational challenges they face when engaging in virtual meetings. Collective efforts to address climate change require leadership and proactive engagement from all countries in the UNFCCC's consensus-based decision-making process.

Moreover, the pandemic has impacted developing countries' ability to develop strategies, policies and plans that support climate mitigation and adaptation action. Capacity-building – including in the energy sector – is critical, through integrating climate change and support action to reduce emissions, adapting to its negative consequences, and eliminating the impacts of the implementation of response measures.

On post-2020 climate action, the collective progress toward the Paris Agreement's goal has been assessed by the UNFCCC Secretariat, based on Parties' NDCs submitted by the end of 2020. This analysis concludes that some Parties have strengthened their commitment to reducing or limiting GHG emissions by 2025 and/or 2030, demonstrating increased ambition to address climate change. Parties have increased the coverage of sectors and GHGs, but while the COVID-19 pandemic was mentioned by many Parties, most of them have not reflected its potential impacts in their NDCs.

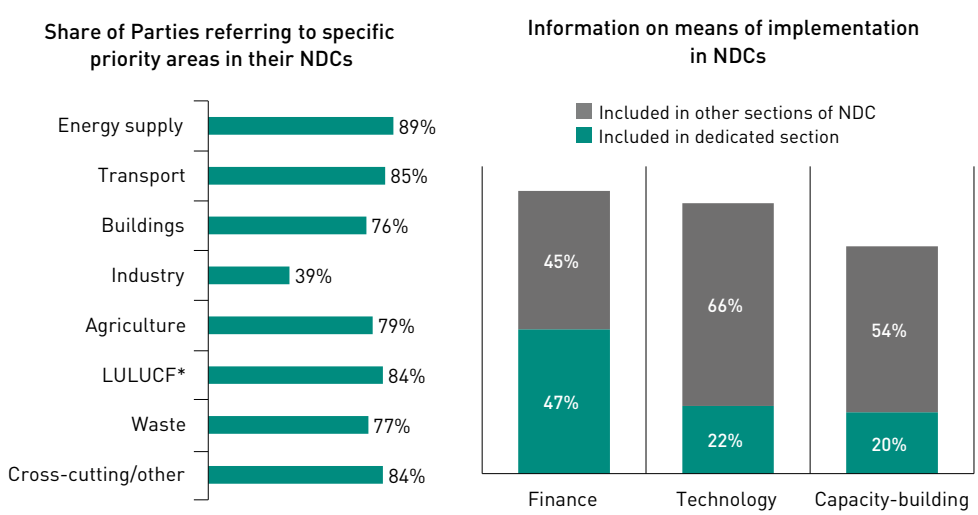
It is further stressed that submitted NDCs cover the energy sector. Almost all Parties outline national mitigation measures as key instruments for achieving emission reduction targets in specific priority areas, including energy supply, transport, buildings and industry (Figure 7.1). National mitigation measures for renewable energy generation are most frequently mentioned by Parties, followed by measures for energy efficiency improvement. In order to reduce the carbon intensity of electricity and other fuels, Parties consider shifting to low- or zero-carbon fuels, as well as to increased electrification of the supply and end-use of energy. To reduce energy demand, options such as improving energy efficiency and shifting to more efficient modes of transport are mentioned.

Compared to the previous NDCs, more Parties report in their new or updated NDCs on mitigation co-benefits of adaptation action and economic diversification plans. Therefore, more Parties provide information on their consideration of the socio-economic impacts of the implementation of climate mitigation response measures, including on just transition and economic diversification. Besides increasing the share of renewable sources in energy generation and improving energy efficiency, the critical role of technologies such as CCS, fuel switching and the enhanced use of the circular economy are highlighted.

Almost all Parties also refer to the means of implementation in their NDCs, with some including dedicated sections on finance, technology and/or capacity-building, and even providing quantitative estimates of financial support needs for NDC-implementation. Specific technology needs relate to the areas of energy, industry, infrastructure and buildings, as well as transport, among others. Identified areas include capacity-building needs for formulating policy; integrating mitigation and adaptation into sectoral planning processes; accessing finance; and the need for international cooperation.

More importantly, it is to be highlighted that the estimated emission reductions resulting from NDC-implementation fall far short of what is required, indicating the need for Parties to further

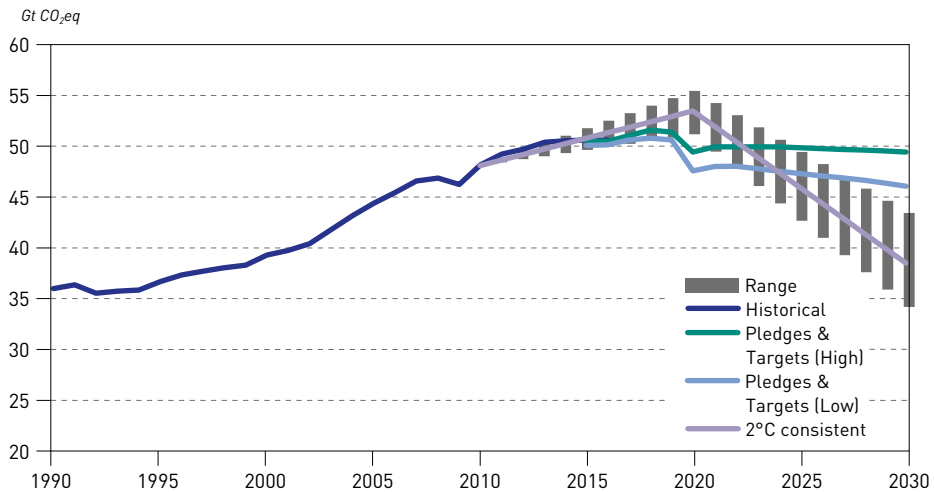
Figure 7.1
Elements of Parties' new or updated NDCs



* *LULUCF stands for land use, land-use change and forestry.*
Source: UNFCCC Secretariat, 2021.

strengthen their mitigation commitments under the Paris Agreement (Figure 7.2). At the time of writing, major economies such as China and India had not submitted their new or updated NDCs. More Parties are expected to communicate these prior to COP26. The UNFCCC Secretariat set a deadline of 30 July 2021 for collectively assessing submissions to the updated version of its synthesis report that is expected to be considered in Glasgow.

Figure 7.2
Emissions gap, 2030



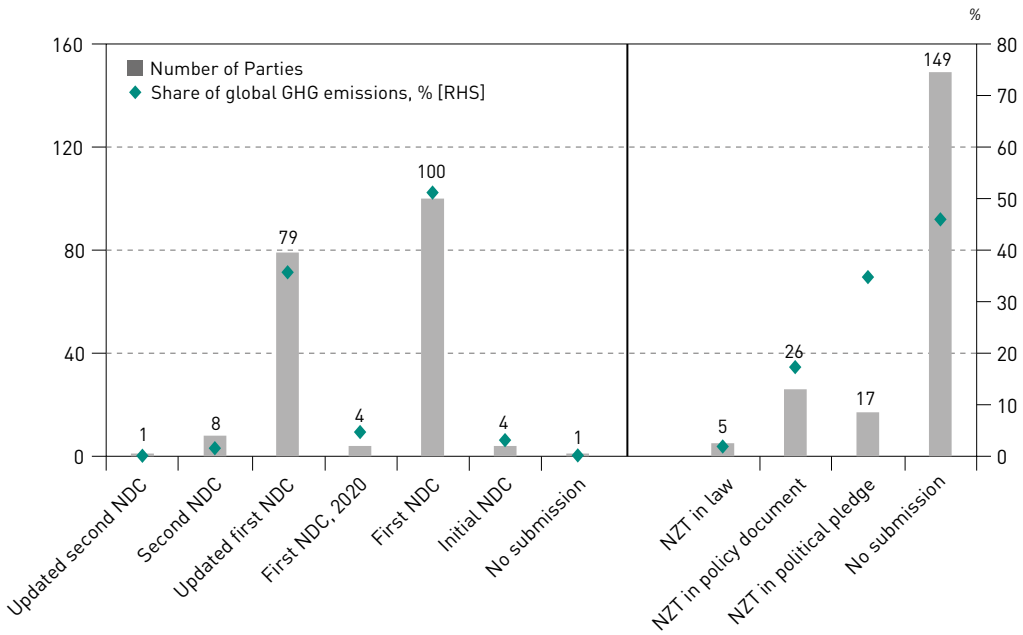
Note: The grey area presents an upper/lower range of a 2°C-consistent pathway.
Source: Copyright Climate Action Tracker, Climate Analytics and NewClimate Institute.

Some Parties have developed their new or updated NDCs, along with their long-term strategies, considering their climate action in the context of socio-economic recovery from the pandemic. It should be noted that the world initially experienced a reduction in emissions due to national lockdowns and travel restrictions in 2020. Yet as restrictions were eased, emission levels began to rise and preliminary data shows that global GHG emissions increased in 2020 on an annual basis.

At the same time, there is growing momentum from countries to set 'net-zero emissions', 'carbon neutrality' or 'climate neutrality' targets, to be achieved by 2050 or 2060. Figure 7.3 shows that as of June 2021, 92 Parties representing more than 42% of global GHG emissions had submitted their new or updated NDCs. Moreover, a total of five countries had enacted 'net-zero' legislation, and 26 had included 'net-zero' goals in policy documents.

Thus, it remains to be seen whether and how countries will fulfil their pledges, implementing mitigation and adaptation action in the context of sustainable development. The Paris Agreement calls on Parties to undertake collective participation in tackling climate change, recognizing the differentiation between countries' responsibilities for emission reductions in light of national circumstances. Innovative solutions such as the CCE could provide an integrated approach for emissions management and reduction to support sustainable energy systems and respond to climate targets (see Box 7.1). Global cooperation, international solidarity and enhanced engagement are also required, ensuring the provision of the means of implementation to developing countries.

Figure 7.3
Status of Parties' NDCs and 'net-zero' announcements



Note: NZT stands for 'net-zero' target.
Source: Climate Watch NDC Content & Net-Zero Tracker. 2020. Washington, DC: World Resources Institute.

Box 7.1

Saudi Arabia and the Middle East Green Initiatives

The Saudi Green Initiative and the Middle East Green Initiative were announced early in 2021 to chart a path for Saudi Arabia and the region to protect the planet by defining an ambitious roadmap that rallies the region and significantly contributes to achieving global climate change targets. These initiatives will entail a number of ambitious actions, including the planting of billions of trees, increasing the share of energy from renewables, and enhancing the efficiency of hydrocarbon technologies.

Recognizing that Saudi Arabia and the region face significant climate challenges, such as desertification and air pollution that can shorten life expectancy, the Saudi Green Initiative will raise vegetation cover, reduce CO_2 emissions, combat pollution and land degradation, and preserve marine life. Ambitious actions will include:

- Planting ten billion trees within the country in the upcoming decades;
- Increasing the percentage of protected areas to more than 30% of the country's land area, exceeding the global target of 17% per country; and
- Reducing CO_2 emissions by more than 4% of global contributions, through a renewable energy programme that will generate 50% of the country's energy from renewables

by 2030, as well as other projects in the field of clean hydrocarbon technologies that are estimated to eliminate more than 130 million tons of CO_2 emissions.

Similarly, the planting of an additional 40 billion trees in the region is foreseen as the world's largest afforestation project, and along with a number of other bold projects, are designed to reduce the region's CO_2 emissions by 60%. The initiatives will reinforce partnerships and collaboration, introduce integrated approaches to achieve regional sustainable development and look to enhance quality of life. They are also envisaged to reflect the interest that Saudi Arabia and other countries in the Cooperation Council for the Arab States of the Gulf and Middle Eastern countries, in general, attach to environmental preservation and international climate action, achieving a collective emissions reduction of more than 10% of global contributions.

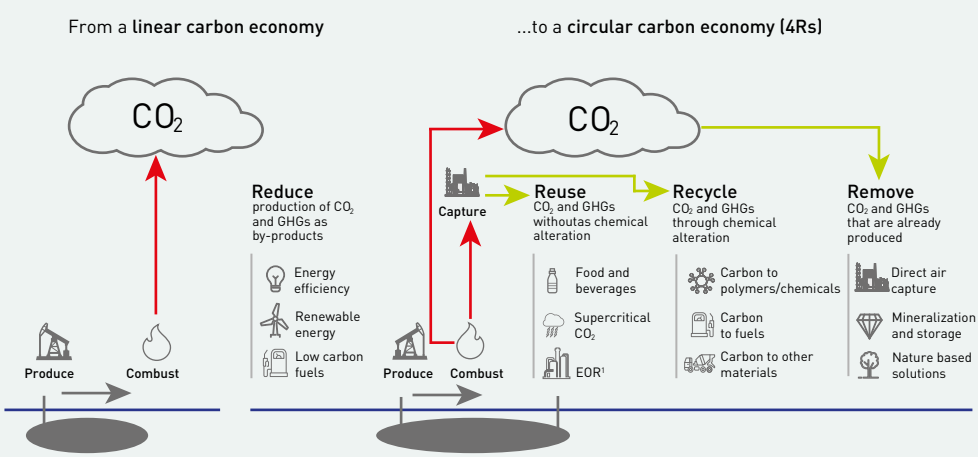
In addition, Saudi Arabia is planning a massive new hydrogen fuel plant in the megacity of Neom, along with the world's largest CO_2 purification plant with a capacity of 500,000 tonnes per year. These are all an extension of the environmental efforts in Saudi Arabia, in line with its Vision 2030 announced in 2016.

Saudi Arabia is also looking to work with neighbouring countries to transfer knowledge and share experiences, considering that these initiatives stem from the leading role of Saudi Arabia in helping meet global challenges. They are a continuation of the Kingdom's efforts to tackle climate change during its G20 Presidency in 2020, which resulted in a declaration on the environment and the adoption of the concept of a CCE.

Acknowledging the need to reduce GHG emissions, the G20 Energy Ministers endorsed the CCE Platform with its 4Rs framework (reduce, reuse, recycle and remove), proposed by the Kingdom (Figure 1).

The CCE is a voluntary, holistic, integrated, inclusive, pragmatic and complementary approach towards more comprehensive, resilient, sustainable and climate-friendly energy systems that support and enable sustainable development, ensuring energy access and

Figure 1
The circular carbon economy



[1]*Enhanced Oil Recovery.*
Source: Ministry of Energy, Saudi Arabia.

enhancing climate action. The CCE framework encourages countries to use all technologies, forms of energy and mitigation opportunities, in light of resource availability, capacities and national circumstances.

In the CCE, the 4Rs help to develop a strategy for managing carbon. The amount of carbon that needs to be managed is reduced using energy resources that do not emit carbon (e.g. nuclear power) as well as energy efficiency measures. Biomass resources, such as trees and plants recycle carbon by drawing it from the atmosphere. These resources also derive bioenergy, whereas carbon capture and direct air capture (DAC) technologies can remove carbon from the atmosphere. Moreover, carbon can be reused and converted to feedstock for chemicals, concrete and other building aggregates, or even fuels.

Overall, the CCE offers an approach to address climate challenges, while contributing to sustainable development and economic diversification. It utilizes all available levers to address emissions while generating value. Focusing on energy and emissions, it takes a holistic view on emissions reduction technologies, recognizing the economic value of carbon and emphasizing the diversity of national circumstances.

Finally, the following should be highlighted on issues related to the UN climate process. First, the US officially withdrew from the Paris Agreement on 4 November 2020 and formally re-joined on 19 February 2021, as further explained in a later section of this chapter. Moreover, as of 28 October 2020, the threshold for entry into force of the Doha Amendment to the Kyoto Protocol was achieved, since 147 countries have deposited their instrument of acceptance. The amendment entered into force on 31 December 2020.

7.1.2 Progress towards eradicating energy poverty

With regard to the 2030 Agenda, national priorities have shifted towards the fight against the COVID-19 pandemic. As indicated in the latest report of the UN Secretary-General on progress towards the SDGs, the pandemic has exacerbated inequalities, and the extreme global poverty rate rose in 2020 for the first time in over 20 years. All countries have been impacted, but the world's poorest and vulnerable have been the most affected, with debt distress occurring in many developing countries. In addition, the means of implementation required to achieve the SDGs, including financial flows, have been negatively affected by the pandemic.

Concurrently, the agenda of the 2020 session of the HLPF was adjusted to focus on the impacts of the pandemic on the implementation of the 2030 Agenda and its SDGs. Moreover, the theme of the 2021 HLPF was '*Sustainable and resilient recovery from the COVID-19 pandemic that promotes the economic, social and environmental dimensions of sustainable development: building an inclusive and effective path for the achievement of the 2030 Agenda in the context of the decade of action and delivery for sustainable development*'. Both sessions were convened virtually, using a hybrid approach (namely, in-person and virtual participation) only for the high-level segment of Economic and Social Council (ECOSOC) and the ministerial segment of the Forum.

A key takeaway message from these sessions was the need to enhance global efforts for building resilient and sustainable societies. International cooperation and solidarity are more important than ever, whereas the central principle of the 2030 Agenda – to leave no one behind – must be kept at the heart of efforts toward achieving all SDGs.

Recognizing that energy is inextricably linked to climate change and many other SDGs, and has a vital role to play in COVID-19 recovery efforts, the UN General Assembly (UNGA) has also mandated

the UN Secretary-General to convene a High-Level Dialogue on Energy during the 76th UNGA session in September 2021. This is the first summit-level event on energy since the UN Conference on New and Renewable Sources of Energy held in 1981, in Nairobi, Kenya.

The event will aim to promote the implementation of the energy-related goals and targets of the 2030 Agenda and support the implementation of the Paris Agreement. It will address five themes that focus on the energy transition; energy access; enabling the SDGs through inclusive, just energy transitions; finance and investment; and innovation, technology and data.

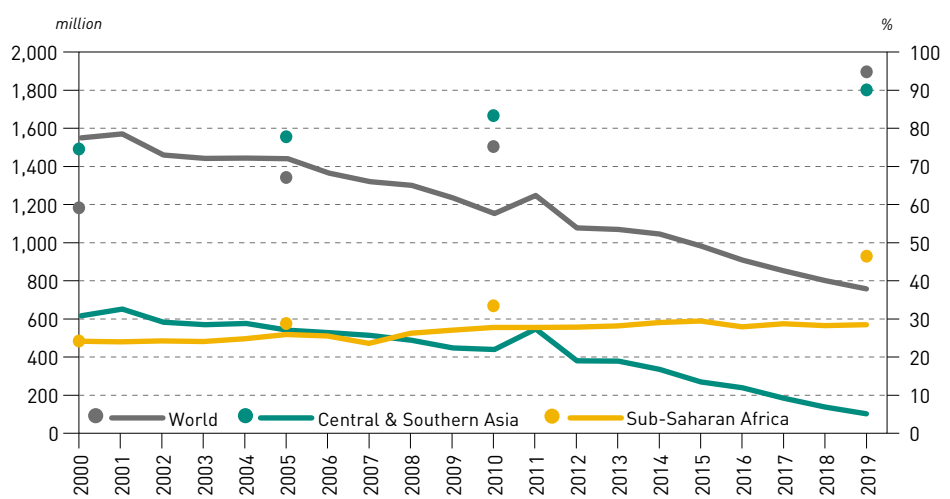
Based on the latest available data, the world is still short of achieving universal energy access. Eradication of energy poverty should, therefore, remain an overarching goal for resilient and sustainable development. As prescribed by SDG7, the provision of universal access to affordable, reliable, sustainable and modern energy is a key enabler for every aspect of sustainable development. A multiplier effect of achieving SDG7 exists for all other SDGs, including the eradication of poverty, improved health, education, tackling climate change, and overall well-being and prosperity.

In the second year of the COVID-19 pandemic, healthcare systems are still struggling to effectively manage this global crisis. Hundreds of millions remain confined to their homes, and for those without access to electricity or the Internet this causes major challenges for issues such as working, shopping and education, and the challenges are further exacerbated if there is an absence of clean cooking fuels. Additionally, increasing household electricity requirements is adding risks to the reliability of creaking electricity grids. The pandemic has revealed significant inequalities in access to reliable energy and healthcare.

It has become evident that energy access is essential to help populations mitigate the effects of, and recover from the impacts of the pandemic and health crisis. As already highlighted, energy access is needed to power healthcare facilities – including for vaccine deployment and storage, supplying clean water for hygiene, and enabling communications and IT services, among others.

Figure 7.4 shows that the global electricity access rate increased from 83% in 2010 to 90% in 2019. Despite this progress in access to electricity over the last decade, however, approximately

Figure 7.4
Population without electricity and share of population with electricity access

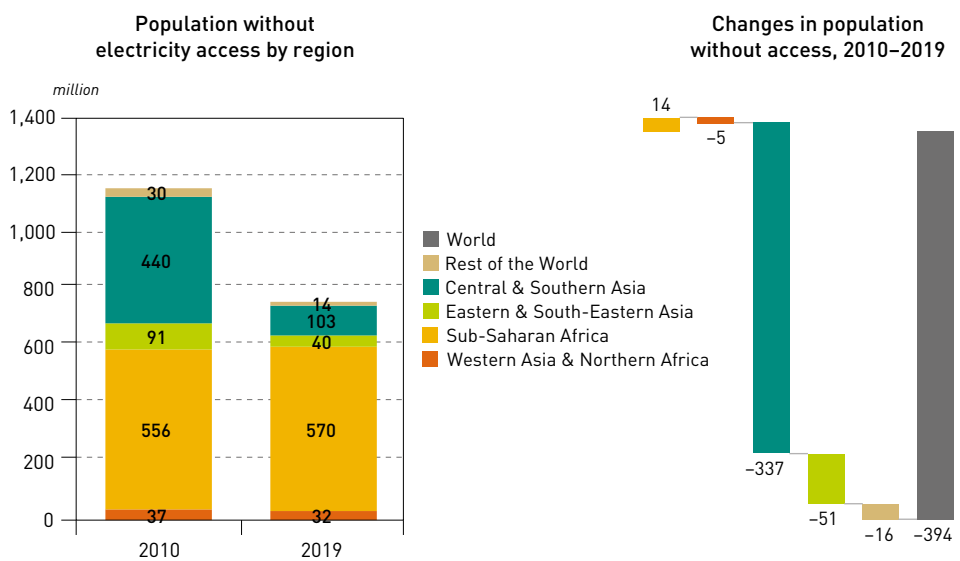


Source: World Bank, 2021.

759 million people remain unserved in 2019, with about 19% of them in Asia and 79% in Africa. According to UN reports launched at the ministerial thematic forums, which were held in June 2021 in preparation for the High-level Dialogue on Energy, progress must be accelerated to achieve universal energy access. The electricity access rate needs to increase by 2 pp on an annual basis to achieve 100% global access by 2020; with current trends and expected population growth only around 92% of the global population will have electricity in 2030. Moreover, the pandemic is expected to impede progress in future electrification.

In general, the total number of people who lack access to electricity has declined by around 34% from 1.15 billion in 2010 to 759 million in 2019 (Figure 7.5). Over the 2010–2019 period, important progress has been made in South Asia, particularly in India, yet only 46% of the population in Sub-Saharan Africa is currently electrified. Population growth has resulted in an increased number of people lacking access to electricity in Sub-Saharan Africa. About 28% of healthcare facilities and only one-third of schools in the sub-continent have reliable electricity.

Figure 7.5
Global access to electricity

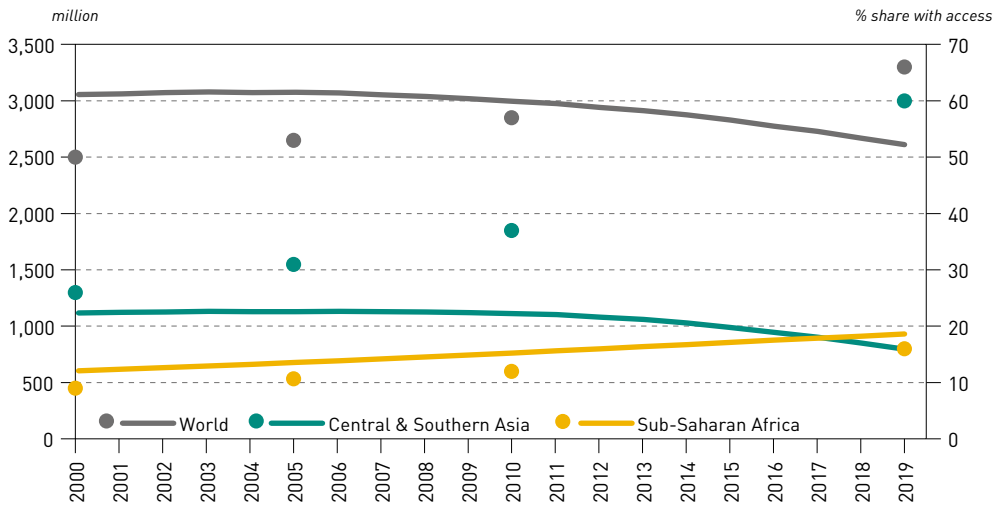


Source: World Bank, 2021.

In addition, it is estimated that during the pandemic, basic electricity services have become unaffordable for up to 30 million people in Africa who had previously enjoyed access. Thus, the number of people without electricity access in Africa is likely to be even higher in 2020. It means that in the period up to 2030, efforts to eradicate energy poverty in Africa should be substantially enhanced on an annual basis to close the access gap.

At the same time, access to clean fuels and technologies for cooking has been stagnant. Clean fuels recommended by the World Health Organization (WHO) include LPG, ethanol, biogas, solar cookers and electricity. In 2019, approximately 34% of the global population, or 2.6 billion people, lacked access to clean cooking fuels and technologies (Figure 7.6). More than 70% of Africans lack access to clean cooking fuels and technologies, and are thus exposed to high levels of household air pollution, with serious health implications that increase their vulnerability to diseases such as COVID-19.

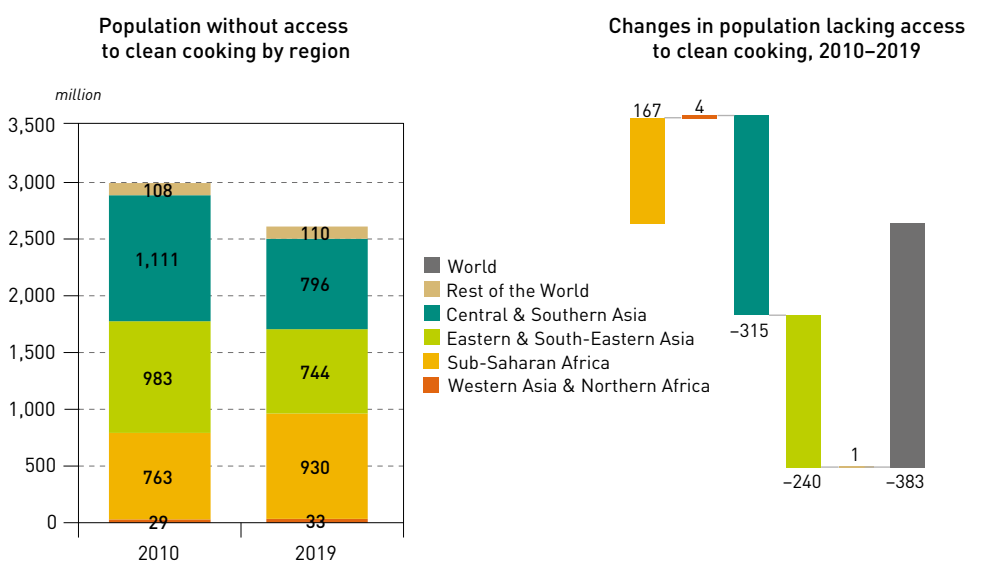
Figure 7.6
Population without access to clean cooking and share of population with access to clean cooking



Source: WHO Household Energy Database. Geneva: WHO; 2020.

Over the period 2010–2019, the number of people who had to rely on wood, coal, charcoal and animal waste for cooking declined by 9%, from approximately three billion to 2.6 billion at a global level. As indicated in Figure 7.7, both in Eastern and South-Eastern Asia, as well as in Central and Southern Asia, some improvements have been achieved, with the number of

Figure 7.7
Population without access to clean cooking fuels and technologies



Source: WHO Household Energy Database. Geneva: WHO; 2020.

people without access declining from about 2.1 billion in 2010 to 1.54 billion in 2019. Yet the number of people without access in Africa has increased from around 793 million to 963 million people.

The access deficit between urban and rural areas at a global level has dropped since 2010. However, population growth continues to outpace the annual increase in the number of people gaining access to clean cooking in Sub-Saharan Africa. With its access deficit having increased by almost 20% since 2010, Sub-Saharan Africa accounted for more than 35% of the global population that had no access to clean cooking in 2019. Considering different regional trends, it is expected that about 28% of the global population may still be without access to clean cooking fuels by 2030. Thus, the clean cooking access rate needs to increase by 3 pp on an annual basis to fully address this challenge by the end of this decade.

To tackle this challenge, electrification could support efforts for the enhanced use of clean cooking fuels and technologies. The pandemic, however, has caused both supply and demand shocks in the energy sector. If economic conditions weaken it can make it harder for low-income households and small companies to pay their electricity bill, which can lead to disconnection. Moreover, nascent companies operating mini-grids in rural locations and providing off-grid solar services to an increasing share of the African population could face financial hardship and even insolvency due to the pandemic.

Overall, discrepancies prevail both between and within countries, and exposes a significant divide between urban and rural regions. Affordability for the poor and rural communities has been hampered due to the economic downturn. Finance for energy access has not reached the level required to eliminate the access gap by 2030. In fact, international financial flows, particularly in support of modern energy to developing countries, has actually declined in recent years, although it remains higher than in 2010.

Energy poverty remains a challenge for developed regions too. In the EU, for example, it is estimated that currently almost 7% of the population cannot afford to heat their homes sufficiently. Globally, a significant number of grid-connected customers experience unreliable service. Increasing fiscal constraints post-COVID could hinder a rapid expansion of reliable grid-connected electricity access.

In light of the above, it is essential to maintain momentum for building back better, inclusive, resilient and sustainable societies. Key to achieving this is providing access to electricity and other modern energy sources, promoting clean cooking solutions, supporting the poorest and most vulnerable energy consumers and ensuring energy access for health services. It is also important to align the cost, reliability, quality and affordability of energy services, within a policy framework that does not discriminate against any energy source and ensures that no one is left behind.

International cooperation and global partnerships could play a pivotal role so that all countries, especially developing countries, can address the compounding and parallel health, economic and environmental crises. Achieving universal energy access should also be an integral part of a just and inclusive energy transition that is not a one-size-fits-all process and takes into account national priorities, capabilities and circumstances. The provision of financial support and technology transfer are enabling factors for enhancing efforts to promote energy access, particularly in developing countries.

7.2 Energy policies of major economies

7.2.1 US

Policy measures and the priorities of the US government can vary significantly between administrations and the new Biden administration is no exception, especially in the realm of energy policies. President Biden has very quickly put climate change at the front and centre, to be considered on par with other top issues of the government.

One of President Biden's first executive orders set the US on the path to formally re-join the Paris Agreement on 19 February 2021. Others provided a variety of instructions to parts of the government to undertake actions related to climate change, including an instruction to review the regulations and actions undertaken in the previous four years, ultimately to reverse and undo many of the Trump administration's actions.

In another contrast to the previous administration, Biden sought to return the US to the world stage of climate change diplomacy and in April 2021 hosted a Leaders' Summit on climate, which saw new announcements from a number of countries to tackle climate change. The US also submitted its NDC after re-joining the Paris Agreement.

While aspects of the US-China relationship remain challenging, climate change is one area that could facilitate closer relations between the two countries. It should be noted, however, that the broad trade tariffs are unlikely to be undone by the current administration. This is important when pushing for rapid increases in renewable energy use as the impact of tariffs on supply chains that support renewable energy – such as solar panels, batteries and other components – is a major challenge.

Climate policy

In terms of the country's high-level targets, the US has announced the goal to reach net-zero emissions by 2050 and, as laid out in its NDC, it aims for a reduction in emissions of 50–52% by 2030, from 2005 levels. Additionally, the US targets having a carbon-free electricity sector by 2035. This bold target would require a major ramp up of renewable sources in the energy mix, even at the expense of natural gas, which has been a transition fuel towards lower-emission sources of electricity generation for many countries.

The Biden administration will look to make the 2050 target legally binding. However, even with control of both houses of Congress there is no guarantee such legislation would be passed, or for that matter, other legislation in support of the administration's major ambitions. As well as legislative means, policy changes will also be sought through regulatory measures, for instance, through the EPA, and the toughening of efficiency standards. In contrast to other major regions, such as the EU and China, it is unlikely that the US will pursue a national carbon tax.

In general, the new government will have to put significant efforts into ensuring that policy changes can survive likely court challenges, a lesson learned from the Obama presidency when a Supreme Court ruling meant the Clean Power Plan never took effect.

Energy policy

Among the Biden administration's actions on its first day was the revocation of a permit for the Keystone XL oil pipeline between Nebraska and Alberta, Canada. This doomed the project that had been blocked and then restarted under the previous two administrations. Additionally, a moratorium on drilling on federal lands has been put in place, but this will not necessarily lead to an outright ban and the many projects that have already been approved can proceed, limiting any short-term impact on the oil and gas industry. The main purpose of the pause is likely to give the new government time to review policies in this area.

In addition to new projects and infrastructure developments, there are two other factors to be taken into account. Firstly, the Social Cost of Carbon (SCC) has been increased to $51 per tonne (reversing a cut to $7 per tonne under the previous administration), which is used in permit and financial decision-making processes. Secondly, from July 2021 the Democrats will have a majority on the Federal Energy Regulatory Commission (FERC), giving them the ability to account for the SCC and change the focus of the Commission, which could potentially restrict pipeline project approvals. Both of these developments have the potential to limit future fossil fuel-related projects.

Methane emission policy is another important area of change. Methane is a gas that is more potent than carbon in the atmosphere, but remains in it for a much shorter time. As the oil and gas industry is one of the largest sources of methane emissions (e.g. from flaring and leaks), it is naturally a target for emissions reduction policies. The current administration wants to impose rules on methane emissions from both new and existing installations.

Transportation policy

In terms of the adoption of EVs, which already enjoy subsidies at a state and federal level, charging infrastructure is one of the major factors that helps facilitate mass adoption and it could receive a boost from the administration's infrastructure plans that will reach into the trillions of dollars. While the final size and scope is still under negotiation in Congress, the administration would see a share of this spending earmarked for investment in the EV industry, including support for a network of 500,000 charging points across the US by 2030.

Standards for the fuel efficiency of passenger vehicles are set to be tightened, after being loosened by the previous administration, with the creation of the Safer Affordable Fuel-Efficient (SAFE) vehicles rule. Between 2021 and 2026, fuel economy is only required to increase by 1.5% p.a. The new administration instructed the EPA to revisit these standards in 2021 and they are likely to rise nearer to the 5% annual increase of the Corporate Average Fuel Economy (CAFE) standard from the Obama administration. Furthermore, the ability of California and other states to set their own standards will again be reviewed and could determine whether targets should be nationwide or whether individual states can pursue their own ambitions.

7.2.2 European Union

Since setting out the European Green Deal in 2020, a framework establishing the key aim of the EU to reach net-zero emissions by 2050, the EU's energy policies have continued to evolve at a relatively fast pace. Importantly, in April 2021 the EU agreed to enshrine the 2050 target into law, therefore, requiring all Member States to act to achieve this target.

Efforts were also refocused on targets within the current decade, as progress made in the years to 2030 will be vital in determining whether the 2050 goals can be met. Acknowledging that the speed of progress has to be increased, in September 2020 the European Commission proposed increasing the 2030 target to reduce GHG emissions by 55%, compared to 1990 levels, from the original 40% target.

With these overall climate policy goals set, the Commission sought out proposals for strengthening legalization across the board to facilitate the new targets. On 14 July 2021 a wide-ranging set of proposals, the 'Fit for 55' package, were released. These are explored in more detail below.

Climate policies

The reduction of GHG emissions in the EU is covered primarily on two fronts: by the EU ETS and the Effort Sharing Regulation. The latter formalizes emission reduction targets of EU Member States for 2030 and 2050, while taking into account the per-capita GDP of each country. The ETS, on the other hand, applies to certain economic sectors and uses a 'cap and trade' style system, setting an upper limit (cap) on GHG emissions each year. The cap is gradually lowered to encourage participants of the system to reduce their emissions or pay for allowances to cover their emissions liability.

The 'Fit for 55' proposals, if adopted, would dramatically change the ETS, which has been designed to target an overall reduction in emissions of 43% by 2030, compared to 2005 levels. Despite the European Commission expecting this target to be surpassed, potentially achieving a

51% reduction, the EU is looking to the system to contribute more towards the overall 2030, target of 55%. Therefore, the 'cap' on emissions, which was already due to drop by 2.2% each year as part of the scheme's fourth phase, will now drop by 4.2% each year from 2021–2030. As a result, the scheme would target a 61% emissions reduction in sectors covered by the ETS by 2030.

The scope of the system will change too, with the maritime sector being phased in over a four-year period up to 2026. It will join the existing sectors including power generation, energy-intensive industry, raw materials production and aviation. The aviation sector itself will no longer have separate allowances and overall will be aligned with the global Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) initiative.

A separate ETS has been proposed for the EU's road transportation and buildings sectors. These sectors are to be kept separate (at least initially) to allow the main ETS to continue to operate as it has been and in recognition of the differing potential for emissions reduction of these two sectors. These sectors are responsible for large shares of the EU's total emissions and, while over 50% of buildings emissions are covered in some way by the existing ETS, the proposals highlight the sector's potential to benefit from an ETS, reducing emission costs effectively in a market-based system.

In a significant development, the EU has proposed a Carbon Border Adjustment Mechanism (CBAM) that would be phased in starting in 2026. The EU had previously highlighted the difficulty of establishing such a mechanism. The CBAM aims to help better solve the issue of 'carbon leakage' whereby manufacturers move operations that are emissions intensive outside of the EU to avoid any additional costs due to the EU's more stringent climate policy (and ultimately not contributing to reducing global emissions). The mechanism would require the surrender of CBAM certificates for imports of selected products at the border and these would reflect a market price for carbon. It is expected this would encourage trading partners to lower their own GHG emissions.

As well as reducing net emissions, targeted by the above policies, the other component of the 'net zero' emissions equation is absorbed emissions where 'carbon sinks' remove carbon from the environment. The EU's 2018 Land Use, Land-Use Change and Forestry (LULUCF) regulation sought to ensure that the sector does not have any net emissions for the period of 2021–2030 and discourages the removal of carbon sinks. Changes in how the regulation operates are proposed for the second half of the applicable period and would set targets for individual Member States rather than provide an overall EU target. After 2030, the regulation would encompass the entire land sector with the addition of agricultural non-CO_2 GHG emissions.

Energy policies

The 'Fit for 55' proposals also seek to strengthen legislation covering renewable energy and energy efficiency. The Renewable Energy Directive has set a 2030 target of 32% renewable energy in terms of gross final energy consumption, but it is suggested to increase this to 40%. In another potential change to the energy mix, the amendment to the directive would seek to phase out biomass from electricity generation from 2026.

The EU's Energy Efficiency Directive was amended once before in 2018 to install a higher energy efficiency target of 32.5% for 2030 (compared to projections for 2030 generated in 2007). This reduction target could now rise to 39% of primary energy consumption. More focus is also being placed on the buildings sector with an expansion of the directive to also require public sector buildings to be renovated at a rate of 3% p.a.

Transportation policies

As well as the addition of the road transportation sector to a new ETS, the EU has submitted an amendment that would increase the EU's emissions performance standards for passenger cars

and light commercial vehicles. Emissions reduction targets for new vehicles in 2030 have been increased while, from 2035, a 100% reduction in emissions, compared to 2021 levels, has been added.

Moreover, the EU announced the ReFuelEU Aviation Initiative and the FuelEU Maritime Initiative in July 2021. The former would require a gradual increase in the use of sustainable aviation fuels at EU airports. For the maritime sector, the primary mechanism to drive improvements in marine fuel is a new limit on GHG content of energy used by ships that visit ports within the EU.

Furthermore, taxes applied to fossil fuels could change with a revision to the Energy Taxation Directive of 2003, which among other reforms would seek to remove any incentive for fossil fuels and consider tax rates based on energy content and environmental performance.

7.2.3 China

In September 2020, China announced that it would reach a peak in its CO_2 emissions by 2030 and achieve 'carbon neutrality' by 2060. More clarity on these targets was expected from the publication of the 14th FYP and long-term targets for 2035, published at China's National People's Congress in March 2021. However, the 14th FYP and long-term targets to 2035 did not cover specific details on climate- and energy-related policies. These may now be published in a separate energy plan possibly later in 2021 or 2022. The 14th FYP does set targets for reducing energy intensity and carbon emission intensity at 13.5% and 18%, respectively, from 2021–2025. It also mentions the possibility of setting a CO_2 emission cap. Important aspects of the FYP are energy security and self-sufficiency, which was underscored in some of the high-level details made available.

Non-fossil fuels (renewables and nuclear) would play a more important role in the primary energy mix with their share increasing to 20% in 2025 and 25% in 2030. Targets for specific fuels, such as wind and PV, are not yet available. Natural gas is expected to have a more prominent role in the energy mix, due to its lower CO_2 emissions, which could help to reach an emissions peak in 2030. The plan also mentions coal and its clean and more efficient use through large, highly efficient plants, while closing old and inefficient coal-fired facilities. This is an important aspect, as it targets more efficient use of primary fuel, while recognizing the importance of this fuel for China's energy mix and energy security.

The plan also focuses on the development of technology from EVs to hydrogen, as well as on the production of gas turbines and LNG ships. Oil and gas upstream technology is also one of the topics of the plan, including the development of deep-sea production platforms.

Furthermore, in mid-2021, China launched the world's largest ETS market as one of the tools to reach its 2030 and 2060 targets on emissions. It currently only covers the power and heat generation sector (around 40% of total CO_2 emissions), but could potentially include other sectors in the future. The initial price was reportedly around $7.5 per tCO_2, which is still significantly lower relative to the EU ETS price.

Related to the road transportation sector, China published its 'Technology Roadmap 2.0 for Energy-Saving and New Energy Vehicles' in late 2020. This roadmap contains guidelines and ambitions for passenger and commercial vehicles to 2035. At the time of writing, however, it is understood that this roadmap is not binding. According to the roadmap, 'new energy vehicles' should have a 40% share of total sales by 2030 and 50% by 2035. In 2035, all ICE vehicles (new sales) should at least be hybrid, with average fuel consumption of four litres per 100 km, down from 5.6 litres in 2025 and 4.8 litres in 2030. Furthermore, the roadmap calls for China to have one million hydrogen-fueled vehicles by 2035. For commercial vehicles, the average fuel consumption in 2035 should be reduced by around 15%, and for busses by 20%, from 2019 levels.

7.2.4 India

Energy policies in India are based on the seven major goals as stipulated by Prime Minister Narendra Modi in October 2020. These include:

- Accelerating efforts to move towards a gas-based economy;
- Cleaner use of fossil fuels, particularly petroleum and coal;
- Greater reliance on domestic sources to drive biofuels;
- Achieving the renewables target of 450 GW by 2030;
- Increasing the contribution of electricity to decarbonize mobility;
- Moving into emerging fuels, including hydrogen; and
- Digital innovation across all the energy systems.

All these are explained in greater detail in Chapter 9, Section 9.4.

7.2.5 Japan

In April 2021, Japan announced its revised 2030 target to reduce GHG emissions by 46%, relative to 2013 levels, and Prime Minister Yoshihide Suga said the country would strive to reduce GHG emissions by as much as 50% in the same timeframe. This was significant, since the previous target was 26%. The new reduction target is in line with a previously announced (October 2020) commitment to become carbon neutral by 2050.

The current energy strategy of Japan (from 2018) foresees an increase of the share of renewables in power generation to 22–24% (up from 17% in 2018) and nuclear to 20–22% (up from 6% in 2018) by 2030. However, given the new revised GHG emission reduction commitments, these targets could be revamped in the near future. One step in this direction was the announcement by the Ministry of Industry that Japan intends to increase its offshore wind power capacity to 10 GW by 2030 and up to 45 GW by 2040.

In the transportation sector, the fuel economy standard for passenger and light commercial vehicles sets a target of 20.3 km/l and 17.9 km/l by 2020 and 2022, respectively. The 2020 standard applies to diesel vehicles weighing less than 3.5 metric tonnes, as well as gasoline and LPG vehicles. These targets should result in a 13.4% improvement in efficiency in 2025, compared to 2015 levels, for trucks and other heavy vehicles, and 14.3% for buses.

In the longer-term, Japan initially intended to increase the sales of next-generation vehicles from below 40% in 2018 to 50–70% in 2030. However, given more ambitious plans related to GHG emission reductions, these targets may need to be revised up. Accordingly, Japan recently announced it would ban sales of new gasoline or diesel-only passenger cars by 2035, but will allow HEVs and PHEVs. No further details were available at the time of writing.

Japan also has a regulatory framework that ensures compliance with mandatory efficiency standards for large-scale non-residential buildings through incentive measures that include a performance improvement planning certification system and energy labelling system. The government expects to achieve net-zero emissions in new building construction projects by 2030.

Finally, Japan's Fifth Strategic Energy Plan calls for using CCUS technology to meet its energy and climate goals beginning from 2020. It has already made provisions for this in its marine pollution protection law covering offshore and sub-seabed storage.

7.2.6 The UK

In a recent move, the UK increased its emissions reduction targets to 78% by 2035, compared to 1990 levels. For the time being, this is arguably the most ambitious target of major world

economies and should be enshrined into law during 2021. Among other actions, the pathway to meeting this target includes the continued deployment of renewables in the electricity sector and electrification of the transportation and residential sectors. Furthermore, support for low-carbon hydrogen is envisaged.

The UK ETS, effective from January 2021, replaced the EU ETS following Brexit. This scheme covers emission-intensive industry, power generation and flights within the UK and the European Economic Area. The UK ETS is similar to the EU ETS, and the aim is to align it to the UK 2050 net zero targets by 2024.

In 2018, the UK published 'The Road to Zero' that outlines the next steps towards cleaner road transport and its industrial strategy. This provided a long-term plan for zero emissions for most light vehicles by 2040. However, in line with the more ambitious emission reduction targets already mentioned, the UK decided to ban new sales of ICEs from 2030, although some hybrids will be allowed until 2035. The transport decarbonization plan (effective 2021) established a 'Jet Zero Council' whose target is to develop a net-zero emission aviation sector.

The government published a ten-point plan for a Green Industrial Revolution in 2020. The new strategy aims to make the manufacturing and construction sectors 'greener' and replace gas boilers in existing homes with low-carbon heating systems. Starting from 2023, gas boilers will be banned in new buildings and pilot projects will allow up to 20% blending of hydrogen into the gas distribution grid. There is a temporary target for 1 GW of hydrogen production capacity by 2025 and a small-scale hydrogen heating trial in the same year. The government's plan sets a low-carbon hydrogen capacity target of 5 GW for 2030. Some companies such as BP and Equinor have announced plans to invest in low-carbon hydrogen (green and blue) in the medium- and long-term.

The government's 2020 budget set aside about £1 billion for the development of a new CCUS Infrastructure Fund to establish support for various carbon capture projects, including projects for developing blue hydrogen infrastructure combined with the CCUS.

The UK government also supports small modular nuclear reactors. Up to £500 million was made available for these projects. However, the support for future large-scale nuclear project development is currently unclear.

7.2.7 Canada

Canada's NDC calls to reduce GHG emissions by 30% by 2030, relative to 2005 levels. However, it was announced at the Leaders' Summit on Climate, convened by the Biden administration in April 2021, that by 2030 Canada would reduce its GHG emissions by 40–45% below 2005 levels, and move forward on a path to reach 'net-zero' emissions by 2050.

The Canadian government is at the development phase of the Clean Fuel Standard (CFS) policy in order to reduce the lifecycle of carbon intensity of fuels and energy consumed. This approach could reduce about 30 million tonnes of GHG emissions annually by 2030, and also reduce the country's national emissions by 30% compared to 2005 levels. The CFS is expected to become legally binding by the end of 2021. To achieve this emissions reduction goal, the government plans to stimulate investment and innovation in low-carbon intensity fuels and set separate requirements for liquids, gaseous and solid fuels.

The CFS policy is a subset of Canada's climate plan that will work in tandem with carbon pricing in order to make it more effective and to create incentives for investment in innovation and clean-energy technology across the economy. The CFS and the carbon pollution pricing policy are intended to encourage fossil fuel suppliers, such as refineries, to install more efficient technology to reduce overall emissions and earn credits that can be sold or re-used.

Canada also introduced a carbon tax in 2018 with the current price above $20 per tonne of CO_2. It is scheduled to increase to almost $140 per tonne of CO_2 by 2030.

7.2.8 South Korea

South Korea's NDC calls for a 24.4% reduction in emissions by 2030, compared to 2017 levels. However, the government is looking to increase the target to 37% by 2030 against its initial business-as-usual scenario levels. Moreover, on 28 October 2020, the government announced its intention to achieve carbon neutrality by 2050. Hydrogen is specified as playing a key role in achieving this target.

In terms of renewables, South Korea has a supply target for renewable energies under the Third Renewable Energy Basic Plan, which foresees the share of renewables at 30–35% by 2040. However, its ninth basic plan for power supply and demand calls to increase the share of installed renewable capacity to 40% by 2034. Both plans aim to reduce coal and nuclear generation, while increasing the share of renewable energy generation by a factor of four. South Korea also plans to improve its renewable fuel standard by requesting that oil importers and exporters have a 3.5% biodiesel blend in transportation fuels from July 2021 through 2023, up from the 3% requirement as of 2018.

7.2.9 Brazil

The Brazilian government recently announced its 2050 net-zero emissions target at the US-led Leaders' Summit on Climate in April 2021. Brazil also made a commitment to halt illegal deforestation in the country by 2030. Another important target is to reduce overall emissions by 43% by 2030, compared to 2005 levels.

The government has also set a target of increasing the share of renewables in the country's energy mix to 45% by 2030. It plans to increase the share of biofuels to 18% and non-hydropower renewable energy to 28–33% by 2030.

The PROCONVE L-6 emission standard for passenger vehicles set by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) establishes maximum emission limits for nitrogen oxides, carbon monoxide and all other particulate matter. However, it did not set emission limits for CO_2 and other greenhouse gases. The PROCONVE L-7 and L-8 were adopted in 2018 with a plan that the L-7 would be in place by 2022, with the L-8 coming into force in 2025. The PROCONVE P-8 emissions standard for heavy vehicles took effect in 2018 and by 2023 all new sales of vehicles that weigh over 3,856 kg will be subject to the standard. These approvals are the equivalent of Euro 6 standards for emissions.

7.2.10 Russia

The government of the Russian Federation has pledged to reduce its emissions by between 30% and 35% by 2030, compared to 1990 levels, although this is subject to the capacity of its forests to absorb carbon emissions. The Federal Law on 'The limitation of GHG', which will come into force in January 2022, will define the regulatory basis for economic activities accompanied by GHGs and is aimed at creating conditions for the country's sustainable and balanced economic development under the auspices of GHG reduction. Moreover, the Russian government plans to adopt the country's 'Reduced GHG socio-economic development strategy until 2050' by the end of 2021.

The government has also pledged to raise the share of renewables in final energy consumption to no less than 6% by 2035, and a medium-term target of 4.5% by 2024. This target excludes the large hydropower stations that currently produce 97.5% of the country's clean power generation.

In March 2020, the Russian government adopted a plan for the development of gas in the road transportation sector. This programme aims to increase CNG use in vehicles to 2.7 billion cubic metres (bcm) by 2024. To achieve this, it plans to scale up the number of CNG stations by 2.5-fold in order to make available CNG for the targeted increase of 40,000 natural gas vehicles by 2024.

The government has also encouraged the construction of CNG stations by providing 25% of the cost of construction to prospective partners. It also subsidizes up to 60% of the cost for civilian use of CNG vehicles. There is a similar plan to increase the use of LNG in the road transportation by developing a network of 200 LNG fuel stations for long-haul heavy trucks by 2030. According to Russia's 'Long-term LNG production development programme' the country's overall transport sector LNG demand is expected to increase to 0.8 mt by 2024 and reach 5.5 mt by 2035.

It is also worth noting that the Russian government, through its Russia's Fund for Prospective Research, is supporting the development of hybrid electric aircraft.

7.2.11 Africa

The African energy sector has made progress on energy policies in recent years. Many African countries have national energy strategies, albeit with differing time horizons. In some cases, these energy strategies are part of a broader effort to boost the country's economy and/or to reduce energy poverty.

Major regulatory frameworks have been put in place to achieve economic growth and sustainable development in the African energy sector and to ensure access to affordable, reliable and sustainable energy for all, with a focus on UN SDG 7. The African Union Agenda 2063, the NEPAD, in collaboration with the AfDB and the Programme for Infrastructure Development in Africa (), undertake policy development and coordination at the continental and regional levels.

Nigeria LNG Limited recently launched Train 7, which is projected to expand gas production by 35% and further reduce gas flaring and GHG emissions. At the end of March 2021, the Nigerian government led by President Muhammadu Buhari formally declared 1 January 2021 to 31 December 2030 as 'the Decade of Gas Development for Nigeria.' The Mozambique natural gas master plan is another example of a policy focused on issues related to further developing home-grown energy sectors, reducing emissions and helping to manage energy transitions.

The government of South Africa has approved a Low Emission Development Strategy (SALEDS) with a goal to achieve net-zero emissions by 2050. It plans to achieve this goal with NDC target emissions of 398–510 million metric tons of CO_2 equivalent ($MMtCO_2e$) for 2021–2025 and 398–440 $MMtCO_2e$ for the 2026–2030 period. It also seeks to reduce emissions from the rail sector to meet its 2050 target. Moreover, South Africa plans to retire up to 11 GW of its coal power plants and install 14.8 GW of renewable energy capacity for new buildings by 2030.

In June 2019, the government introduced a sectoral carbon tax on emitters above a 100,000 litres p.a. threshold for GHG emissions. This tax currently applies to domestic aviation, rail and waterborne navigation. Moreover, passenger vehicles that emit over 120 gCO_2 per km are subject to the emissions tax.

The Kenyan government's energy efficiency strategy calls to eliminate kerosene as a household fuel by 2022 and replace it with renewable sources, for instance, by installing solar water heaters in buildings served by the grid. Similarly, Mozambique aims to install 100,000 solar water heaters, 50,000 lighting systems, 5,000 refrigeration systems and 2,000 televisions powered by solar PV or wind turbine systems in off-grid areas by 2025.

7.2.12 Hydrogen

It is clear that hydrogen could play an important role in efforts to reduce future emissions. As a result, many countries are focusing increasingly on hydrogen as an integral part of their energy policies.

The EU is moving towards making hydrogen production in the region a priority. The European Commission's 'Hydrogen Strategy for Climate-Neutral Europe' sets a minimum target of 40 GW of hydrogen electrolyzers to be installed by 2030. The strategy focuses on the use of hydrogen in transportation, for heating in the residential and industrial sectors, as well as using hydrogen as a form of energy storage.

The EU's 'Fit for 55', published in July 2021, goes even further by proposing specific requirements for hydrogen infrastructure in the road transportation sector. If adopted, EU Member States would be required to expand the network of hydrogen fuelling stations to every 150 km. It should be noted that the European Commission supports hydrogen production based on renewable electricity.

Hydrogen policies in the US do not directly support the production of either green or blue hydrogen. US hydrogen policies were established in the Energy Policy Act of 2005 and is further supported by tax credits for carbon sequestration, often referred to as the 45Q tax credit, which was approved in 2008. The hydrogen part of the energy law is intended to promote the development of hydrogen and fuel-cell technologies in tandem with targets for the transportation sector.

As a monetary incentive, the 45Q tax credit was intended to help reduce CO_2 emissions, but also to incentivize carbon capture and sequestration in energy-intensive applications such as blue hydrogen production. The California Low Carbon Fuels Standard (LCFS) is another example of a market incentive that has been implemented to encourage the uptake of low-carbon fuels.

In Canada, the promotion of hydrogen is part of an energy diversification effort outlined in the 'Hydrogen Strategy for Canada', published in December 2020. Canada has a low-carbon intensity electricity grid, abundant fossil fuel reserves and geology well suited to CO_2 storage. In this strategy, the Ministry of Natural Resources set a target for hydrogen delivering up to 30% of Canada's end-use energy by 2050.

Japan released its 'Basic Hydrogen Strategy' in 2017 and announced its 2050 net-zero emission target in October 2020. Japan is a major CO_2 emitter and still relies on coal for a large portion of its electricity generation. The Japanese government considers hydrogen as part of a foundation for a modern economy, a way to lower its dependency on imported fossil fuels, as well as reduce CO_2 emissions to help meet its commitments to the Paris Agreement. Japan has the highest number of hydrogen fuelling stations in the world (currently almost 100) and plans to expand this network to 1,000 stations by 2030.

South Korea has a similar plan to extend its hydrogen network and intends to have 1,200 fuelling stations by 2040. This target was set in its 'Hydrogen Economy Roadmap', which also envisages producing 6.2 million FCEVs by 2040.

China is one of the few large countries that has so far not announced a separate hydrogen strategy. Hydrogen is mentioned in the recently released 14th FYP, though without providing specific targets. It is very likely that these will be released in the near future, possibly later in 2021 or 2022, with expectations for more detail on specific regions and industries. Bearing in mind China's target for achieving carbon neutrality by 2060, it is very likely that hydrogen will play an important role in the country's future energy system and become the subject of additional policy measures.

In order to supplement Russia's 2035 Energy Strategy, in August 2021 the government approved the 'Concept of developing hydrogen energy in the Russian Federation'. This

document identifies the goals, initiatives and measures needed to develop the Russian hydrogen industry in the planning horizon to 2050.

The Middle East region and Africa are also moving towards putting in place hydrogen enabling policies. Saudi Arabia's announced green initiatives for the Kingdom and the Middle East cover a large spectrum of measures, from increasing renewables to planting billions of trees. Hydrogen development projects have already begun in Saudi Arabia and the UAE. In September 2020, Saudi Arabia sent the world's first blue ammonia cargo to Japan to be used for the production of emissions-free electricity.

All six Gulf Cooperation Council (GCC) states have expressed interest in developing hydrogen production capacity. With their combination of low-cost gas resources and low-cost renewable energy, as well as other advantages, the Gulf states are strong candidates to emerge as major exporters of blue and green hydrogen. Saudi Aramco and ADNOC are making a push to do just that – positioning themselves to build upon their well-established and extensive energy ties with the Asia-Pacific region.

The African Hydrogen Partnership (AHP) was established recently and many African countries are expressing interest in developing hydrogen through national initiatives. South Africa, with a technological edge in GTL technologies, has the potential to supply zero-carbon fuels through green hydrogen.

Finally, hydrogen related policies in India are outlined in Chapter 9, section 9.4.5.

Demand and supply uncertainties

Key takeaways

- To account for uncertainties related to economic growth, two alternatives to the Reference Case were developed – a Higher GDP Case and a Lower GDP Case.

- Global GDP is projected to reach $280 trillion (2017 PPP) in the long-term in the Higher GDP Case and around $253 trillion (2017 PPP) in the Lower GDP Case. These compare with almost $270 trillion (2017 PPP) in the Reference Case.

- In the Higher GDP Case, Africa plays an important role in supporting higher long-term economic growth. African oil demand in the Higher GDP Case is expected to grow to 5.2 mb/d in 2026, marginally higher than in the Reference Case. However, this upside will expand to 0.7 mb/d in 2035 and 3.3 mb/d in 2045.

- With respect to economic uncertainties, the risk for oil demand over the medium-term is skewed to the downside and primarily related to a potentially extended pandemic. In the long-term, the risk is rather symmetric with each case deviating from the Reference Case by more than 6 mb/d at the end of the forecast period.

- The potential implications of the faster penetration of more efficient technology and more stringent policy measures are assessed in the Accelerated Policy and Technology (APT) Case.

- Oil demand in the road transportation sector in the APT Case could decline by some 3 mb/d in 2045 compared to the Reference Case.

- The gap between the Reference Case and APT Case could be as high as 8 mb/d in 2045 when oil demand in the APT Case falls below 100 mb/d.

- There are uncertainties on the oil supply side too. Lower and Higher Supply Cases indicate a range of some 7.5 mb/d in the medium-term and as much as 10 mb/d in the long-term, heavily skewed to the downside.

- In the Lower Supply Case, the impact on US tight oil becomes rapidly visible. Rather than recovering from its slump as projected in the Reference Case, US tight oil declines gradually until it stages a modest rebound in the latter part of the 2020s, albeit not to pre-pandemic levels. The impact of a slowdown in output in other non-OPEC countries takes longer to materialize, but eventually project cancellations, lower investment and to some extent, policy measures, contribute to the downside.

- The Higher Supply Case projects relatively modest upside for US tight oil (above the cumulative 1.7 mb/d growth assumed in the Reference Case for 2022 and 2023) until the latter part of the medium-term time horizon; by 2026, production is around 1 mb/d higher, and output plateaus at around 16 mb/d before declining again from the mid-2030s. Other non-OPEC supply responds more quickly, adding 1.2 mb/d to the upside by 2026 and 2.5 mb/d in the long-term, as growth centres including Guyana, Brazil and others add projects, and unconventional and frontier resources elsewhere are tapped.

Developments over the past year have made it clear that there are a variety of uncertainties related to both future oil demand and supply, including prospects for economic growth. This Outlook assumes a strong economic recovery in 2021 and 2022, solid GDP growth over the medium-term and decelerating growth during the rest of the forecast period. However, this view is subject to considerable uncertainty on both sides.

Uncertainty during the medium-term period is skewed to the downside on the back of a possibly extended pandemic, continued regional lockdowns, inflationary pressure, the ineffective use of stimulus packages and rising financial stress leading to a higher number of bankruptcies.

On the other hand, accelerated vaccination rates, the rapid suppression of COVID-19 and the effective use of huge stimulus packages in advanced economies could not only trigger stronger growth in these countries, but also have long-term spill-over effects in many developing countries, especially in Africa.

Therefore, to account for this uncertainty, two alternative cases were developed, each complementing the Reference Case and depicting different, but possible economic developments.

Secondly, there is a growing awareness among policymakers of the need to accelerate actions addressing climate change, and an increasing public acceptance of products and services with a lower environmental footprint is rising. Indeed, several major countries, including EU Member States, the US, Japan, the UK, Canada and Brazil have recently announced their intention to reach net-zero emissions by 2050, with China aiming to reach a peak in its emissions before 2030 and be carbon-neutral by 2060. At the same time, negotiations at the international level to achieve the Paris Agreement goals are intensifying.

While these are all welcome initiatives, they inevitably bear an element of uncertainty. This is not only in respect to their viability, but also due to the lack of clarity on how these targets will be achieved. Despite the fact that these targets are extremely ambitious and challenging, any substantive move in this direction would likely have significant implications for future oil demand and supply.

Thirdly, 2021 has been marked by a number of announcements that potentially could have far reaching implications for oil demand in the road transport sector. The European Commission, in its 'Fit for 55' package of measures, proposed that all new cars in the EU registered as of 2035 should have zero emissions. Similar initiatives also exist in the UK, Iceland, California (with varying timetables and engine specifics), while Norway intends to achieve this already by 2025.

There also is a move in this direction by major car makers, especially in Europe. Several leading manufacturers, such as Volkswagen, Ford, Stellantis and Audi, recently announced plans to stop developing and selling cars with ICEs, at least in some markets (typically Europe), within the timeframe of this Outlook. This could accelerate the electrification of the road transport sector beyond what is assumed in the Reference Case.

To assess the likely impact of both tightened energy policies and a faster penetration of EVs, together with other options to improve energy efficiency, the Accelerated Policy and Technology Case (APT Case) was developed and is presented in this chapter.

Finally, 2020 and 2021 were years that saw significant underinvestment in the oil upstream sector. Despite higher oil prices, many companies preferred to pay higher dividends or improve their balance sheets instead of making large investments in new oilfields. Moreover, several large oil companies, again especially in Europe, redirected part of their investments into renewable energy and infrastructure projects, hence reducing the resources available for the upstream sector. This chapter attempts to shed light on how these developments could affect future non-OPEC oil supply.

Clearly, these alternative cases do not address all potential oil industry uncertainties, but they serve to indicate the range of uncertainty in the years to come.

8.1 Economic uncertainties

The long-term link between oil demand and the level of economic activity is complex. Common sense suggests that GDP growth should result in higher oil demand in a country/region, with the strength of the link depending on how oil intensive the economy is or, in turn, how large is the share of oil intensive industry and transport services in the GDP composition.

However, with changing GDP structures and increasing options for oil substitution, this link can change significantly over time, especially if a longer horizon is considered. Despite the expectation of a weakening GDP impact on future oil demand, the level of economic activity will remain an important driver, especially in developing countries. Therefore, it is important to assess the likely implications of alternative paths of economic development on future oil demand.

To account for the uncertainty stemming from differing economic assumptions, similar to last year's WOO, two alternatives to the Reference Case were developed. Bearing in mind current circumstances, it is unavoidable to start with broad assumptions about the direction of the economic recovery from the COVID-19-induced crisis in 2020. As stated in Chapter 1, global GDP is expected to grow by 5.5% in 2021 and 4.1% in 2022.

These growth assumptions are based on the expectation that COVID-19 is broadly contained and will not continue to materially impact global economic growth patterns over the medium-term. It is also important to note that this growth is unevenly distributed among major regions. The bulk of it comes from developing countries, which are set to expand by more than 6% in 2021 and 5% in 2022. Considering that the decline for this group of countries was 2.2% in 2020, they show strong growth potential.

Moreover, Chapter 1 also emphasized the potential for downward global GDP revisions in the case of a prolonged COVID-19 pandemic. This issue stands as a starting point for developing the Lower GDP Case, which assumes that the world will still be plagued by COVID-19 throughout most of the medium-term. In this case, new COVID-19 variants emerge in various parts of the world and lead to renewed regional or local lockdowns. While COVID-19 testing is widespread and the treatment of patients improves, vaccination progress remains slow, especially in developing countries. Moreover, some virus variants prove to be resistant to vaccines, which supports scepticism in some parts of the population, creating another barrier to successfully containing the pandemic.

Under these conditions, industries dependent on the global trade of goods and various components will suffer the most. As a result, the number of bankruptcies will grow, starting with smaller companies, but gradually affecting major international corporations too.

An extended period of occasional lockdowns will increasingly affect public finances. A large part of stimulus packages will be used to compensate for shortfalls to prevent further bankruptcies and growing unemployment, while a smaller part will be available to revive economic growth. Hence increasing inflationary pressure. Moreover, some countries that were already heavily indebted before the crisis could face defaults on sovereign debt.

In this case, even after the pandemic is controlled in later years, the effects are felt for longer as it will take some time to return to growth levels assumed in the Reference Case. An extended period of lockdowns will likely change trade relations and increase protectionism which, in turn, will reduce global trade. In addition, internal unrest in economies hurt by the pandemic could increase. In this case, lingering social issues that were suppressed during lockdowns could re-emerge and further extend the period of lower economic growth.

On the positive side, the Higher GDP Case represents a world where the pandemic is soon contained. Vaccination programmes progress faster in both developed and developing countries. Advanced economies are ready to provide vaccines to a broad range of countries and the entire vaccination process is well organized. Moreover, modified vaccines prove to be effective against new variants, so that the number of global infections declines faster than in the Reference Case.

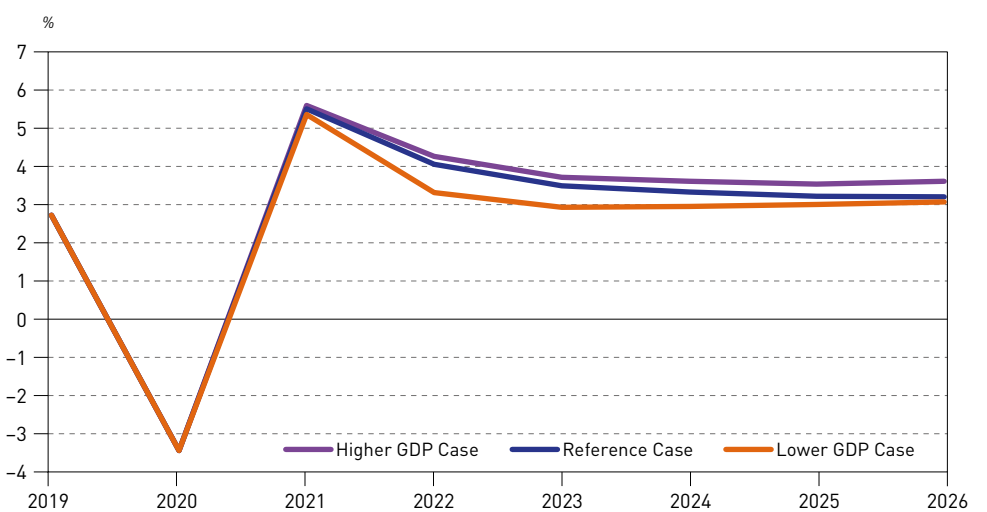
Consumer confidence returns relatively quickly and spending grows, leading to higher demand for goods and services which, in turn, supports new business opportunities. Moreover, the stimulus measures of major economies are primarily used for investments in industries with high growth potential. Furthermore, they drive technological innovation that generates economic growth, increases productivity and creates new jobs. Importantly, this ignites growth that is sustainable and continues during the long-term period with significant spillover effects for developing countries, in particular, Africa.

Under the Higher GDP Case, investors increasingly find opportunities to develop new projects in Africa. Given its young, dynamic and growing labour force; rapid urbanization; required infrastructure expansion; and rich resource endowments, this continent provides a unique opportunity for economic development. This attracts investors' attention and starts a spiral of positive growth which, in turn, attracts higher capital inflows.

Figures 8.1 and 8.2 present the quantification of the narrative of these two cases. Figure 8.1 shows global GDP growth rates during the medium-term period, while Figure 8.2 translates these growth rates into absolute GDP levels (in billions of US dollars 2017 PPP), including the extension to the long-term period.

The difference between the Reference Case and the two alternative cases is already visible in 2022. The extended pandemic situation in the Lower GDP Case limits global GDP growth to 3.3% in 2022 (compared to 4.1 % in the Reference Case) and 3% in 2023, also significantly lower than

Figure 8.1
Global GDP growth rates in the medium-term, 2019–2026



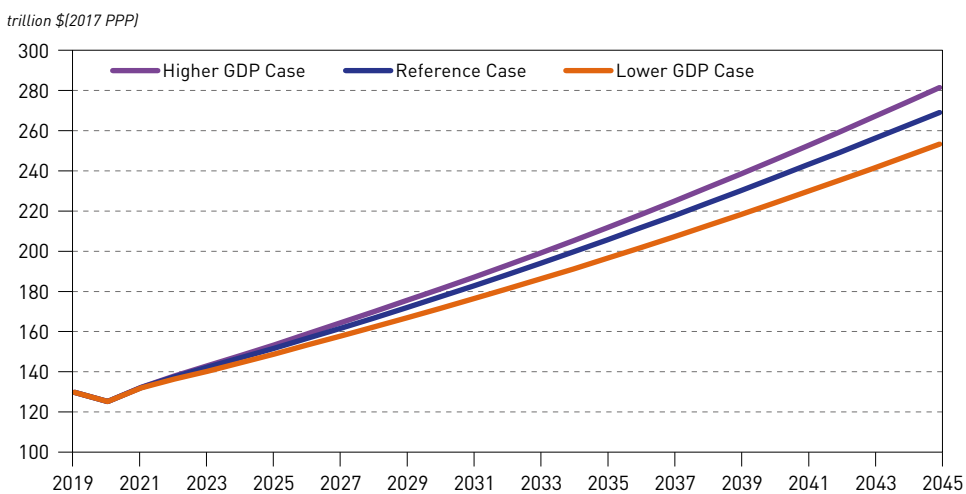
Source: OPEC.

the Reference Case. Moreover, these lower rates of around 3% p.a. are expected to persist for the rest of the medium-term. The gap in annual GDP growth rates to the Reference Case gradually narrows, but rates in the Lower GDP Case remain below those in the Reference Case for most of the forecast period.

A different pattern evolves in the Higher GDP Case. Generally, the difference in annual GDP growth rates between this case and the Reference Case is smaller, in the range of 0.1 to 0.4 pp during the forecast period. Moreover, this difference is relatively small in the initial years of the forecast period, while the gap widens gradually to around 0.4 pp in 2026. It then remains at this level for several years before returning to around 0.1 pp towards the end of the forecast period.

These differences appear to be marginal, but the cumulative effect at the global level during the entire medium-term period is significant (Figure 8.2). Indeed, the difference between the two alternative cases rises to around $5.6 trillion (2017 PPP) at the end of the medium-term period, which represents almost 4% of global economic activity by then. The difference compared to the Reference Case is higher for the Lower GDP Case, at more than $3.2 trillion (2017 PPP), while the comparable number for the Higher GDP Case is more than $2.3 trillion (2017 PPP).

Figure 8.2
Global GDP in the long-term, 2019–2045



Source: OPEC.

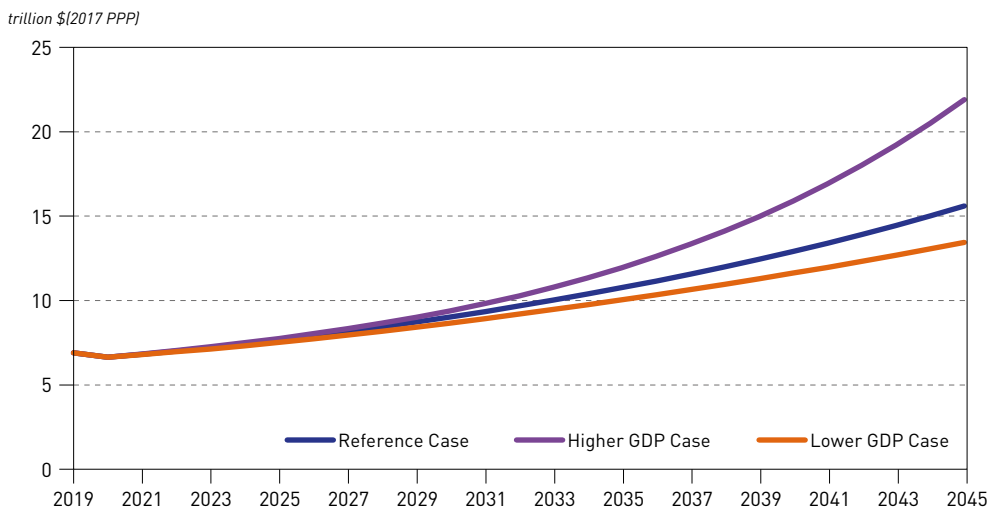
As already indicated by corresponding growth rates, this gap widens significantly over the long-term. The global GDP is projected to be above $280 trillion (2017 PPP) in the Higher GDP Case and around $253 trillion (2017 PPP) in the Lower GDP Case. This compares to almost $270 trillion (2017 PPP) in the Reference Case.

In the Higher GDP Case, Africa plays an important role in supporting stronger GDP growth in the long-term. Higher annual GDP growth rates in Africa will start emerging during the medium-term, but it will take time until these make a material difference in GDP levels. This, together with GDP levels in the other two considered cases, is presented in Figure 8.3. Therefore, the difference between these cases is relatively small during the current decade. However, this

changes after 2030, especially for the Higher GDP Case as annual growth rates in the region surpass 4% p.a. and continue expanding towards the level of 7% p.a. at the end of the forecast period.

In the Reference Case, Africa's GDP grows from less than $7 trillion (2017 PPP) in 2020 to around $9 trillion (2017 PPP) in 2030 and further to almost $16 trillion (2017 PPP) in 2045. This figure is projected to be more than $6 trillion (2017 PPP) higher in the Higher GDP Case reaching almost $22 trillion (2017 PPP).

Figure 8.3
Africa's GDP in the long-term, 2019–2045



Source: OPEC.

However, long-term impacts on Africa's GDP are estimated to be less pronounced under the Lower GDP Case. Because of its high growth potential, Africa is expected to remain resistant to downward pressure in this case with the region's GDP projected to decline by around $2 trillion (2017 PPP) compared to the Reference Case in 2045.

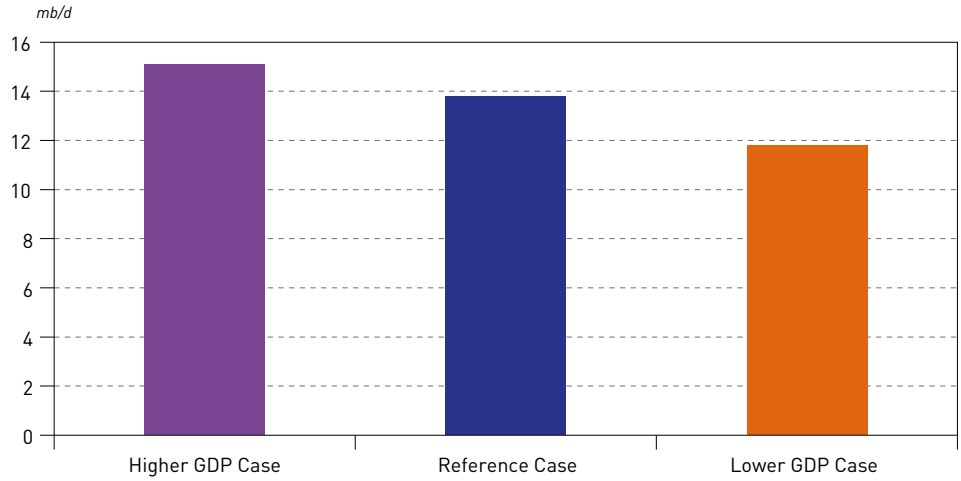
Implications for oil demand

Figures 8.4 and 8.5 present the summary of expected implications on future oil demand under the Higher and Lower GDP Cases. It is worth noting that these implications are assessed under an assumption that major policy measures in the alternative cases remain broadly similar to those outlined in the Reference Case. At the same time, however, issues like faster efficiency improvements under the Higher GDP Case and some demand rebound due to expected lower prices under the Lower GDP Case are reflected in projections.

On this basis, the gap between oil demand in the Reference Case and alternative cases evolves during the medium-term period and is skewed towards the Lower GDP Case. The difference between this case and the Reference Case is forecast to be in the range of 2 mb/d by 2026, while the corresponding number for the Higher GDP Case is 1.3 mb/d.

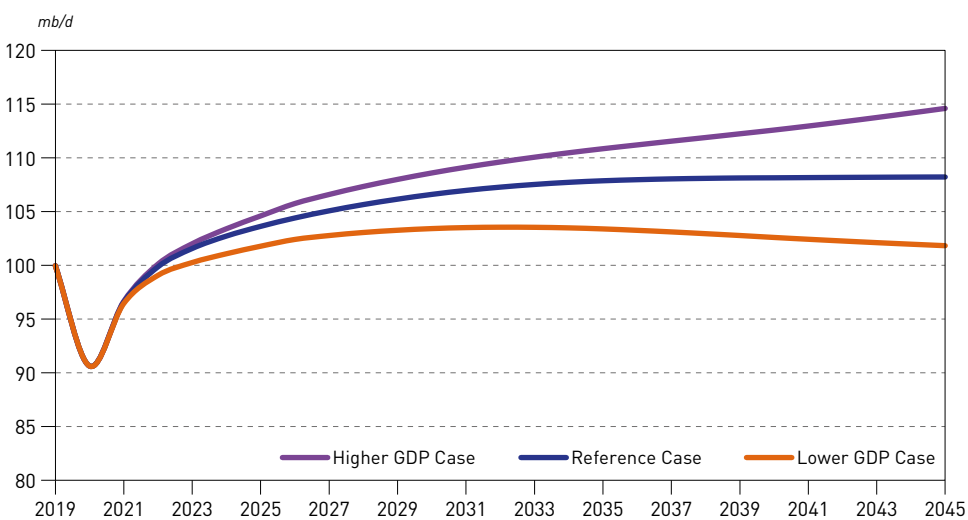
In the Higher GDP Case, long-term oil demand implications are much more pronounced as demand rises to almost 115 mb/d by 2045, which is more than 6 mb/d higher than the Reference

Figure 8.4
Incremental oil demand over the medium-term, 2020–2026



Source: OPEC.

Figure 8.5
Global oil demand in alternative cases, 2019–2045



Source: OPEC.

Case. Naturally, this mirrors the narrative of the case and the corresponding pattern for global GDP. Therefore, oil demand increases only slightly faster during the current decade and extends the difference by almost 2 mb/d in 2030. By then, around one-third of this difference is expected to be linked to the OECD, where oil demand will be on a declining trajectory, though at a slower pace than in the Reference Case (Table 8.1).

However, this temporary positive oil demand effect in the OECD due to faster GDP growth will be broadly offset in the long-term by the second-order effects in the higher GDP environment.

An example is that disposable incomes available to households would be greater in the Higher GDP Case, potentially stimulating a gradual shift towards a more efficient use of oil including, for instance, more energy-efficient household appliances; more cars with better fuel economy (including hybrids and EVs); better building insulation; and improved cooling systems. Furthermore, governments would likely be in a position to raise subsidies for clean-energy initiatives, while the private sector could invest more in advanced technologies and processes. The net effect would be a slowly diminishing gap between OECD oil demand in the Higher GDP and Reference Cases.

In contrast to the OECD, oil demand in the non-OECD regions is set to remain on a growth trajectory in the Higher GDP Case during the entire forecast period. The second-order effect of higher GDP will play a marginal role in non-OECD countries as it will apply to more advanced countries with higher GDP per capita only.

For many countries, including most countries in Africa, higher GDP will boost oil demand even higher than the corresponding change, *ceteris paribus*. In this case, oil products would be affordable to a larger part of the population and replace traditional fuels; car ownership would increase with the majority being ICE-based vehicles; and new industries and trade relationships would arise, thus providing support to oil demand. Projections indicate that under this scenario, oil demand in the non-OECD could be as high as 80 mb/d by 2045, more than 6 mb/d higher than in the Reference Case.

Table 8.1
OECD and non-OECD oil demand in alternative cases, 2019–2045

mb/d

	2019	2020	2025	2030	2035	2040	2045
OECD							
Higher GDP Case	47.7	42.1	46.7	44.6	41.3	37.6	34.3
Reference Case	47.7	42.1	46.3	44.0	40.8	37.3	34.2
Lower GDP Case	47.7	42.1	45.5	42.9	39.5	35.9	32.7
Non-OECD							
Higher GDP Case	52.3	48.6	57.9	64.0	69.5	74.9	80.3
Reference Case	52.3	48.6	57.3	62.6	67.1	70.8	74.1
Lower GDP Case	52.3	48.6	56.3	60.5	63.9	66.7	69.2

Source: OPEC.

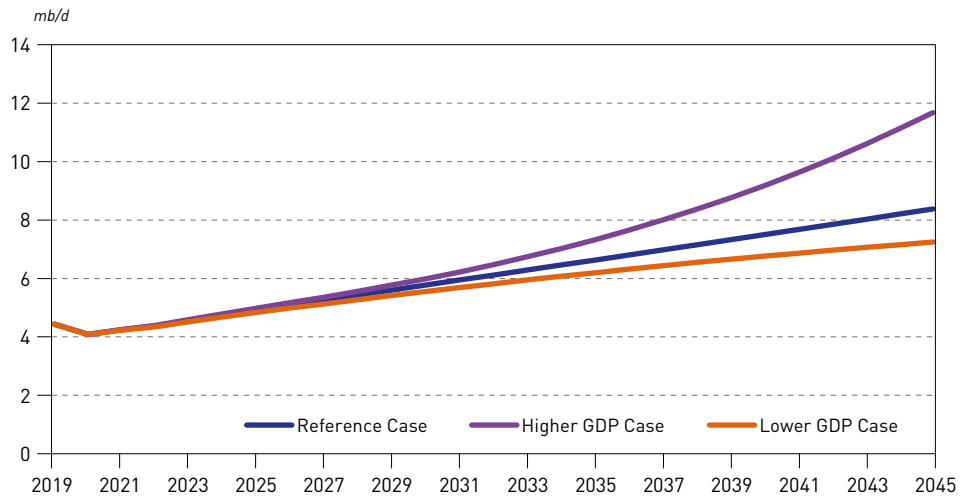
Around half of this demand increase in non-OECD countries is associated with Africa. Oil demand in this region declined slightly in 2020, to around 4 mb/d, on the back of the COVID-19 pandemic and the related global GDP decline. However, demand returned to growth territory in 2021 and, in the Reference Case, is projected to reach 5.1 mb/d by 2026 and 8.4 mb/d in 2045.

As presented in Figure 8.6, Africa's oil demand in the Higher GDP Case will grow to 5.2 mb/d in 2026, marginally higher than in the Reference Case. However, this difference will expand to 0.7 mb/d in 2035 and 3.3 mb/d in 2045. The bulk of this overall difference will take place during the last ten years of the forecast period when annual GDP growth in Africa will be in the range of 5.5% to 6.8% and demand will double compared to 2020. The combined effect of these two parameters will result in rapid oil demand growth, which is projected to reach 11.7 mb/d in 2045.

In contrast to the Higher GDP Case, Africa's oil demand will likely be much less affected in the Lower GDP Case. Oil demand in this case will be around 1.1 mb/d lower than in the Reference Case in 2045. This is because the GDP decline will be more widely spread across regions and

the counterbalancing effect of lower prices plays a much lesser role. Moreover, the GDP decline is more concentrated in other regions, such as OECD Americas, OECD Europe, India, China and Other Asia. Therefore, oil demand in these regions will also drop accordingly.

Figure 8.6
Oil demand in Africa in alternative cases, 2019–2045



Source: OPEC.

As presented in Table 8.1, the distinct pattern between the OECD and non-OECD is less pronounced. Differences to the Reference Case projections for these regions evolve almost in parity over the medium-term period, with both diverging by around 1 mb/d from the Reference Case. In the later years of the forecast period, these differences widen further for both regions, but the decline in non-OECD is significantly larger. Non-OECD demand is projected to reach 69.2 mb/d in 2045, which would be almost 5 mb/d lower than in the Reference Case. Corresponding figures for the OECD are expected at 32.7 mb/d in 2045, which is 1.5 mb/d lower compared to the Reference Case.

It needs to be emphasized that the implementation of any necessary production adjustments in response to reduced oil demand assumed in the Lower GDP Case would have a bearing, as these would affect the so-called 'marginal barrel'. The projections shown in Figure 8.5 and Table 8.1 presume only minimal impact on the structure of the marginal barrel, which in turn indicates only modestly lower oil prices and the related rebound effect on oil demand.

To conclude, there are two observations worth noting. With respect to economic uncertainties, the risk for oil demand over the medium-term is skewed towards downward revisions and primarily related to a potentially extended pandemic. Turning to the long-term prospects, the risk is rather symmetric, with each side deviating from the Reference Case by more than 6 mb/d at the end of the forecast period. The combined effect of these two alternative cases indicates that future oil demand could be in a broad range of almost 13 mb/d, anywhere between 102 mb/d and 115 mb/d. This is a clear sign of increased uncertainty for future oil demand.

8.2 Policy and technology uncertainties

Energy efficiency improvements have been long recognized as a key policy element aimed at reducing emissions. Typically, these policy measures include financial and fiscal instruments, such as energy audits, subsidies, loans, tax credits; direct regulations in the form of minimum

energy efficiency standards; building codes; various labels and certificates; and other measures such as voluntary agreements.

At the same time, energy efficiency is not just a matter of policies and regulations. It is also closely linked to technological developments. In fact, it is technology that provides the ways and means for the more efficient use of energy, whereas policies can support both technological progress and its accelerated implementation.

Considering oil demand specifically, an APT Case has been developed to assess the potential future oil demand implications if additional policy measures across all major consumption sectors were adopted, thus allowing (and supporting) the faster penetration of more efficient technology. It is important to note that this case does not assume any major technology breakthrough. It simply explores the potential for the faster penetration of existing technology that could be achieved at reasonable costs if adequate incentives are in place.

Road transportation is a central focus of policymakers due to the sector's large share in global oil demand, as well as the opportunity for potential fuel substitution and efficiency improvements. Fuel economy standards are in place in all major countries and serve as a key policy tool to drive efficiency improvements in this sector, while most countries follow either the Euro standards or the CAFE standards in the US. While the next Euro 7 standard is being prepared in the EU, the discussion has shifted to the intended deadline to discontinue selling ICE-based passenger cars in the region. Of course, this discussion is not limited to the EU. Similar measures with varying dates and specifics regarding types of vehicles are under consideration in many other countries.

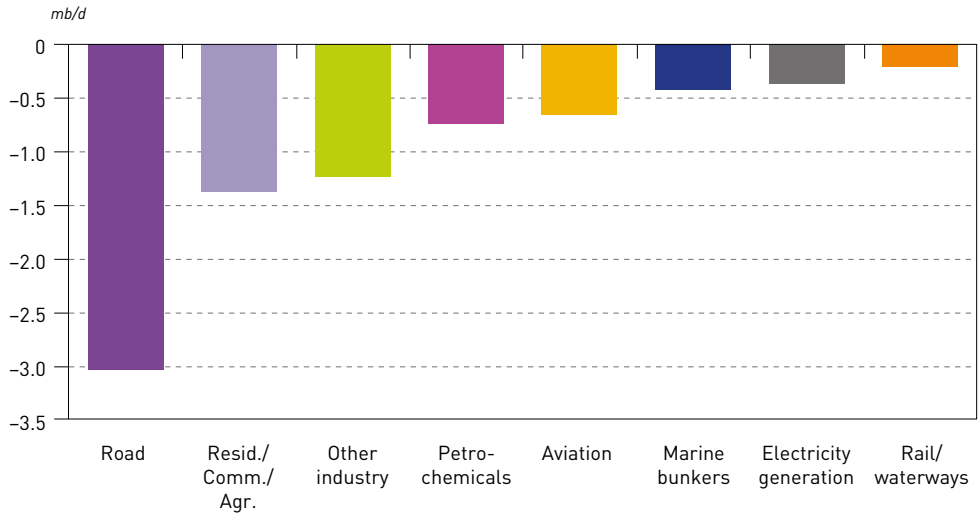
These discussions coincide with the maturing of technologies for AFVs, which has led to a rising number of EV sales in advanced economies, as well as in China. This is reflected in the Outlook's Reference Case projections, which assume a faster penetration of EVs compared to past Outlooks. The number of EVs is expected to surpass 100 million sometime around 2030 and reach almost 500 million in 2045. By then, they are expected to constitute almost 20% of the global vehicle fleet. This number rises to almost 25% if all AFVs are considered.

However, the majority of these AFVs will be concentrated in the three major demand regions – OECD Europe, OECD Americas and China. In the case of OECD Europe, the share of AFVs is set to be around 20% in 2030, 30% in 2035 and more than 50% in 2045. With this level of penetration assumed in the Reference Case, even if full electrification of the passenger car segment in OECD Europe is achieved by 2045, it would only result in the substitution of an additional 100 million of vehicles in the region. The APT Case goes beyond this level assuming that the number of EVs would approach 700 million at the end of the forecast period.

Similar to the Reference Case, the largest number of these additional AFVs in the APT Case is assumed to penetrate OECD markets, China, and to a lesser extent India and Other Asia. Moreover, ICE efficiency improvements will also contribute to reducing future oil demand. Although the Reference Case assumes rather ambitious fuel economy improvements, further potential exists in several areas. Therefore, the combined effect of fuel substitution and some tightening fuel efficiencies will be that oil demand in the road transportation sector could be further reduced by some 3 mb/d in 2045 compared to the Reference Case.

In addition to road transportation, as presented in Figure 8.7, significant potential for future demand reduction exists in other sectors. This is especially the case for the residential, commercial, agriculture and 'other industry' sectors mainly due to options for further oil substitution by electricity and natural gas. This transformation of the industry sector has been ongoing for some time, although its effect at the global level is broadly offset by growing industrialization in developing countries. Nevertheless, the expansion of emission trading systems and higher carbon prices could expedite the shift to gas and electricity.

Figure 8.7
Potential efficiency improvements and fuel subsitution in the APT Case by 2045



Source: OPEC.

In the residential and commercial sectors, electricity could play a key role in displacing oil from heating and cooking and supplementing it with natural gas wherever the gas network can be expanded. One example in this direction can be found in India with its City Gas Distribution (CGD) programme, which aims to improve access to natural gas, especially in larger cities. To a large extent, this programme is incorporated into the Reference Case. However, the faster implementation of the CGD and a widening of the areal coverage in India could further reduce oil demand, primarily LPG and kerosene.

Apart from fuel substitution, some demand reduction in these sectors could be achieved through more efficient technologies, such as low-temperature condensing boilers and heat recuperation, and better insulation. The combined effect of such measures and fuel substitution is estimated to reduce oil demand by 1 mb/d to 1.5 mb/d in each of these sectors.

In the petrochemical industry, the largest potential for reducing oil demand is through the enhanced recycling of plastics and chemicals. Some estimates indicate that less than 10% of produced plastics are recycled on a global scale despite the fact that virtually every country has a plan to improve recycling rates. Moreover, recycling (not only of plastics) is also one of the cornerstones of plans for the circular economy. Although the Reference Case assumes improvements in this respect, clearly there is room for further increasing the recycling rates of petrochemical products.

On the efficiency side, options for further improvements are quite limited since only a small portion of oil demand in this sector is used for energy. Nevertheless, more efficient catalysts, waste heat recovery and optimized heat exchangers and process control could lead to some demand reduction. Modelling exercises indicate that such reductions could be somewhere in the range of 0.7 mb/d in 2045, again compared to the Reference Case.

A similar oil demand reduction could also be achieved in the aviation sector. On the one hand, this is a sector with high growth potential, especially in terms of passenger and cargo traffic. Mirroring this expectation, aviation oil demand is set to grow by almost 6 mb/d in the Reference Case between 2020 and 2045.

On the other hand, it is also a sector with ambitious plans to improve energy efficiency and reduce emissions. The IATA has set two major targets to achieve carbon neutral growth and to reduce net aviation CO_2 emissions by 50% by 2050, relative to 2005 levels. Clearly, fuel economy is an important part of this plan with direct implications for future oil demand. Another component of the plan is the substitution of jet kerosene with sustainable aviation fuels, which potentially could have far-reaching implications for oil-based products in this industry depending on how these are produced.

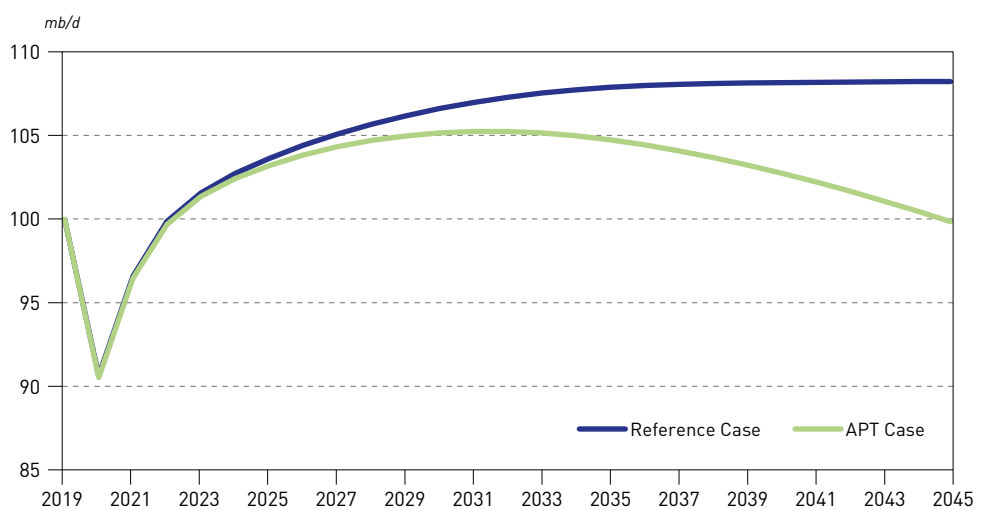
As presented in Figure 8.7, there is much lower potential for additional demand reduction in the remaining sectors – namely the marine sector, rail and domestic waterways, and power generation – and this is especially true with respect to potential efficiency improvements. Oil in these sectors is mainly used in medium or large reciprocating engines with a potential for future improvements mainly limited to the waste heat recovery, which would require significant investment.

Therefore, the larger potential relates to oil substitution. In the marine sector, the highest uncertainty relates to the rate of progress in the penetration of LNG-based vessels. Ship owners appear to be increasingly interested in the use of ammonia and hydrogen. However, it is unlikely that these fuels would replace a significant part of oil demand within the forecast period.

In rail and domestic waterways, the main risk stems from electrification and the use of LNG in domestic waterways. Finally, oil use for electricity generation is already at relatively low levels and is declining due to competition from gas and renewable electricity. Nevertheless, the faster displacement of oil in this sector, compared to the one assumed in the Reference Case, is still possible.

Figure 8.8 presents the cumulative effect of possible developments in various consumption sectors under the APT Case over the forecast period. At the global level, oil demand in this case is projected to reach 103.8 mb/d in 2026, just 0.5 mb/d lower than in the Reference Case as the implementation of new policies and the penetration of more efficient technologies require some time to have a material impact. Even by 2030, oil demand in the APT case is projected to be only 1.4 mb/d lower than in the Reference Case.

Figure 8.8
Demand in the Reference Case and APT Case, 2019–2045



Source: OPEC.

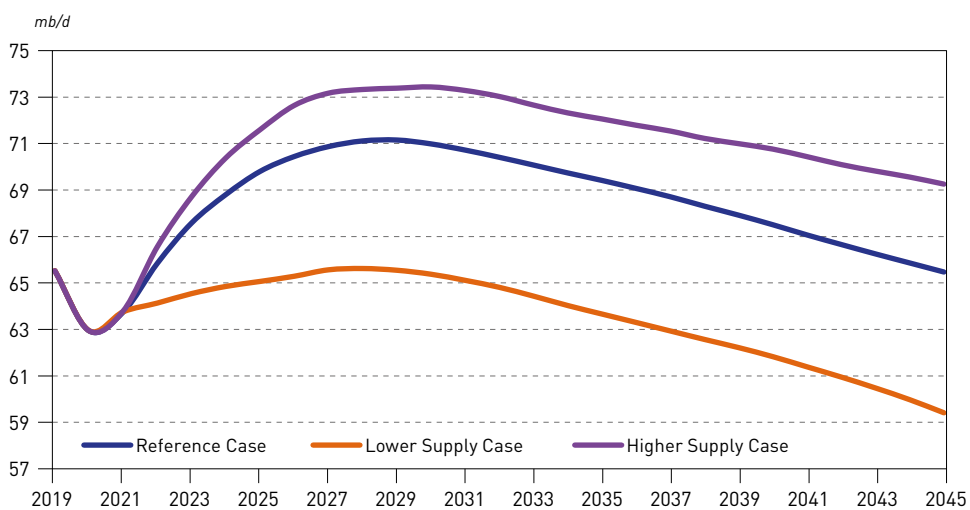
The impact of technology and policies will be much more pronounced in the second part of the forecast period. Indeed, the gap between the two cases widens to more than 5 mb/d in 2040 and further to 8 mb/d in 2045 when demand in the APT Case falls below 100 mb/d.

8.3 Oil supply uncertainties

Similar to the demand side, there are naturally also considerable uncertainties related to the oil supply side of the equation, as highlighted in previous WOOs. These uncertainties can be divided both in terms of time horizon – in the medium-term, the focus is rather on post-pandemic recovery, and how resulting macroeconomic developments determine the oil market fundamentals and related balances. In turn, oil producers' and investors' perceptions of these factors determine the outlook for upstream investment.

In the longer-term, while the global economy and fundamentals also play a role, uncertainties rather relate to policy choices, including decisions with a more specific, if not immediate impact, such as drilling bans, pipeline cancellations and the like. Moreover, the implications of the gradual and increasingly widespread push towards the greater use of renewable energy sources – what is often referred to as the energy transition – will become increasingly relevant. Closely related to this is the potential impact of breakthroughs due to advancements in technology, and the related cost reductions.

Figure 8.9
Long-term non-OPEC supply sensitivities



Source: OPEC.

Another differentiation runs between US tight oil and other sources of non-OPEC liquids supply. The former is clearly one of the most price-sensitive supply components, and by its nature can respond more quickly to underlying changes in fundamentals, policy and technology – as seen for instance in the market downswing in 2014–2015, and a resulting decline in US tight oil in 2016.

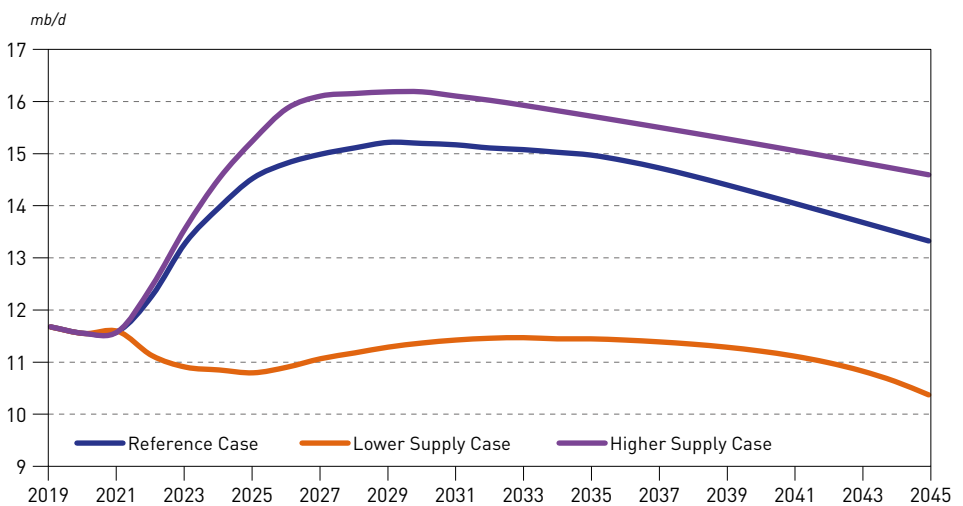
Thus, the sensitivity modelling underpinning the cases shown here indicates that US tight oil responds more quickly than other non-OPEC supply, and, therefore, has a greater impact on the medium-term outlook. Moreover, US tight oil is seen to be significantly more responsive in the Lower Supply Case, providing much more downside in the medium- and long-term. Conversely,

the relative significance of the cumulative impact on sensitivity modelling for other non-OPEC production sources is of greater significance in the long-term.

According to the sensitivity modelling, this results in potential upside and downside for non-OPEC supply in a range of nearly 7.5 mb/d in the medium-term and, given cumulative effects, nearly 10 mb/d by 2045. Importantly, the uncertainly is heavily skewed to the downside, with the potential shortfall in supply roughly double that of the potential upside (Figure 8.9). Naturally, any such alternative outcomes to the Reference Case would have significant implications for oil market balances.

In the Lower Supply Case, the main shortfall in oil production in the medium-term is expected to be seen in US tight oil (Figure 8.10). Here, the assumption is that output declines rather than recovers in the next couple of years, as producers remain cautious or unable to invest in further growth and prefer to continue to return funds to investors. Access to capital is also assumed to become more difficult, with lenders increasingly hesitant to provide funding to what is seen to be risky and/or environmentally sensitive upstream enterprises. Additionally, policies adopted by the current US administration gain traction, including at least a partial ban on drilling and new lease sales on federal lands, and possibly some tightening of environmental measures, including, for instance, methane emissions.

Figure 8.10
Long-term US tight oil sensitivities

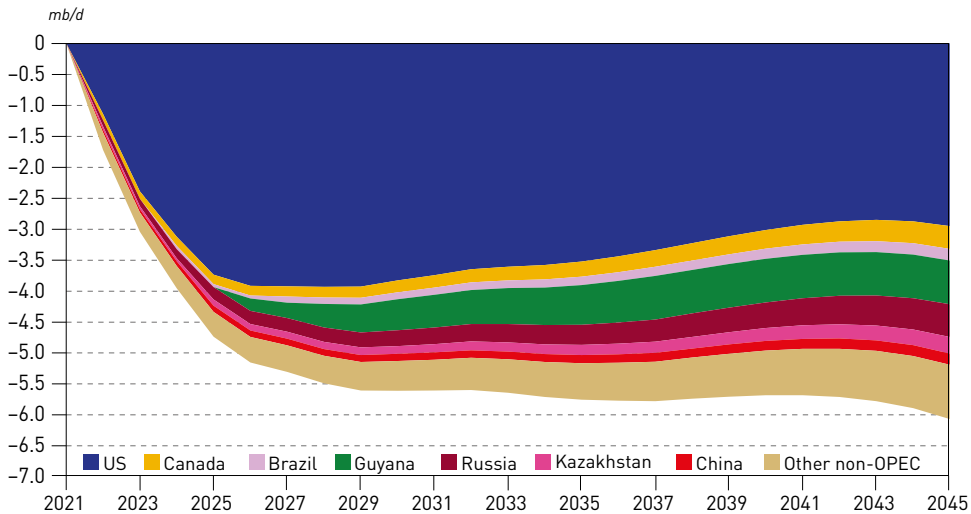


Source: OPEC.

More generally, a prolonged macroeconomic recovery from the pandemic, assuming further waves of lockdowns, disruptions to supply chains, and as a result weaker oil demand, would give rise to deteriorating market fundamentals.

Oil supply in other non-OPEC countries would be affected more modestly in the medium-term, as upstream projects already under development are assumed to go ahead, including notably some of the larger fields in Brazil, Guyana and Norway, among others. Here too, however, some of the more marginal and smaller upstream additions are assumed to be cancelled due to uncertainty about the economics, leading to further underinvestment and lower supply (Figure 8.11).

Figure 8.11
Non-OPEC liquids supply in the Lower Supply Case: deviation from the Reference Case



Source: OPEC.

Beyond the medium-term, US tight oil is assumed to show a partial recovery in the latter part of the 2020s, in response to tightened fundamentals in the previous period, as supply falls short. However, US tight oil supply never again quite reaches pre-pandemic production levels of 11.7 mb/d seen in 2019. Production is sustained at a longer plateau than in the Reference Case, due to slower resource depletion. However, output also slows gradually from the late 2030s, declining to 10.4 mb/d by 2045.

In other non-OPEC countries, by contrast, the cumulative effect of lower investment, less E&P activity, and fewer new upstream projects being signed off, means that the potential downside to supply expands over time.

For instance, the Lower Supply Case assumes that beyond the first 3–4 projects already underway in Guyana (or very likely to go ahead; plus a bit of organic growth), no new phases are signed off, capping capacity at around 0.7 mb/d. Incremental capacity additions from Canadian oil sands come to a halt. Russian supply peaks around 2030, as longer-term, large new developments such as the potentially massive Vostok Oil project essentially never really take off, and other, frontier Arctic developments, or deepwater Caspian, never materialize. Elsewhere, further growth assumed in the Reference Case, such as in Brazil or Kazakhstan, is capped from around 2025–2030.

Moreover, policy implications of decisions related to ESG concerns affect investment sentiment, as do moves towards boosting the use of renewable energy sources. Any specific measures, such as widespread CO_2 taxes, or even stricter regulations on emissions and other production-related processes, would inevitably raise production costs, thereby potentially making some assets unprofitable to develop and off-limits.

In sum, in the Lower Supply Case, total non-OPEC liquids is forecast to increase from the 2020 baseline of 62.9 mb/d to 65.2 mb/d in 2026, slightly lower than the pre-pandemic average of 65.5 mb/d in 2019. After 2026, liquids supply would only increase very marginally to a plateau around 65.5 mb/d in the latter part of the 2020s, before declining again to reach 59.3 mb/d in 2045.

In the Higher Supply Case, the US tight oil outlook is for only relatively modest upside compared to the Reference Case in the initial years of the medium-term period. The assumption is that

there is limited potential for upside (relative to the recovery trajectory projected in the Reference Case, which assumes a healthy 1.7 mb/d cumulative increase in 2022/2023) even if market fundamentals and producers' appetite for investments were supportive.

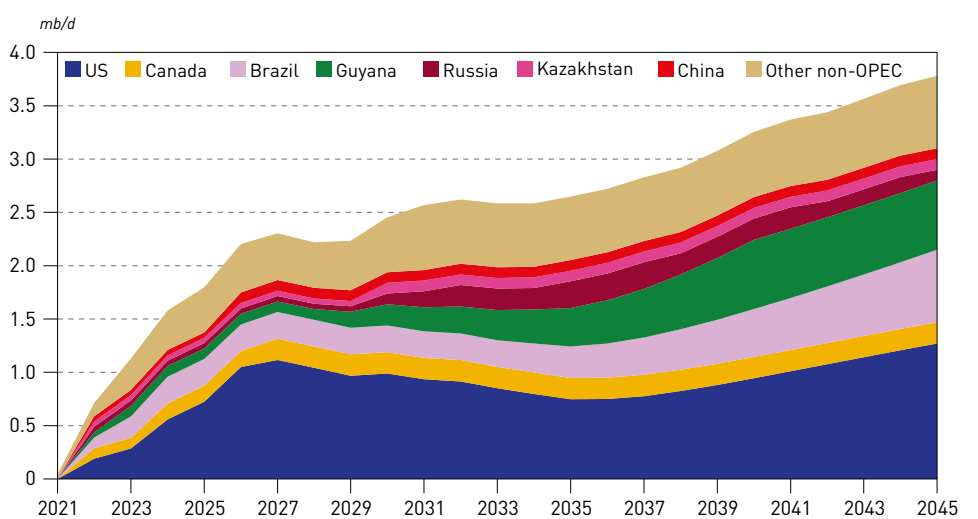
Thus in 2022/2023, upside is for some 200–300 tb/d. Only by 2024 does the higher production level relative to the Reference Case rise to 0.6 mb/d, before increasing to a more significant 1 mb/d by 2026, or 15.9 mb/d in absolute terms. This trajectory assumes that there are no obstacles to significant investment into the US upstream, with market fundamentals such that producers can both return money to investors and still have ample funds to reinvest.

With regard to other non-OPEC supply, this has the potential to pick up more quickly. All remaining non-OPEC shut-in volumes are returned; upstream projects already underway are developed without delays, as market fundamentals are supportive; incentives to increase investment are put in place in key producing areas; and additional capacity increments are put on the drawing board. By 2024, upside potential is thus already 1 mb/d, and by 2026 it is at 1.15 mb/d, resulting in non-OPEC liquids supply of 72.6 mb/d.

Looking to the long-term, US tight oil remains at a plateau of just over 16 mb/d, or around 1 mb/d higher than the Reference Case, until the end of the decade. From the mid-2030s, output declines again, to reach 14.6 mb/d in 2045. However, compared to the Reference Case trajectory, the decline takes place at a slower pace, as technology advances are assumed to keep production break-evens low, ultimately unlocking more resources. Investment flows are ample and sufficient to sustain these higher production levels.

In other non-OPEC producers, the cumulative supply upside relative to the Reference Case rises from 1.2 mb/d in 2026 to 2.5 mb/d in 2045 (Figure 8.12). Those producers already expected to provide most of the incremental Reference Case supply, such as Brazil, Guyana and Kazakhstan, are assumed to bring on additional projects. Guyana's total output, for example, is assumed to ultimately reach a higher 2 mb/d, or around 50% above that in the Reference Case, as additional fields are developed. Brazil meanwhile hits 6 mb/d in the long-term.

Figure 8.12
Non-OPEC liquids supply in the Higher Supply Case: deviation from the Reference Case



Source: OPEC.

Norway, while not actually increasing its production after a medium-term peak, manages to successfully slow its decline in the Higher Supply Case through a host of tie-backs and additional drilling. Countries with significant tight oil potential, such as Argentina, are seen to boost output. In Mexico too, onshore unconventional resources are finally developed in a meaningful way, and deepwater provinces are opened up. Russia is also assumed to put in place comprehensive tax breaks that incentivizes a full development of new areas, including the large and ambitious Vostok Oil project and perhaps other frontier areas.

In absolute terms, this results in the Higher Supply Case for non-OPEC liquids expanding from 62.9 mb/d in 2020, to 72.6 mb/d in 2026, then to a peak of 73.4 mb/d around 2030, before declining again to 69.2 mb/d in 2045.

Focus on India

Key takeaways

- India's population will continue to expand and is expected to reach 1.62 billion by 2045, adding around 241 million over the forecast period.
- India is forecast to continue growing at above 6% p.a. over the next one-and-a-half decades. As a result of this impressive growth, India will account for almost 14.4% of global GDP in 2045.
- Energy demand in India is set to more than double between 2020 and 2045 reaching a level of 38 mboe/d by 2045.
- Oil is expected to constitute 28.6% of India's primary energy mix in 2045, an increase of more than 3 pp compared to 2020.
- Over the projection period, other renewables (especially solar and wind) have the highest growth rate of 11% p.a., aided by the Indian government's policy and vision towards cleaner and sustainable energy.
- India has an ambitious objective to reach 63 GW of nuclear power capacity by 2032, a multi-fold increase compared to the current installed capacity of around 7 GW.
- India accounts for around 18% of the world's population, but uses only around 7% of the world's primary energy. India's per capita energy consumption equates to 4.7 boe, compared to the global per capita average of 13.2 boe.
- Oil demand in India is projected to reach 11 mb/d in 2045.
- India's oil demand growth will be led by road transportation followed by the residential, commercial and agriculture sectors.
- Diesel/gasoil and gasoline are expected to contribute almost two thirds of India's oil demand growth over the forecast period.
- The goal of India's hydrocarbon policies has been to undertake a full appraisal of all possible producing regions, including deep-sea offshore areas, with a view to tapping its full potential.
- India's total liquids supply is projected to reach 0.8 mb/d in 2026 and then drop slightly to 0.7 mb/d in 2045.
- India's refining sector has grown rapidly since 2000, keeping pace with oil demand growth.
- Cumulative potential refining capacity in India reaches a level of 6.1 mb/d by 2026, which is equal to the cumulative required capacity in the same year. This means that India's capacity expansion is fully justified by the oil demand outlook.
- Considering the ambitions of India's downstream sector to maintain its strong position in the international downstream market through product exports, higher capacity expansions would be required.

9.1 Population and demographics

India is the second-most populous country in the world, with a population of more than 1.38 billion. It is projected that India's population will continue to grow and reach 1.62 billion by 2045, adding around 241 million to the world population during the period 2020–2045. This population growth is quite remarkable and follows an addition of 416 million people over the previous 25-year period from 1995–2020. To put this in further context, China's population over the next 25 years is projected to remain fairly stable at a level of about 1.45 billion. These trends will mean that, during the current decade, India is projected to surpass China to become the world's most populous nation, crossing the 1.5 billion mark. With approximately half of its population below the age of 25, India is also a young nation.

While China's working population is projected to decline in the coming decades, India's working population is expected to increase over the same period. By 2045, India is expected to have more than 1.1 billion working age people in the country. This rise reflects an increase of 179 million compared with the 2020 level of 928 million. Even today, 20% of the world's working population are in India.

This growth is based on improved health facilities that has led to low infant mortality and higher life expectancy. However, it should be noted that government efforts and increasing education levels, especially among women, are slowing population growth. As a result, most Indian states should reach replacement fertility levels of 2.1 children per woman in the near future. According to government estimates, the fertility rate in the country's 22 major states is already at 2.2, and in urban areas the rate has fallen below the replacement level to only 1.7 children per woman. (The replacement fertility level is the number of children born per woman so that one generation exactly replaces the preceding one.)

India's population is expected to peak in around 2060 at about 1.65 billion and then start tapering, with expectations for a decline to 1.45 billion by the end of this century. This will be the

Box 9.1

India's Census 2021

India conducts its census every 10 years with the next one due in 2021. The 2021 census is the 16th the country has undertaken and the 8th since independence, and for the first time it will be a 'digital census' with a mobile app used to collect data. The use of new technology will make census data more quickly available to policymakers. This year's census will be the world's largest enumeration exercise. India's previous census was carried out in 2011, when the country's population stood at 1.21 billion.

The enormity of the exercise can be gauged by the fact that a total of 3.3 million enumerators – persons who conduct door-to-door counting – will be mobilized for data collection. The exercise will be done in 16 languages to facilitate the proper filing of accurate details.

The exercise will be conducted in two phases – House Listing and Housing Census and Population Enumeration. The government has allocated Rs 3,768 crore ($490 million) for the census in the budget. The census will not only count people, but also undertake a comprehensive demographic study. Thirty-one questions will be asked, including questions on energy usage and shifts to cleaner energy.

outcome of faster urbanization and improving education levels, as a result of progressive government policies.

Status of urbanization in India

Urbanization represents a social transformation from traditional rural societies to modern urban communities. In India, there is a long tradition of urbanization dating back 5,000 years, when the Indus Valley civilization saw one of the earliest urban settlements in human history. Urbanization is not just an indicator of societal development, but key to population management. Countries and societies with higher urbanization rates, along with better education and health care, have lower fertility rates and often better standards of living for their population. India's regional population statistics confirm this. The states with the highest fertility rates – Bihar, Uttar Pradesh, Jharkhand, Rajasthan and Madhya Pradesh – are less urbanized. Fertility rate declines have been significant in India's urban areas, where both parents are educated, and the age for marriage has risen.

There are approximately 3,700 urban local bodies with 100 corporations, 1,500 municipal councils and 2,100 Nagar panchayats (Notified Area Councils), besides 56 cantonment boards (under the Ministry of Defence) in India. The country is home to many of the world's most populous cities, making India the place with the largest urban agglomerations globally, although its overall urbanization, until recently, has been building slowly. Only around 34% of India's population lives in urban areas, a significantly lower figure than in other developing countries. For example, urbanization levels reach up to 50% in China.

With many policy interventions in recent years, urbanization is set to rise considerably in the coming decades. To promote urbanization at a faster pace, the government started the 'Smart Cities Mission' initiatives for 100 cities in 2015. There are various other schemes for the poor like the flagship Pradhan Mantri Awas Yojana – Urban (Prime Minister Residence Scheme - Urban) – to promote and provide housing for the urban poor. The scheme addresses the urban housing shortage among indigent categories of city dwellers, including slum dwellers, by ensuring a 'pucca' (permanent) house is available to all eligible urban households by 2022, when the nation reaches 75 years of independence.

The government has also initiated affordable rental housing complexes, on the back of the reverse migration of many urban migrants due to the COVID-19 pandemic. This initiative will make it easier for urban migrants and the poor in the industrial sector, as well as in the non-formal urban economy, to have access to dignified and affordable rental housing close to workplaces. Various other programmes also aim to improve urbanization. The urbanization momentum is projected to pick up, with many large cities also adapting rapid transport metro systems as part of the development of high-quality, inter-city expressways.

Demographic dividend in India

India is a young country with a large working age population that is set to grow further in the coming decades. This gives the country an edge over other developing and developed nations, where this advantage is now declining in comparison. This demographic dividend can help accelerate the pace of economic growth and the country's demographic profile is subject to growth through five distinct forces.

The demographic advantage began for India in recent years and is projected to last for the next four decades, translating into the world's largest labour force to support its development. The demographic advantage does not only come from a gradual population rise, but also through more women joining the workforce. The large workforce is supported by improving health and education infrastructure, as well as technological innovation.

The Indian government is aware of this enormous advantage and is keen to provide the best demographic dividend. Launched in 2015, 'Skill India Mission' aims to identify and enable a strong skill development system. Skill enhancement and training for the acquisition of these skills is the focus of educational and employment programmes. Moreover, there are other programmes that support entrepreneur skills through start-up initiatives to create self-employment opportunities and employment for others.

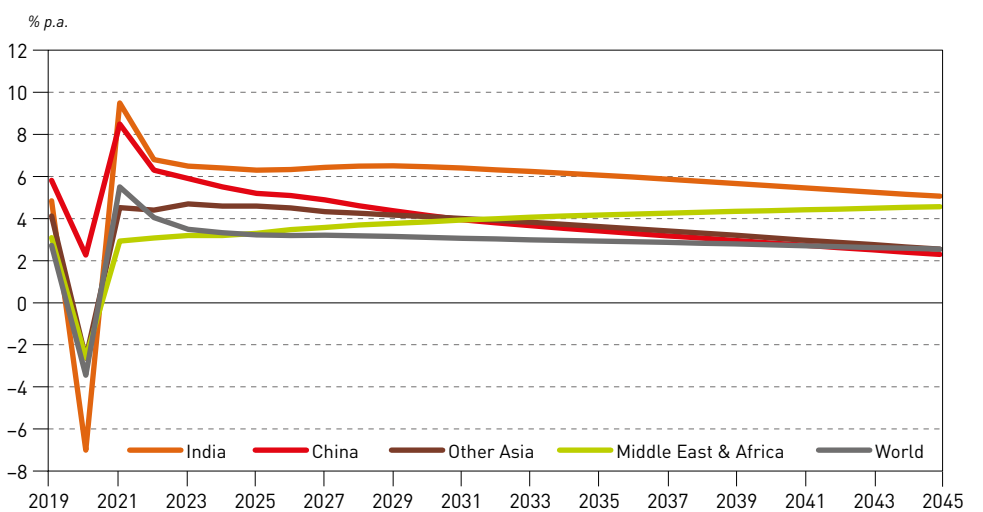
9.2 Economic developments

The Indian economy is notable for its resilience. In the past, India was able to resist downturns and recover quickly. All economic projections show confidence about its prospects to accomplish nearly double-digit growth among major economies in 2021. This does not only offset precipitated COVID-19 losses from last year, but puts the country in a net gain position.

The Ministry of Finance's 'Economic Survey 2021' notes that, learning from the Spanish flu experience, India implemented an early and stringent lockdown from late March to May 2020 to curb the pace of the spread of COVID-19. With the economy brought to a standstill for two months, the inevitable effect was a 23.9% GDP contraction compared with the previous year's second quarter. This contraction was consistent with the stringency of the lockdown. This economic suffering came at the comparatively better and much praised management of the first wave of the pandemic. The Indian economy showed early signs of recovery with a modest 0.4% growth in the 4Q20 and 1.6 % in the following quarter (January-March) of 2021.

As further detailed in the 'Economic Survey 2021', the fiscal policy response of the Indian government to the pandemic was strategized using a step-by-step approach. During the first two quarters of the 2020–2021 fiscal year, the government ensured that funds for essential activities were available despite a sharp contraction in revenue receipts. The initial approach was to provide a cushion for the poorer sections of society and the business sector (especially medium and small enterprises) to tide over the distress caused by the economic disruption.

Figure 9.1
GDP growth rates in selected regions



Source: OPEC.

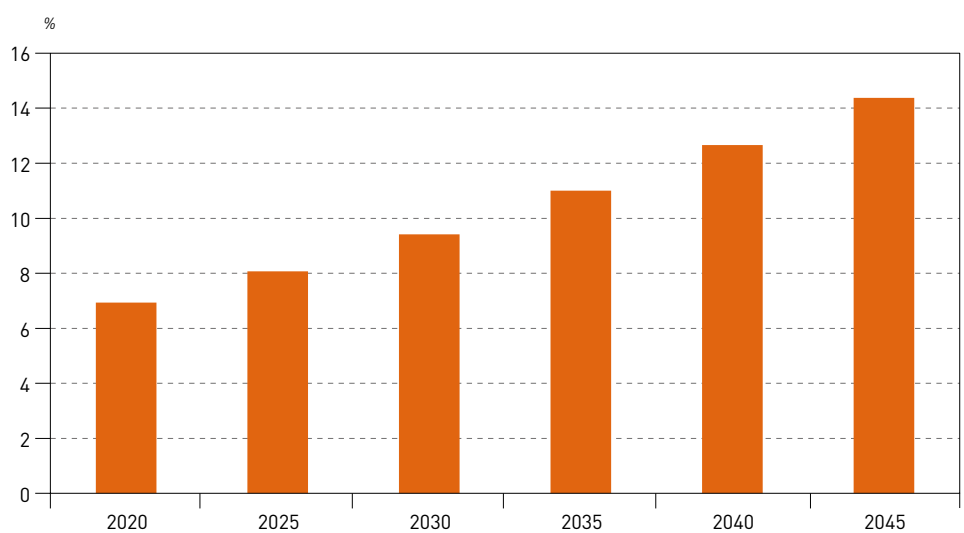
This included government measures such as the Pradhan Mantri Garib Kalyan Yojana (PMGKY) scheme for ensuring food security through the public distribution system, with direct benefit transfers to widows, pensioners and women, additional funds for the Mahatma Gandhi National Rural Employment Guarantee Scheme and debt moratoria and liquidity support for businesses. With the easing of mobility and health-related restrictions in the third quarter, the government transited in a calibrated fashion to support investment and consumption demand. The economic recovery has gained momentum since the 1Q21. Unfortunately, the second COVID-19 wave, including virus mutations, struck India hard at a time when the economy was looking for upside momentum in all sectors ranging from manufacturing to tourism.

In June 2021, India's Finance Minister announced a slew of measures to provide relief to diverse sectors affected by the second wave of the COVID-19 pandemic. The measures announced were also aimed to prepare the health system for emergency response and provide impetus for growth and employment. A total of 17 measures amounting to $84 billion were announced. Most of these schemes focused on providing economic relief to people and businesses affected by the pandemic.

There has been a special focus on health and reviving the travel and tourism sectors. Earlier, the country's Union Budget had evidently energized the Indian economy through various short-, medium- and long-term measures. The 2021–2022 budget targeted capital expenditure for the fiscal year 2022 at $75.81 billion, an increase of 34.5% over the previous fiscal year. Higher government expenditure, along with proactive encouragement and policy support, will help boost the economy.

Despite these setbacks, India is expected to grow at almost double-digit figures of 9.5% in 2021 against the world average of 5.5%. Beyond this, as presented in Figure 9.1, India is expected to continue growing at above 6% over the next one-and-a-half decades, while other developing countries will hover around 3–4%. India's economic growth rate will continue to be above global GDP growth rates by a margin of more than 2% until 2045. As a result of this impressive growth, India is set to account for almost 14.4% of global GDP in 2045 (Figure 9.2).

Figure 9.2
Share of India's economy in global GDP



Source: OPEC.

Vaccine for the economy

While India has announced various stimulus packages to support the economy, it recognizes that the COVID-19 vaccination is crucial to reinvigorating the engines of economic growth. Accordingly, the government announced a new policy for a fresh phase of universal COVID-19 vaccinations starting on 21 June 2021. India has shifted to the centralized procurement of vaccines, realizing the need to accelerate vaccinations. As per India's demographic distribution, 865 million people, or 63.1% of the population, is above 18 years of age. Assuming herd immunity at 80%, the population to be vaccinated is around 700 million. The focus is on the use of technology to ease vaccine administration to enhance faster coverage. In fact, India's vaccine management portal 'CoWin' has found favours from various countries that are also keen to use it. The desire of India to help the world community is an extension of its earlier Vaccine Maitri to provide COVID-19 vaccines to more than 90 countries around the world.

9.3 Primary energy demand

India is the third-largest energy consumer in the world and its primary energy demand is poised to grow at an average rate of 3.1% p.a. over the period 2020–2045 (Table 9.1), compared with a 0.9% p.a. average global growth rate. India's primary energy demand more than doubled from 2000–2019, before slowing temporarily in 2020 due to the impact of the COVID-19 pandemic. India's energy demand is already expected to reach a pre-pandemic high in 2021 and will continue its growth trajectory throughout the projection period. India's per capita energy consumption is expected to almost double from 4.65 boe in 2020 to 8.56 boe in 2045, on the back of the fastest-growing major economy.

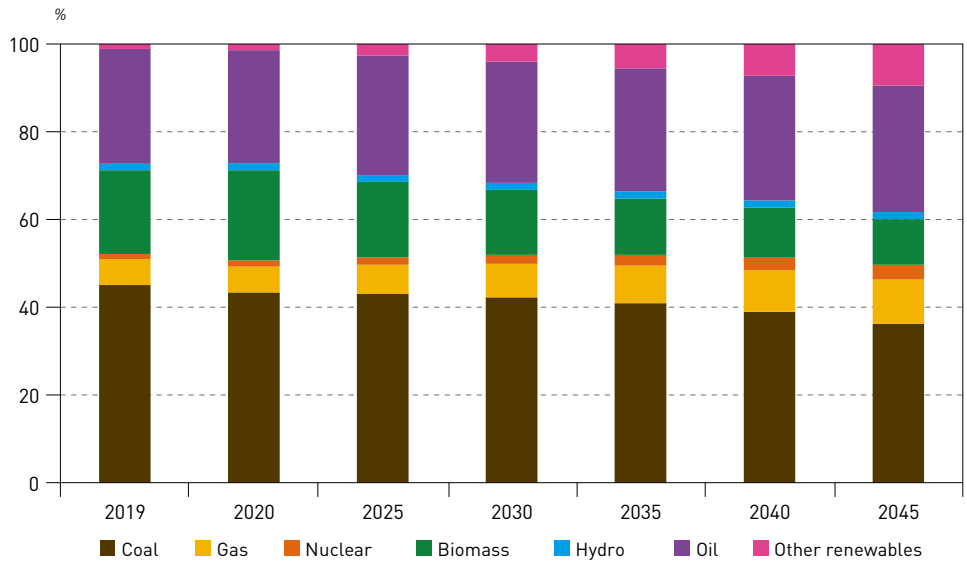
Table 9.1
India primary energy demand by fuel type, 2020–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Fuel share *%*	
	2020	2025	2030	2035	2040	2045	2020–2045	2020–2045	2020	2045
Oil	4.4	5.8	7.1	8.4	9.7	10.8	6.4	3.7	25.2	28.6
Coal	7.6	9.4	10.9	12.4	13.4	13.8	6.1	2.4	43.7	36.3
Gas	1.0	1.5	2.0	2.6	3.2	3.8	2.8	5.4	5.9	10.1
Nuclear	0.2	0.4	0.5	0.8	1.0	1.3	1.0	6.8	1.4	3.4
Hydro	0.3	0.4	0.4	0.5	0.5	0.6	0.3	3.0	1.6	1.6
Biomass	3.6	3.7	3.8	3.9	3.9	4.0	0.3	0.4	20.7	10.4
Other renewables	0.3	0.6	1.0	1.7	2.5	3.6	3.4	11.1	1.5	9.6
Total	**17.5**	**21.7**	**25.8**	**30.3**	**34.3**	**37.9**	**20.4**	**3.1**	**100.0**	**100.0**

Source: OPEC.

Looking at India's energy mix (Figure 9.3), the highest growth rate between 2020 and 2045 of just over 11% will be for other renewables, in line with the emphasis on efforts related to reducing carbon emissions and increasing 'green' energy. The share of coal in primary energy demand is expected to come down from the existing level of 43.5% to 36.3% in 2045, but it would still be the highest level of all energy sources by 2045. Oil is expected to constitute 28.6% in the primary energy mix in 2045, an increase of more than 3 pp compared to 2020.

Figure 9.3
Structure of the energy mix in India



Source: OPEC.

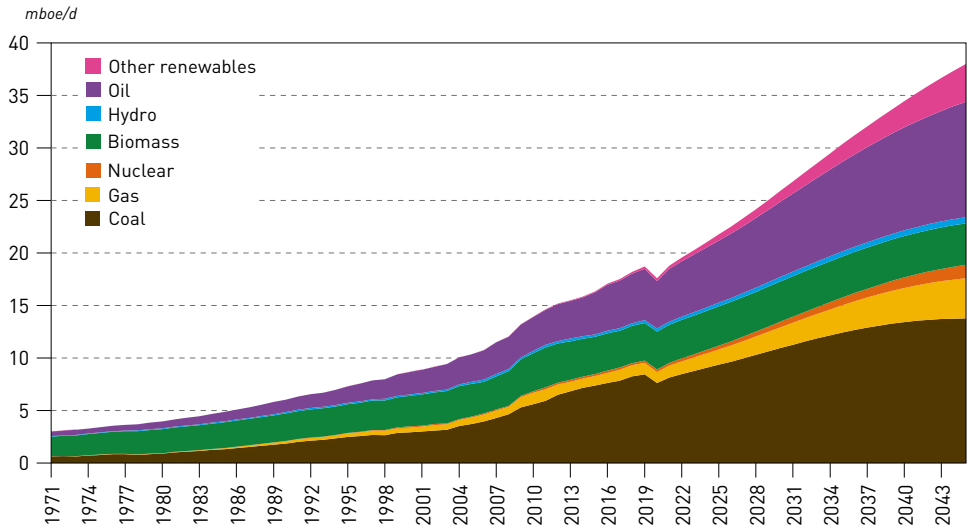
Biomass currently provides more than 20% of India's energy demand, but that is set to drop to about 10% in 2045 due to the various policy interventions of the Indian government. Currently, India's energy mix is primarily dominated by fossil fuels which contribute 75% of India's energy demand. This level is expected to be the same in 2045, with natural gas increasing from around a 6% share to over 10% by 2045.

Overall, the Indian government's ambitious push towards clean energy will increase the share of other renewables from around 1% in 2019 to almost 10% in 2045. By comparison, during the 2000–2019 period, Indian energy demand growth was led by coal and oil, which accounted for more than 80% of new energy demand. In contrast, during the 2020–2045 period, energy sources other than oil and coal will increasingly play a significant role, accounting for nearly 40% of the energy demand growth.

The average growth rate of India's total primary energy demand has increased from 2.8% in last year's WOO projections (2019–2045) to 3.1% in the current projections (2020–2045). However, total energy demand in 2045 has dropped to 38 mboe/d in the current projection from the last year's estimate of 38.8 mboe/d. This is explained by a lower base in 2020 of 17.6 mboe/d due to the impact of the COVID-19 pandemic on primary energy demand during the two waves. India's energy demand by fuel can be viewed in Figure 9.4.

Supply chain disruptions caused by the COVID-19 pandemic further accelerated the adoption of non-fossil fuels. In the WOO 2020, it was estimated that coal would have a share of 42.7% in the Indian energy mix by 2045, but this has now been revised down to 36.2%, albeit still largest contributor to India' energy mix throughout the outlook period. Nevertheless, coal's average annual demand growth is estimated at 2.4%, much slower relative to most other fuels in the mix. Coal is mainly used by three sectors in India – electricity generation, cement production and the iron and steel industry. These three sectors are key drivers of India's economic growth. At the same time, growth in coal consumption will be moderated due to climate commitments made by India, within

Figure 9.4
Primary energy demand in India



Source: OPEC.

the framework of the Paris Agreement, environmental issues, and the declining costs of renewables, such as solar PV.

The Indian Central Electricity Authority prepares the country's National Electricity Plan in accordance with the National Electricity Policy. The 2018 Plan outlines that 23 GW of coal-fired capacity is set to retire during the 2017–2022 period and another 26 GW during the 2022–2027 timeframe. The Indian government is aiming to replace old coal-fired thermal units with gas, hydro, nuclear and renewables. This will further systemically reduce the importance of coal in India's energy mix.

Oil remains crucial to India and the second largest provider of energy to the country. Between 2000 and 2020 India's oil demand doubled to 4.5 mboe/d. With the expected strong growth in future oil demand, set alongside stagnant domestic production, India has become more reliant on oil imports, which were more than 80% of demand in 2018. The government has taken many steps to reduce India's oil imports, but due to inherent time lags in the final production of oil and gas from domestic fields, this may take some time to reach fruition.

India's current gas consumption is at close to 6% of the energy mix, but the adoption of gas is rising at a fast pace. During the projection period, it is expected that gas consumption will grow by 5.4% p.a. outpacing total energy demand growth. Currently, residential consumption of natural gas is small, but India is expanding its CGD network quickly. India aims to increase its natural gas share to 15% of the energy mix by 2030, a target higher than the WOO 2021 projections. The Indian government is focused on a more gas-based economy, as well as rapidly expanding its gas grid and LNG import infrastructure.

The Indian Government stated in its commitment to meet the Paris Agreement that its NDCs aims for 40% of its installed electricity capacity to be from non-fossil fuel sources by 2030. By 2027, India aims to have 275 GW of installed solar and wind capacity, 72 GW of hydro and 15 GW of nuclear power that would make up 56.5% of its installed electricity capacity, taking India above its NDCs target.

India has an ambitious objective to reach 63 GW of nuclear power capacity by 2032, a multi-fold increase compared to current installed capacity of around 7 GW. In the WOO, nuclear energy is expected to expand at around 6.8% p.a., more than double relative to the average growth rate of primary energy demand in India. By 2045, the share of nuclear energy in the mix is anticipated to almost triple to around 3.4% of the energy mix.

Hydropower in India is expected to expand at a healthy rate of 3% p.a. which is almost on par with India's average energy growth over the projection period. The Indian government in its push for renewable energy has declared all hydropower projects as renewable energy projects and mandated electricity companies with hydro purchase obligations. This will improve the economic viability of hydropower projects.

Biomass is expected to witness the slowest growth among all primary fuels in India's energy mix. India has been successful in reducing dependence on biomass with its share in the energy mix declining from 63% in 1971 to around 21% in 2020. Going forward, the share of biomass is projected to drop further to 10% by 2045. This change is catalyzed due to the higher penetration of LPG in rural India. The government's flagship Pradhan Mantri Ujjwala Yojna (PMUY) scheme has pushed LPG usage in rural areas for cooking purposes, displacing biomass. To date, more than 80 million LPG connections have been distributed under PMUY, which has significantly reduced the share of less energy efficient biomass from the energy mix.

On 10 August 2021, Prime Minister Shri Narendra Modi launched the second phase of PMUY (2.0) to provide LPG connections to 10 million more households living below the poverty line. Overall, the consumption of biomass in India is projected to increase to 4 mboe/d in 2045 from the current 3.6 mboe/d, but this additional demand comes from biofuels, biomass use for electricity generation and other bioenergy use, with reduced biomass consumption as a traditional fuel.

Over the projection period, other renewables (especially solar and wind) have the highest growth of 11% p.a., which is aided by the Indian government's policy and vision towards cleaner and sustainable energy. India has ambitious plans to expand the use of renewables to meet demand growth for electricity in the industrial, residential and service sectors and to help the country cut its heavy dependence on coal.

In April 2021, the Cabinet, chaired by Prime Minister Modi, approved the implementation of the Production Linked Incentive scheme – 'National Programme on High Efficiency Solar PV Modules' – focused on achieving manufacturing GW-scale capacity in high efficiency solar PV modules with an outlay of $600 million. Solar capacity additions presently depend largely on imported solar PV cells and modules as the domestic manufacturing industry has limited operational capacities for solar PV cells and modules.

The National Programme on High Efficiency Solar PV Modules will reduce import dependence in a strategic sector like electricity. The benefits expected from the scheme include an additional 10 GW capacity of integrated solar PV manufacturing plants and direct investment of around $2.3 billion in solar PV manufacturing projects.

India has the fifth highest installed wind capacity in the world with 39.4 GW (May 2021), and a target of 60 GW by 2022. Wind energy constitutes 41.5% of India's renewable energy basket.

To summarize, Indian energy demand is anticipated to be the fastest growing among all major economies, in line with its strong GDP growth. Its commitment to a cleaner, renewable and more efficient energy mix will result in energy sources such as gas, nuclear and other renewables having greater shares in the country's future energy mix.

9.4 India's energy policies, climate change and sustainable development

India accounts for around 18% of the world's population, but uses only around 7% of the world's primary energy. India's per capita energy consumption equates to 4.7 boe, compared to the global per capita average of 13.2 boe.

India has made huge strides in four key areas to ensure full access to electricity. It has helped bring power to more than 700 million people through its village electrification programme, the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY); given access to clean cooking fuel to every household in the country through its LPG distribution programme, the PMUY; boosted energy efficiency through innovative programmes, such as replacing incandescent light bulbs with LEDs (under the Ujala scheme); and, lastly through a huge sustainability push on renewable energy capacity additions and taking appropriate steps for a 'gas-based economy'.

India's energy policy has seven key pillars:

1. Accelerating efforts to move towards a gas-based economy;
2. Cleaner use of fossil fuels, particularly petroleum and coal;
3. Greater reliance on domestic sources to drive biofuels;
4. Achieving the renewables target of 450 GW by 2030;
5. Increasing the contribution of electricity to de-carbonize mobility;
6. Moving into emerging fuels, including hydrogen; and
7. Digital innovation across all energy systems.

9.4.1 Gas based economy

As already noted, India's share of natural gas in its primary energy mix is about 6% and projections show that by 2045 this could rise to above 10%. However, India is making stringent efforts to increase this share to 15% by 2030.

The three main sectors consuming natural gas are fertilisers (30%), power (20%) and city gas entities (20%), the latter for both domestic and transportation demand. Other important sectors are petrochemicals and refineries for feedstock and energy usage. On the production side, India currently imports more than 50% of its gas needs in the form of LNG.

Gas demand is expected to increase to about 450 million standard cubic meters per day (msm^3/d) from the current level of about 150 msm^3/d through the expansion of the country's gas grid to various industries like fertilisers, refineries, petrochemicals and iron and steel in the coming years. Domestic and transportation natural gas consumption itself is expected to expand to 135 msm^3/d by 2030 on the back of the establishment of 10,000 CNG stations and with domestic piped natural gas (PNG) used for cooking covering most areas. As part of India's Union Budget 2021/22, 100 more districts will be added to the CGD network in the next three years, which involves the participation of private domestic companies, as well as foreign players setting up infrastructure for the distribution of PNG and CNG fuels to the domestic market.

CGD networks for various districts and geographical areas are auctioned off in a competitive bidding process. With the completion of the 10th bidding round, CGD would be available in 228 geographical areas, comprising 406 districts spread over 27 states and union territories that cover approximately 70% of India's population and 53% of its geographical area.

Gas demand in the power sector is also projected to rise to 45 msm^3/d by 2030, especially for peaking and balancing requirements for power plants based on renewable energy.

The Indian government has brought in natural gas marketing reforms to increase the domestic production of natural gas and to bring uniformity to the market price discovery of gas. The initiatives would give greater marketing freedom in the sale of natural gas through e-bidding. India's first automated national-level gas trading platform was launched in June 2020, which prescribes standard procedures to discover the market price of gas.

9.4.2 Cleaner use of fossil fuels

Besides the actions taken by India for the enhancement of natural gas in the primary energy mix, many other interventions are also leading to less carbon emissions alongside fossil fuel usage.

The Indian government has kick-started the use of clean coal technology to help deliver negligible sulphur oxide, nitrogen oxide and free particulate emissions compared to direct coal fired processes, by reviving an erstwhile closed fertilizer plant at the Talcher producing urea, which has an installed capacity of 1.27 million metric tonnes p.a.

The transportation sector has also seen policies geared towards reducing emissions through tightening fuel specifications. India leapfrogged from Bharat Stage IV (Euro IV equivalent) to Bharat Stage VI (Euro VI equivalent) emission standards nationwide in April 2020, for both light-duty and heavy-duty vehicles. The 10 parts per million (ppm) limit in Bharat Stage VI is much lower than the previous sulphur limit of 50 ppm.

In terms of fuel efficiency, passenger vehicle fuel economy standards are measured on a corporate average fleet-wide basis, much as in the US. Fuel economy standards for passenger vehicles were set in 2015 with one set of coefficients in the standard-setting formula adopted for the fiscal years through to 2021–2022, and a second, more stringent set adopted for fiscal years 2022–2023 and onwards. Heavy-duty vehicle economy standards were set in 2017 and light commercial vehicles standards were set in 2019, with the consumption targets defined by specific equations for different categories based on weight. The standard for light commercial vehicles became effective in April 2020.

After the implementation of IMO 2020 on 1 January 2020, which limits the sulphur in fuel oil used for ships operating outside designated ECAS to 0.5%, Indian refineries are consistently supplying bunker fuel of VLSFO grade.

From January 2020, the specification for kerosene has been tightened to 1,000 ppm (0.1 % wt) sulphur for all grades. Also, PNG/LPG has replaced kerosene in a very big way as a household cooking fuel. This has had a positive impact on indoor air pollution and the health of women, particularly in rural areas.

9.4.3 Biofuels

The Expert Group (June 2021) on the 'Roadmap for Ethanol blending in India 2020–25' noted that about 98% of the fuel requirements in India's road transportation sector is currently met by fossil fuels, and the remaining 2% by biofuels. Domestic biofuels provide a strategic opportunity for the country, as they enable India to reduce its dependence on imported fossil fuels.

Ethanol is one of the principal biofuels, which is produced by the fermentation of sugars by yeasts, or via petrochemical processes, such as ethylene hydration. The National Policy on Biofuels (2018), provided an indicative target of 20% ethanol blending under the Ethanol Blended Petrol (EBP) Programme by 2030, which has now been brought forward to 2025. Currently, gasoline with a 10% ethanol blend (E10) is being retailed in India, wherever it is available. However, given that sufficient ethanol is not available, only around 50% of the petrol sold is E10 blended, while the remaining is unblended petrol (E0).

The current average level of annual ethanol blending in the country is 5% (2019–2020), although it reached about 9% in the second quarter of 2021. The step to E10, along with achieving the higher E20 targets, will require nationwide standardization and the adoption of emission standards. As per the 'Gazette Notification' issued on 2 June 2021, oil companies are required to sell EBP with a percentage of ethanol up to 20% as per Bureau of Indian Standards (BIS) specifications in all states and union territories. This notification shall come into force with effect from the 1 April 2023. The Ministry of Road Transport and Highways has greenlighted the use of E20 – a blend of 20% ethanol and 80% gasoline – as an automotive fuel. Mass emission standards for the use of E20 have also been notified in the Central Motor Vehicles (Fourth Amendment) Rules (2021), which came into force on 8 March 2021. According to the notification, hydrogen-enriched CNG can also be used as an automotive fuel.

The government aims to set up distilleries to produce first generation ethanol from feedstocks, such as cereals (rice, wheat, barley, corn, and sorghum), sugar cane, and sugar beet. The government plans to assist units for the conversion of molasses-based distilleries to dual feedstock, in order to increase the availability of biofuels. This policy also envisages blending of diesel with 5% of biodiesel.

Recognizing the potential benefits of biofuels in aviation, its development and deployment in this sector is being studied. A flight was demonstrated in August 2018 from Dehradun to New Delhi using a biofuel developed by the Indian Institute of Petroleum, a Council of Scientific & Industrial Research laboratory. The BIS has already developed the specifications for use on a regular basis for commercial flights.

9.4.4 Renewables

As detailed in the book *'Accelerating Citizen Centric Energy Transition - The India Story'* issued by the Ministry of New and Renewable Energy in June 2021, India declared in 2015 a target of 100 GW of installed solar energy capacity by 2022, quintupling the National Solar Mission's (NSM) earlier target to install 20 GW solar capacity by 2022. The 100 GW target included 60 GW from utility-scale plants and 40 GW from rooftop systems.

Major initiatives to promote the development and deployment of solar energy include the Solar Park Scheme to build solar parks and ultra-mega solar power projects with a target capacity of 40 GW by 2022; the Roof Top Solar Programme to accelerate the deployment of rooftop systems; the Production Linked Incentive scheme to catalyze domestic manufacturing capacity for high efficiency solar cells and modules; 100% FDI through the Automatic Route; the Suryamitra (friend of the Sun) Skill Development Programme to skill solar maintenance and service technicians; and the PM-KUSUM scheme to use solar for agricultural pumps.

As part of the country's current fiscal budget 2021/22, $400 million of additional capital will be infused into the Solar Energy Corporation of India and more than $2 billion to the Indian Renewable Energy Development Agency, to help achieve the country's ambitious target of 450 GW of installed renewable energy capacity by 2030.

The Indian solar market is the third largest in the world. During 2015–2019, solar electricity generation in India expanded by 50%. India's leadership of the International Solar Alliance and the dedicated Central Public Sector Undertaking Solar Energy Corporation of India also provide a geopolitical and institutional boost to this growing sector.

India is also a leading global wind turbine manufacturer for sizes ranging from 225 kW to 3.6 megawatt (MW), with proven technologies to harness low and medium wind flows at hub heights up to 140 metres and rotor sizes up to 145 metres. India also exports turbines and components to Australia, Brazil, Asia, Europe and the US.

Single location solar-wind hybrid projects are also being set up to optimize land use and manage the inherent intermittency of renewable power. India's first large scale-solar-wind project, located at Kavithal in Karnataka, combines a 50 MW wind farm and a 28 MW solar PV plant.

9.4.5 Electrification

The DDUGJY was launched in 2014 by the Ministry of Power to achieve universal village electrification and enable continuous power supply to rural India. It entails an investment of $5.9 billion. The focus included electrifying 18,542 un-electrified villages, improving electrification in those that had, and the provision of free electricity connections to a further four million poor households by May 2018. Village electrification has played a significant role in curbing the use of polluting fuels like kerosene and diesel in rural areas. The DDUGJY is complemented by another flagship programme, the SAUBHAGYA, under which 28 million households were to be provided free or subsidized electricity connections.

Electric vehicles

India has been incentivizing the use of electricity in mobility through the implementation of its scheme titled 'Faster Adoption and Manufacturing of Electric Vehicles' (FAME), with the passing of subsidies directly to the original equipment manufacturer. In Phase II of the three-year programme up to 2021–2022, with an outlay of around $1.4 billion, the government is offering upfront incentives to purchase EVs, as well as establishing the necessary charging infrastructure.

Two and three wheelers dominate India's road transport fleet, but only consume about 20% of the total energy demand in the transport sector. Recently the subsidy on two-wheeler EVs has been

Box 9.2

Electric vehicles in India

In March 2018, the government of India announced its goal of reaching 30% EV penetration by 2030. This is in pursuit of India's commitment to reduce its GHG emissions intensity by 33% to 35% by 2030 below 2005 levels.

India is member of the multi-government policy forum titled the Electric Vehicle Initiative, which was launched at the Clean Energy Ministerial. This promotes the adoption of EVs worldwide. India has also endorsed the 'EV 30@30' campaign launched by the CEM, which has a set goal to reach a share of 30% EV sales by 2030.

The Indian government has boosted the adoption of EVs through the implementation of the FAME schemes (I and II). Through various policies. India is incentivizing three main components of the EV ecosystem – demand generation, charging infrastructure and industrial development. Under the FAME II scheme, the government has allocated $1.4 billion for 1.6 million hybrid and EVs, and includes measures to promote the domestic manufacturing of EVs and their parts.

To promote demand for EVs, incentives such as purchase subsidies, tax exemptions, access to financing, scrapping & retrofit incentives, priority permits, green zones, parking incentives and toll fee waivers are granted via central or state policies.

FAME II also allocated $133 million for expanding charging infrastructure. Under this allocation, the Ministry of Heavy Industries invited Expression of Interest to install a minimum of one charging station every 25 km along key highways and every 100 km to accommodate heavy duty vehicles. To further develop charging infrastructure, incentives such as capital subsidy, concessional land provision, concessional EV tariffs, the use of renewable energy sources and the relaxation of development control regulations are provided.

The government has also offered performance link incentives for battery sectors to aid the adoption of EVs. Further capital and interest subsidies, tax exemptions, land development incentives, battery recycling initiatives, employment incentives, skill development, along with R&D initiatives, are some key actions taken to promote the industrial development of EVs.

To further accelerate the adoption of EVs, the Indian government has tasked state governments and local authorities to enable the transition to EVs. Currently a total of 14 states have notified or have drafted EV policies in place.

increased further to $260/KW with a cap of 40% on the vehicle cost. In the three-wheeler & four-wheeler segment, the incentives are mainly applicable to vehicles registered and used for public transport. It further aims to establish charging stations at 25 km intervals on both sides of all major highways across the country.

9.4.6 Emerging fuels (hydrogen)

India's foray into hydrogen technologies began in 2005 with the National Hydrogen Energy Roadmap, with several technologies developed and demonstrated in the period since. In the downstream, the Ministry of Petroleum and Natural Gas is set to augment India's hydrogen supply chain infrastructure and business models.

The government has supported the use of hydrogen energy and its use as a fuel, which has been instrumental in the development and demonstration of internal combustion engines, two wheelers, three wheelers, and mini buses that run on hydrogen fuel. Two hydrogen refuelling stations have also been established (one each at the Indian Oil R&D Centre, Faridabad, and the National Institute of Solar Energy, Gurugram). In a major thrust for hydrogen energy, the country's largest private player in the hydrocarbon sector, Reliance Industries, has announced the setting up of a green hydrogen production unit at its Jamnagar facility.

India has looked to further jump-start the development of its hydrogen ecosystem with the announcement of the National Hydrogen Energy Mission (NHEM) in the Union Budget 2021. The aim is to make India a global manufacturing hub for hydrogen and fuel cell technologies across the entire value chain. Hydrogen can serve as a transport fuel, an input to refineries, and as a source of heat and power for a wide range of sectors, such as chemicals, iron and steel, fertilisers and petroleum. This versatility, combined with a low-carbon footprint, makes hydrogen a strategic choice for India's energy mix. It can be stored and transported in pressurized, liquefied form, and can be used for power-to-gas, power-to-power, power-to-mobility and vehicle-to-grid applications.

In a push for India's energy security, Prime Minister Modi in his Independence Day speech on 15 August 2021 announced the NHEM for the country. Green hydrogen, produced by splitting water into hydrogen and oxygen, using electricity from renewable energy sources such as wind and solar can be a game changer for India.

Stressing on the need for energy independence, while announcing the mission, Prime Minister Modi said that the plan involves India becoming a global hub for green hydrogen production and exports.

9.4.7 Digitalization of the energy consuming processes

As per the report of the Task Force on Digitalization in Energy (September 2020), which was established by the Committee on Sustainable Energy of UN Economic Commission for Europe (UNECE), digitalization is an emerging trend that is revamping the energy landscape and enabling progress toward continuous energy efficiency improvements. In fact, energy efficiency is at the core of the energy system. As per the report, technologies and digital innovations facilitating new market opportunities include: AI, block chain, machine learning, advanced data analytics, IoT, big data, cloud computing, sensors, automation, 3D printing and robotics. The focus is on establishing new business models that enable the generation, delivery and consumption of energy in an ever more sustainable manner.

The Union Government set up the National Smart Grid Mission (NSGM) in 2015 as an institutional mechanism to accelerate smart grid deployment in India. The NSGM facilitates technology, policy, and training to promote smart grids at the distribution level. The focus of the NSGM is to lower aggregate technical and commercial losses and power purchase costs; manage peak loads; and improve the quality of grid visibility, asset management, renewable power integration, and services, like net-metering. Under this initiative, the Ministry of Power aims to replace 250 million conventional meters with prepaid smart meters over the coming 3–5 years.

The smart meter, which is the main component of advanced metering infrastructure, enables accurate energy audits, reduces utilities' commercial losses, enhances revenues, and allows consumers to track and adjust usage. The transparency and trust enabled by smart meters is an important tool for providing 24x7 quality power for all.

In 2015, the Union Government launched the Ujwal Discom Assurance Yojana (UDAY). One of the priorities of this scheme was the installation of smart meters for all customers with a monthly consumption of over 500 units by December 2017, and for those with a consumption of 200–500 units per month by December 2019. UDAY's term ended in March 2020. A new reforms-based and results-linked distribution sector scheme has now been proposed with an outlay of over $40 billion.

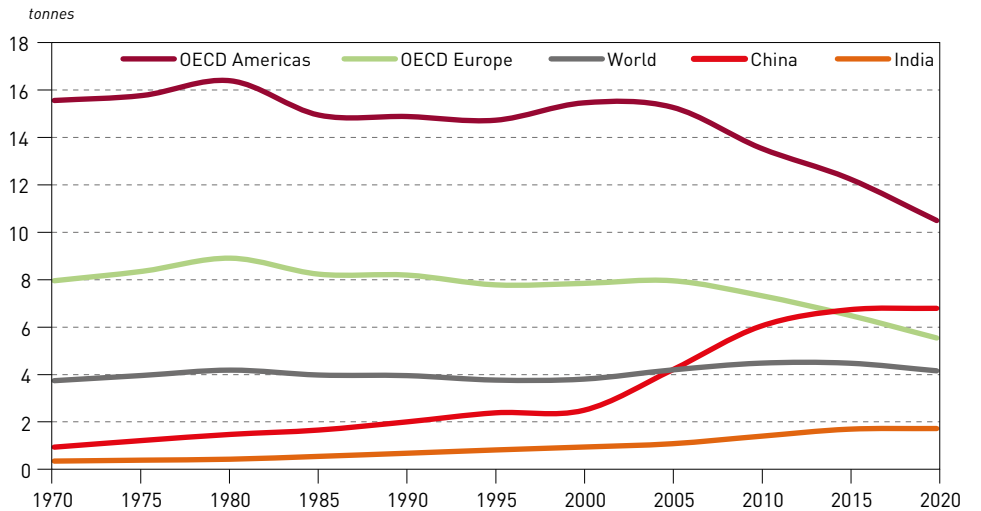
The Department of Science & Technology has also been a collaborating partner with the Joint Programming Platform ERA-Net Smart Energy Systems (JPP SES) and Mission Innovation (MI) in the joint call on Digital Transformation for Green Energy Transition (MICall20). With the MICall20 and JPP SES, in collaboration with MI, there has been a call for global transnational projects and support for the following objectives:

- Advancing the green energy transition in all sectors of the energy system while ensuring security of supply;
- Shaping new transnational business and investment opportunities by sector, with the coupling and development of new value chains in innovative and cost-effective energy solutions; and
- Ensuring social sustainability and coherence with digitalization in other sectors in the progression of the green energy transition.

Climate change and sustainable development

India is set to be at the centre of the world's energy stage, given expectations that it will contribute around 25% to the projected growth in global energy demand. Urbanization will be a key driver of this trend given that an additional 315 million people, almost the population of the US today, are expected to live in India's cities by 2040, pushing up energy demand.

Figure 9.5
Per capita CO_2 emissions in selected countries and regions



Source: OPEC.

In terms of GHG emissions, it is important to examine per capita GHG emissions from nations in comparison with the global average. This is shown in Figure 9.5.

Climate change will be a major challenge for India. While it is the third largest global emitter in absolute terms, with an approximate 6.4% share in global CO_2 emissions, the country's per capita emissions are only 1.9 tonnes of CO_2, compared to the global average of 4.7 tonnes. This is an extraordinary situation with a country high on overall emissions, but still very low on energy consumption per person. The Indian government is cognizant of this dynamic and its policies are focused on ensuring access to sustainable and clean energy sources. This goes hand-in-hand with the UN's SDG7.

The Indian government is taking significant steps towards adopting clean energy. As part of its international commitment, India put forward eight NDCs under the Paris Agreement of the UNFCCC. Three of the eight NDCs set quantifiable targets to be met by 2030: Goal 3, aims to reduce the emissions intensity of its GDP by 33%–35% from 2005 levels; Goal 4, is to have 40% of cumulative electric power installed capacity from non-fossil fuels; and Goal 5, aims to create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent. All efforts are aimed at improving energy security and energy access so as to deliver reliable and sustainable energy for its entire population, while also keeping in mind the global good.

9.5 Oil demand

With the start of the COVID-19 pandemic, oil demand was dramatically hit. While it has recovered somewhat since the 2Q20, further lockdowns, repeated waves of infections, the advent of new virus strains and delays in vaccination programmes have kept oil demand under pressure across the world.

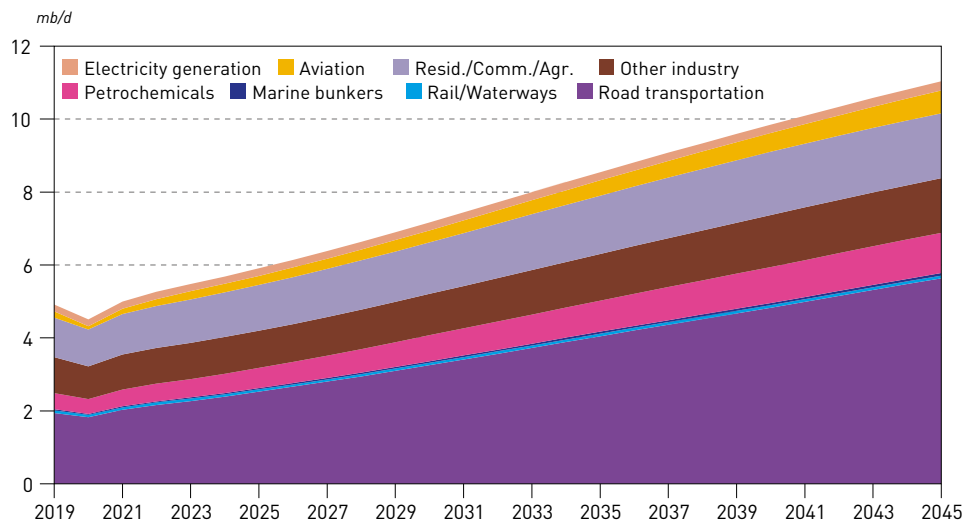
During 2020, Indian oil demand fell on a yearly basis for the first time in 45 years, along with its global peers. As the impact of the initial wave of the virus eased, Indian oil demand recovered quickly. Projections indicate that Indian oil demand is expected to reach its pre-pandemic level of

4.9 mb/d in 2021. Over the WOO's projection period, Indian oil demand is expected to grow by 3.6% p.a., which is consistent with its overall energy demand growth.

In absolute terms, oil demand in India is set to register the highest growth between 2020 and 2045 among all regions considered in this Outlook. However, compared to last year's projections, Indian oil demand in 2045 is slightly lower at 11 mb/d, compared to 11.1 mb/d in last year's Outlook, due to the demand drop in 2020 and the impact of two waves of COVID-19 infections.

As presented in Figure 9.6, India's oil demand growth during the projection period will be led by demand for road transport followed by the residential, commercial and agriculture sectors. Other major contributors will be the petrochemical and aviation sectors.

Figure 9.6
Indian oil demand by sector, 2019–2045



Source: OPEC.

In terms of the product mix (Figure 9.7), diesel/gasoil and gasoline are expected to contribute almost two thirds of the oil demand growth. However, despite an increase of 2.4 mb/d in diesel/gasoil demand from 2020–2045, its share in total oil demand is anticipated to remain at the current level of 37%, as other products expand too.

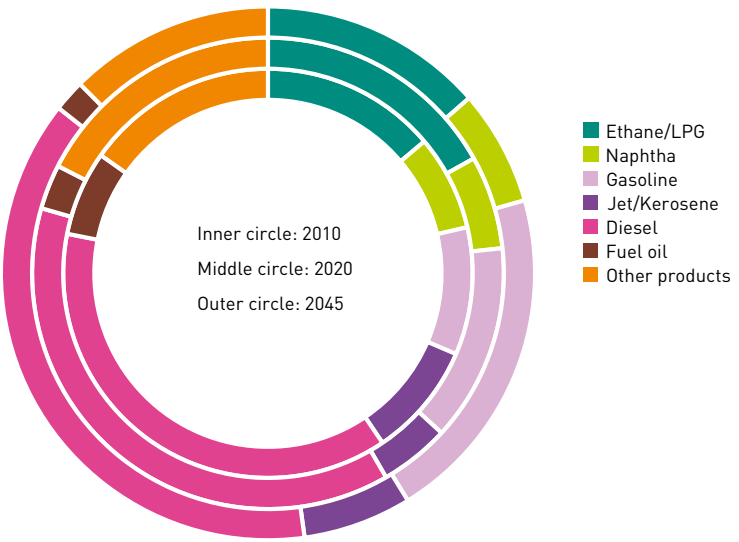
Oil demand by sector in India

As presented in Figure 9.8, Indian oil demand over the next 25 years will be led by the road transportation sector. In the previous ten-year period, demand from road transportation was the fastest growing among all sectors. From 2020–2045, however, the aviation sector is projected to experience the highest growth, at more than 8% p.a. on average, but the overall share of road transportation will remain the highest even in 2045.

In the projection period, road transportation demand is expected to grow at 4.7% p.a., which is higher than total oil demand growth in India. In absolute terms, demand is forecast to reach 5.6 mb/d in 2045, compared to 1.8 mb/d in 2020, representing the highest incremental demand among all sectors. From the products perspective, demand in this sector will continued to be dominated by diesel and gasoline, with gasoline demand growth rate higher than that for diesel, on the back of the fast expansion of India's passenger car fleet.

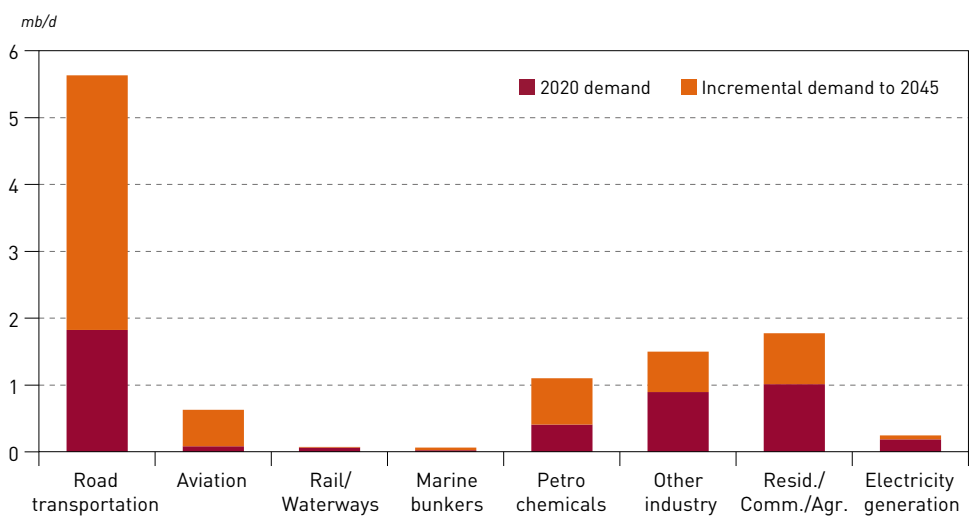
Source: OPEC.

Figure 9.7
Share of refined products in Indian oil demand



Source: OPEC.

Figure 9.8
Sectoral oil demand in India in 2020 and 2045



Source: OPEC.

The share of the road transportation sector in oil demand increased from 35% in 2010 to a current level of more than 40%. This is set to rise further to 50% by 2045, as the number of passenger vehicles is expected to increase by 150 million, and commercial vehicles by more than 50 million. Currently, India's passenger vehicle fleet are mainly two wheeled and four-wheeled vehicles running on gasoline (together with an increasing market share for two wheeled electric

vehicles). Commercial vehicles are mainly diesel powered and conversion to LNG will take time as the LNG infrastructure has only just started to develop. However, lighter passenger vehicles run on CNG are gaining traction due to the enhanced availability of CNG at more than 5,000 CNG stations. The target is 10,000 CNG stations by 2030. The current price differential between CNG and gasoline, as well as diesel, is also a major factor in the gradual shift towards CNG passenger vehicles.

Increasing demand in road transportation is further driven by the Indian government's various initiatives to boost road infrastructure and increase connectivity. The government has launched 'Bharatmala Pariyojana', which is a new umbrella programme for the highways sector that focuses on optimizing efficiencies in freight and passenger movement across the country by bridging critical infrastructure gaps. The focus is on effective interventions, such as the development of economic corridors, inter-corridors and feeder routes, national corridor efficiency improvements, border and international connectivity roads, coastal and port connectivity roads and green-field expressways. A total of around 34,800 km are being constructed with an estimated outlay of $75 billion.

Demand from the aviation sector is forecast to be the fastest growing over the next 25 years. It is expected to grow at 8.4% p.a. on average on account of schemes such as the Regional Connectivity Scheme (RCS) or UDAN. The primary objective of UDAN (letting the common citizen of the country fly) is to facilitate/stimulate regional air connectivity by making it more affordable. Promoting the affordability of regional air connectivity is envisioned by supporting airline operators through concessions by the central government, state governments and airport operators to reduce the cost of airline operations on regional routes; and financial support to meet the viability gap (funding), if any, between the cost of airline operations and expected revenues on such routes.

The petrochemicals sector is set grow by 4.1% p.a. on average between 2020 and 2045, as demand for plastics and its derivatives expands in line with GDP growth. India is set to witness a transformation in oil to chemicals, along with the commissioning of new petrochemical plants that will boost demand from the petrochemical sector.

Increasing commercial activities to cater for the young and expanding working age populations, along with more intensive agricultural activities, will also improve demand for the residential, commercial and agricultural sector. Demand is expected to grow in this sector by 2.3% p.a. over the projection period.

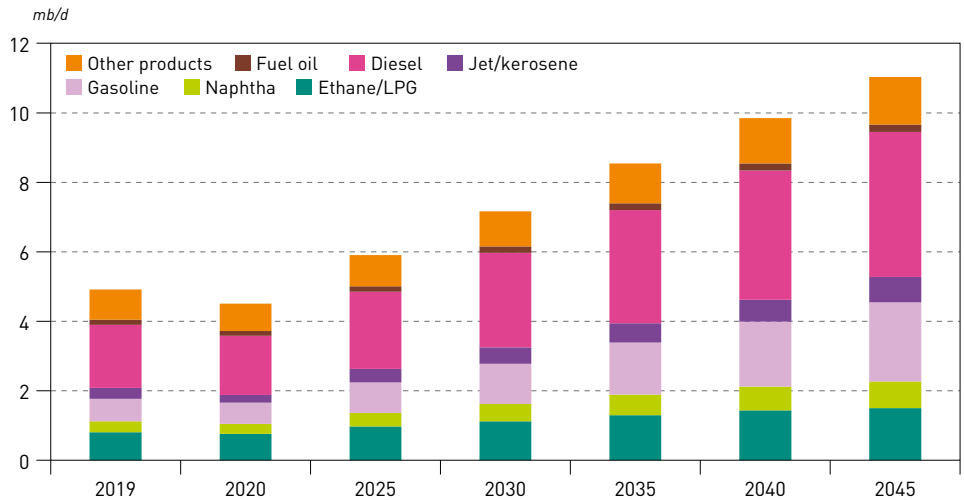
Oil demand by product in India

Currently, Indian oil demand is dominated by diesel/gasoil and gasoline, which constitute around 51% of total demand (Figure 9.9). During the projection period, the share of diesel/gasoil and gasoline is expected to rise further to 57.7%, as these two products will drive the Indian oil demand story, as presented in Figure 9.10. Diesel/gasoil is projected at 4.2 mb/d by 2045 compared to a level of 1.7 mb/d in 2020. The corresponding figures for gasoline are 2.3 mb/d and 0.6 mb/d, respectively.

Increasing activity in the aviation sector, supported by various governmental schemes, is expected to boost demand for jet kerosene, which is projected to be the fastest growing refinery product. Jet kerosene demand is anticipated to grow by 5.1 % p.a. during the forecast period.

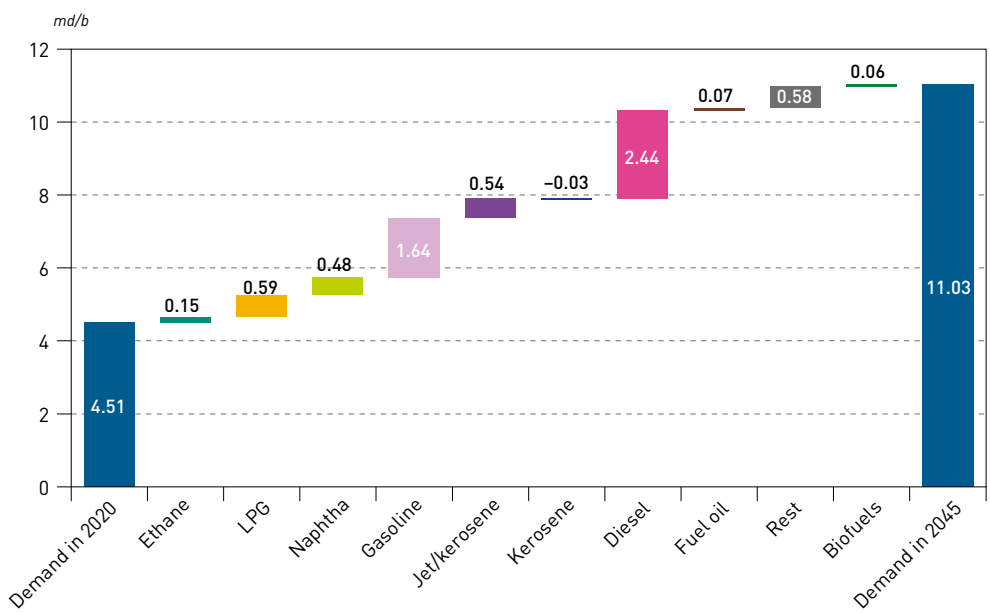
Biofuels are expected to grow at the fastest rate among all oil products over the forecast period. Demand is expected to expand by 5.8% p.a., supported by the push towards cleaner fuels. The Indian government issued the National Policy on Biofuels 2018 wherein, under the EBP programme, an indicative target of 20% blending of ethanol in petrol by 2030 was laid out. Subsequently, the target year for achieving 20% ethanol blending in petrol was advanced to 2025.

Figure 9.9
Oil demand by product in India, 2019–2045



Source: OPEC.

Figure 9.10
Incremental oil demand in India between 2020 and 2045 by product



Source: OPEC and Ministry of Petroleum and Natural Gas, Government of India.

9.6 Liquids supply

Crude oil was first discovered in India in commercial quantities in 1889, long before many of the crude sources known today. Subsequent exploration, however, did not result in large-scale availability, leaving it as a highly import-dependent country with a huge consumer base. Nevertheless, this did not deter India from continuously exploring for crude and gas throughout its coastal and inland

regions. The goal of India's hydrocarbon policies has been to undertake a full appraisal of all possible regions, including deep-sea offshore areas, with a view to tapping its full potential. India is also focusing on the redevelopment of existing mature fields, besides bringing on-stream new oil fields.

Crude oil supply in 2020 averaged 0.62 mb/d, with total liquids supply coming in at 0.77 mb/d. With crude oil production expected to decline in the long-term, India is pivoting to increase biofuels production to make up for the shortfall in total liquids supply. Biofuels production is expected to double to 0.07 mb/d in 2026, from 0.03 mb/d in 2020, while crude production remains flat to 2020 levels at 0.62 mb/d in 2026, despite small increases in the intervening years (Table 9.2).

In the longer-term, crude oil production is expected to decline further to 0.39 mb/d by 2045. However, support from increased biofuels production, rising to 0.19 mb/d in 2045, will help moderate the decline in total liquids supply.

Table 9.2
India medium-term liquids supply outlook

mb/d

	2019	2020	2021	2022	2023	2024	2025	2026	Change 2020–2026
Crude	0.65	0.62	0.60	0.64	0.65	0.64	0.63	0.62	0.00
NGLs	0.13	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.01
Other unconventionals	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Biofuels	0.04	0.03	0.03	0.03	0.04	0.05	0.06	0.07	0.04
Total	**0.82**	**0.77**	**0.76**	**0.81**	**0.82**	**0.83**	**0.82**	**0.82**	**0.05**

Source: OPEC.

Table 9.3
India long-term liquids supply outlook

mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2020–2045
Crude	0.65	0.62	0.63	0.57	0.51	0.45	0.39	–0.23
NGLs	0.13	0.12	0.13	0.13	0.13	0.13	0.13	0.01
Other unconventionals	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02
Biofuels	0.04	0.03	0.06	0.10	0.14	0.19	0.19	0.15
Total	**0.82**	**0.77**	**0.82**	**0.81**	**0.79**	**0.78**	**0.72**	**–0.04**

Source: OPEC.

India's proven crude oil reserves stood at 4.7 billion barrels in 2019, with a share of just 0.3% of the world's total proven reserves, leaving the nation dependent on imports for most of its crude oil needs. To reduce its dependence on fossil fuel imports, the government is focusing on increasing oil and gas production from existing and potential new fields in the country.

In order to increase exploration activities and to attract domestic and foreign investment in local upstream production, the Indian government approved the Hydrocarbon Exploration and Licensing Policy (HELP), replacing the erstwhile New Exploration Licensing Policy (NELP). Additionally, the Open Acreage Licensing Policy (OALP), along with the National Data Repository (NDR), were launched as the key drivers to accelerate E&P activities in India.

The licensing programme under HELP adopted a revenue sharing model and is a step towards improving the ease of doing business in India's E&P sector. It comes with attractive and liberal terms, such as reduced royalty rates, marketing and pricing freedom, submission of expression of interests the year round, a single license to cover conventional and unconventional hydrocarbon resources, exploration allowed during the entire contract period, a simplified bidding process, transparent awarding procedures and a swift approvals process.

To date, four OALP bid rounds have been conducted, with a total of 94 blocks awarded with leading E&P companies, covering an area of 136,790 km^2. The operators of these blocks have since then initiated petroleum exploration activities, or are in the process of obtaining Petroleum Exploration Licenses.

The successful roll-out of the HELP regime, followed by the OALP bid rounds, has led to an increase in exploration acreage in India, which is expected to boost production in the medium-term.

Furthermore, the government has developed a National Policy on Biofuels to bring about accelerated development and the promotion of the cultivation, production and use of biofuels.

In recent years, the Indian government's attention has shifted to production enhancement rather than revenue maximization, harnessing technological innovation, fostering collaboration and providing a stable and simplified policy and fiscal regime. The ground-breaking system in the Indian E&P sector, combined with a single window clearance system, strong institutional frameworks, attractive corporate taxes and revitalized regulatory regimes has generated phenomenal investment opportunities in India across the entire E&P value chain, including both greenfield and brownfield sites. The Indian Ministry of Petroleum's projections sees liquids supply in 2021 averaging 0.8 mb/d, rising to just over 1 mb/d by 2025.

Over the next five years, it is expected that investment in upstream development by production companies will reach $5 billion p.a. from current levels of $3.8 billion p.a. The proposed capex investment from operators has already exceeded the targets for the next two years with expectations for further investments. This higher investment will likely boost the number of flowing wells from 6,500 to 8,000, a 23% increase, in the next five years (Table 9.4).

In addition to increasing production, the Indian government is also employing a focused strategy to continue to boost exploration activity in India. There are expectations for more than 200% growth in exploration acreage, which is anticipated to increase from 157,000 km^2 to 500,000 km^2

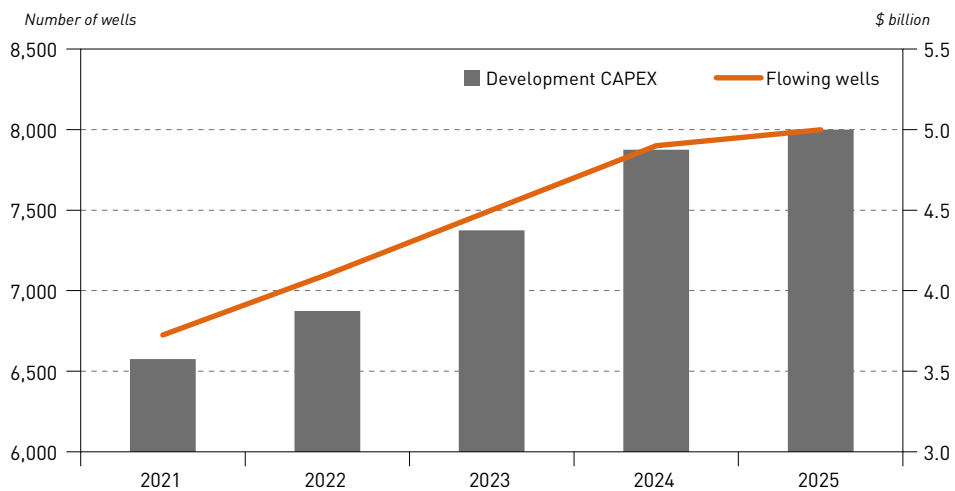
Table 9.4
India liquids supply outlook according to the Ministry of Petroleum and Natural Gas *mb/d*

	2020	2021	2022	2023	2024	2025	2020–2025
Total	0.77	0.80	0.88	0.97	1.01	1.01	0.24

Source: Ministry of Petroleum and Natural Gas, Government of India.

over the next five years. Along with an increase in exploration acreage, the government is also investing in enhancing the technology used by E&P companies, including substantially expanding the areas covered by 3D seismic data. In the short-term, the government is targeting the timely completion of greenfield projects, intensifying exploration in brownfield areas, and advancing the standardization of petroleum resource accounting and reporting.

Figure 9.11
Indian crude production parameters



Source: Ministry of Petroleum and Natural Gas, Government of India.

Box 9.3

From Margherita to Bengal

The story of oil exploration in India began in the north-eastern corner of the country. Oil seepages had been reported since the early 19th century on the banks of the River Dihing, during prospecting for coal in Upper Assam, a region in Northeast India.

In fact, India was on the crude map within seven years of the drilling of the world's first oil well in 1859 at Titusville, Pennsylvania, US, when a hand-dug well of 102 feet at Nahorpung, near the Jeypore area of Upper Assam, yielded oil, even though production proved not satisfactory. In the second attempt in 1867, oil was struck at merely 118 feet in Asia's first mechanically drilled well at Makum, near the Margherita area of Upper Assam.

During the period 1889–1890, the Digboi Well no.1 was drilled to a depth of 662 feet and commercial quantities of crude oil were discovered. Digboi has an interesting story concerning its name. The engineer in charge used to urge his men to "Dig boy, dig" and hence the name 'Digboi' was coined. Moreover, Asia's first oil refinery was set up at Digboi in 1901, which is still functional and one of the world's oldest operating refineries.

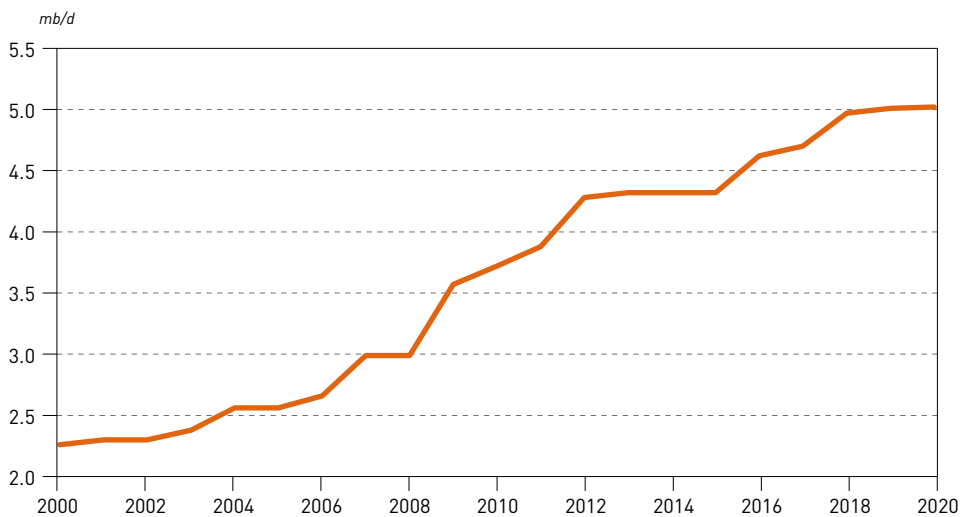
Offshore exploration was later initiated in the form of experimental seismic surveys in 1962 in the Gulf of Cambay and later in other western offshore areas. Detailed seismic surveys resulted in the discovery of a large structure offshore of Bombay in 1972–1973 and drilling led to India's biggest commercial oil discovery – the Bombay-High field in 1974. In 1982, the Oil and Natural Gas Corporation (ONGC) made its biggest gas discovery in Gandhar, Cambay Basin, Gujarat and by 1986, the Krishna Godavari Basin had been placed on the global map with several significant discoveries made. The most recent oil find in India was at Ashok Nagar in the Bengal Basin.

9.7 Downstream and oil trade

India has witnessed remarkable growth in its refining sector since the start of the century. From a deficit in 2001, the country pushed to achieve self-sufficiency in refining and is currently a major exporter of petroleum products. Today, India has the world's fourth largest refining capacity. As shown in Figure 9.12, India's refining sector has grown at a rapid pace since 2000, to keep up with the growth in oil demand.

India currently has 23 refineries spread geographically and connected via a series of cross-country crude and product pipelines. Traditionally, refinery utilization in India remains more than 100%.

Figure 9.12
Crude distillation capacity in India

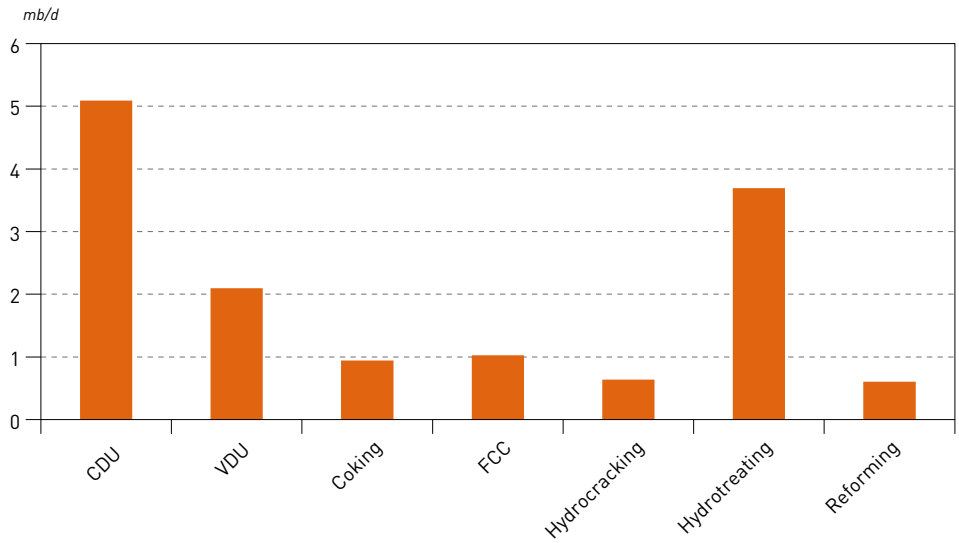


Source: Ministry of Petroleum and Natural Gas, Government of India.

Indian refineries have large cracking, coking and desulphurization capacities as the majority of Indian crude feed is made up of medium- and heavy-sour crude whereas the majority of domestic demand is for light and middle distillates with strict sulphur limitations (Figure 9.13).

India implemented the Euro VI fuel standard for gasoil and gasoline in 2020. As already discussed in Section 9.6, during the WOO's projection period, demand from road transportation will witness the lion's share of expanding oil demand. This will further enhance cracking, coking and desulphurization capacities in India's refining system.

Figure 9.13
Indian refining system in 2020



Source: Ministry of Petroleum and Natural Gas, Government of India.

The Indian government has taken various steps to bring more investment to the Indian downstream sector to help unlock its full potential. India started opening up its downstream retail sector from 2002, initially by allowing the marketing of gasoil, gasoline and jet fuel to private companies. Private companies were free to price their products. From 2010, the Indian government started deregulating retail pricing through the gradual removal of subsidies. Gasoline subsidies were fully removed by 2010 and gasoil subsidies were completely removed by 2014. Furthermore, to ensure that Indian retail prices for gasoil and gasoline are in line with the international market, daily pricing adjustments were introduced in 2017, instead of the previous fortnightly pricing.

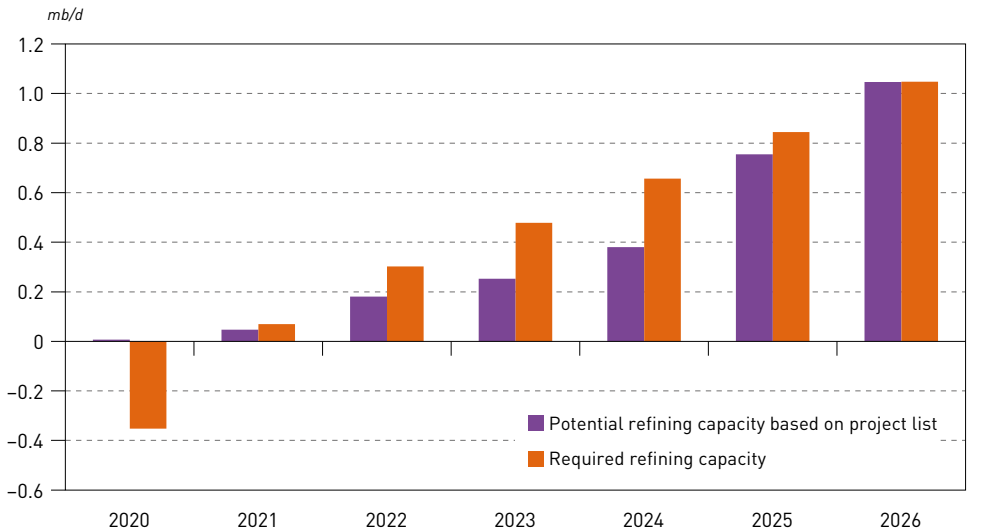
Then in 2019, the government relaxed norms for setting up retail outlets in India by allowing non-oil companies to venture into the business by lowering the criteria for the required minimum investment. India's new retail outlet norms require these companies to set up a minimum of 100 outlets with at least 5% of them in remote areas (those that still have a deficit in the availability of retailing stations). The liberalization process has also not lost sight of the bigger picture of the need for cleaner fuel expansion so licensees are required to have at least one new alternate fuel such as, CNG, biofuels, LPG and EV charging points, at their proposed retail outlets within three years of the commissioning of the outlet.

Out of 23 refineries, 14 are located along India's coastline. The remaining nine refineries are located inland, which has necessitated a requirement for cross country pipelines of crude and products. India has a crude pipeline network of 10,419 km with a carrying capacity of 2.97 mb/d, along with a product pipeline network of 18,465 km, with a capacity of 2.25 mb /d. Alongside pipelines, oil products are also distributed via rail, coastal movement and road transportation. India currently has 77,331 retail outlets spread across the length and breadth of the country.

Since 2000, India's refining capacity has grown by 4.1% p.a. *versus* growth in demand at 3.8% p.a. This has enabled India to become one of the key product exporters in the Southeast Asia region.

Figure 9.14 contrasts the cumulative potential refining capacity against the required refining capacity in India. It is based on the list of 'firm' refining projects in the medium-term and includes probability

Figure 9.14
Additional cumulative crude runs in India, 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.

profiling. It also assumes average utilization of 100% for new projects, which is based on India's historically high utilization rates that have often been above 100%. The cumulative required refining capacity is based on India's medium-term oil demand and also considers demand for non-refinery fuels, including biofuels and NGLs. The detailed methodology is described in Chapter 5.

Figure 9.14 shows that the rapid demand recovery in India outpaces refining capacity additions in the period 2022–2024 with a gap of up to 0.3 mb/d. However, with new capacity coming online in the latter part of the medium-term, the cumulative potential refining capacity reaches a level of 6.1 mb/d by 2026, which is equal to the cumulative required refining capacity in the same year. This means that India's capacity expansion is fully justified by the oil demand outlook. However, considering the ambitions of India's downstream sector to maintain its strong position in the international downstream market through product exports, higher capacity expansions would be required.

Table 9.5 provides a list of refinery projects assessed as possible for completion in the medium-term period (2021–2026), with a total estimated additional cumulative capacity of 1.7 mb/d. However, due to uncertainties and possible delays, it is expected that only around 65% of this cumulative capacity will materialize in the 2021–2026 timeframe. Beyond 2026, OPEC's Reference Case does not project the construction of specific refining projects, but estimates required refining capacity for a specific region based on oil demand, supply and trade.

In order to meet growing domestic requirements, Indian oil companies will undertake various greenfield and brownfield refinery projects. Indian refinery capacity additions are not only aimed to cater for domestic demand, they are also intended to capture supply deficits in South Asian and neighbouring regions.

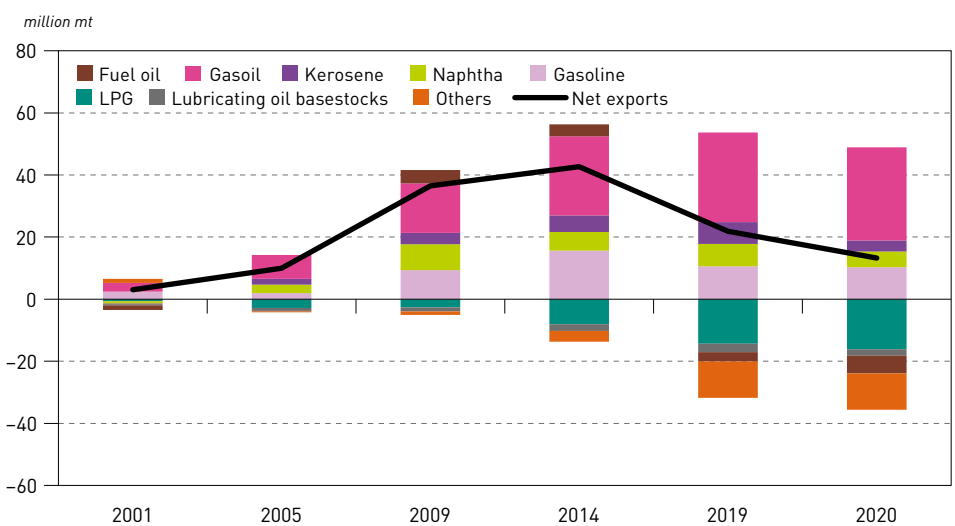
Currently, India is the second biggest net exporter of oil products in the Asia-Pacific market, behind South Korea, although it is the largest net exporter of gasoil in this region. Over the WOO's projection period, India is expected to maintain its position as a key exporter in the Asia-Pacific region.

Table 9.5
List of existing refinery projects in India

Company	Location	Completion	Distillation capacity *(kb/d)*
HPCL	Mumbai, MH (Mahul)	2021	40
HPCL	Visakhapatnam, AP	2022	134
IOCL	Baraundi, Bihar (Barauni)	2023	60
IOCL	Koyali, Gujarat	2023	86
Nagarjuna Oil Corporation	Nagarjuna	2023	120
IOCL	Panipat (Phase 1)	2024	100
Reliance Industries	Jamnagar, Gujarat	2024	116
MRPL	Mangalore, KA	2025	74
BPCL (NRL)	Numaligarh, AS	2025	120.5
CPCL	Nagapattinam - Cauvery Basin	2025	160
HPCL / ONGC	Barmer, Rajasthan	2025	180
Nayara Energy (Rosneft (Fmr: Essar Group))	Vadinar, Gujarat	2025	400
Total			**1,590.5**

Source: OPEC.

Figure 9.15
Refined products exports/imports from/to India



Source: Ministry of Petroleum and Natural Gas, Government of India.

Annex A
Abbreviations

AfDB	African Development Bank
AFREC	African Energy Commission
AFVs	Alternative fuel vehicles
AHP	African Hydrogen Partnership
AI	Artificial Intelligence
ANWR	Alaska National Wildlife Refuge
APPO	African Petroleum Producers' Organization
APT	Accelerated Policy and Technology
ARDA	African Refiners and Distributors Association
BaaS	Battery-as-a-service
bcm	Billion cubic metres
BEV	Battery electric vehicles
BLM	Bureau of Land Management
boe	Barrels of oil equivalent
BoJ	Bank of Japan
bt	Billion tonnes
BWR	Boiling light-water cooled and moderated reactors
CAFE	Corporate Average Fuel Economy
CARES	Coronavirus Aid, Relief, and Economic Security
CBAM	Carbon Border Adjustment Mechanism
CCE	Circular carbon economy
CCGT	Combined cycle gas turbine
CCPPs	Combined cycle power plants
CDG	City Gas Distribution
CFS	Clean Fuel Standard
CHP	Combined heat and power
CNG	Compressed natural gas
CNOOC	China National Offshore Oil Corporation
CO_2	Carbon dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
COTC	Crude-oil-to-chemicals
COVID-19	Coronavirus disease 2019
CTLs	Coal-to-liquids
CTO	Coal-to-olefins
DAC	Direct air capture
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana
DoC	Declaration of Cooperation
DUCs	Drilled-but-uncompleted wells
E&P	Exploration and production
EBP	Ethanol Blended Petrol
ECAs	Emission control areas
ECB	European Central Bank
ECOSOC	Economic and Social Council
EEDI	Energy Efficiency Design Index
EIA	Energy Information Administration (US)
EPA	Environmental Protection Agency (US)
ESG	Environmental, social and governance
ETBE	Ethyl tertiary butyl ether
ETS	Emissions Trading System

EU	European Union
EV	Electric vehicle
FAME	Faster Adoption and Manufacturing of Electric Vehicles
FCC	Fluid catalytic cracking
FCEVs	Fuel cell electric vehicles
FED	US Federal Reserve
FERC	Federal Energy Regulatory Commission
FID	Final investment decision
FPSO	Floating production storage and offloading vessel
FYP	Five-Year Plan
GCC	Gulf Cooperation Council
GDP	Gross domestic product
GHG	Greenhouse gas
GTLs	Gas-to-liquids
GW	Gigawatt
HELP	Hydrocarbon Exploration and Licensing Policy
HEV	Hybrid electric vehicle
HLPF	High-level Political Forum
HSFO	High sulphur fuel oil
IAEA	International Atomic Energy Agency
IATA	International Air Transport Association
IBAMA	Institute of the Environment and Renewable Natural Resources
ICAO	International Civil Aviation Organization
ICE	Internal combustion engine
ICP	International Comparison Programme
ICTs	Information and Communication Technologies
IEA	International Energy Agency
IIF	International Institute of Finance
IMF	International Monetary Fund
IMO	International Maritime Organization
IOCs	International Oil Companies
IOT	Internet of Things
JPP	Joint Programming Platform
kW	Kilowatt
kWh	Kilowatt hour
LCFS	Low Carbon Fuels Standard
LED	Light emitting diodes
LNG	Liquefied natural gas
LOOP	Louisiana Offshore Oil Port
LPG	Liquefied petroleum gas
LULUCF	Land Use, Land-Use Change and Forestry
M&A	Mergers and acquisitions
MARPOL	International Convention for the Prevention of Pollution from Ships
mb/d	Million barrels per day
mboe/d	Million barrels of oil equivalent per day
Mbtu	Million British thermal unit

MET	Mineral Extraction Tax
MICall20	Mission Innovation on Digital Transformation for Green Energy Transition
MIT	Massachusetts Institute of Technology
mmtco$_2$e	Million metric tons of CO_2 equivalent
MOMR	Monthly Oil Market Report (OPEC)
mt	Million tonnes
MTBE	Methyl tertiary butyl ether
MTO	Methanol-to-olefins
MW	Megawatts
NDC	Nationally determined contribution
NDR	National Data Repository
NELP	New Exploration Licensing Policy
NEPAD	New Partnership for Africa's Development
NEV	New energy vehicle
NGEU	Next Generation EU
NGLs	Natural gas liquids
NGVs	Natural gas vehicles
NPR-A	National Petroleum Reserve in Alaska
NSGM	National Smart Grid Mission
OALP	Open Acreage Licensing Policy
OECD	Organisation for Economic Co-operation and Development
OEMs	Original equipment manufacturers
ONGC	Oil and Natural Gas Corporation
OTC	Oil-to-chemicals
p.a.	Per annum
PAWP	Paris Agreement Work Programme
PHEV	Plug-in hybrid electric vehicles
PHWR	Pressurized Heavy-Water Moderated Cooled Reactors
PIDA	Programme for Infrastructure Development in Africa
PMGKY	Pradhan Mantri Garib Kalyan Yojana
PMUY	Pradhan Mantri Ujjwala Yojn
PNG	Piped natural gas
pp	Percentage point
ppm	Parts per million
PPP	Purchasing power parity
PV	Photovoltaic
PWR	Pressurized Light-Water Moderated and Cooled Reactors
QE	Quantitative easing
R&D	Research and development
RFCC	Resid fluid catalytic cracking
RFS	Renewable Fuel Standard
RPK	Revenue passenger kilometre
SAF	Sustainable Aviation Fuel
SAFE	Safer Affordable Fuel-Efficient
SALEDS	South Africa Low Emission Development Strategy
SB	Subsidiary bodies
SCC	Social Cost of Carbon

SDGs	Sustainable Development Goals
SMR	Small Modular Reactors
SUV	Sport utility vehicle
TWh	Terawatt hour
UDAY	Ujwal Discom Assurance Yojana
UK	United Kingdom
ULS	Ultra-low sulphur
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDESA	United Nations Department of Economic and Social Affairs
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
UNGA	United Nations General Assembly
US	United States
VGO	Vacuum gasoil
VLCCs	Very large crude carriers
VLSFO	Very low sulphur fuel oil
VMT	Vehicle miles travelled
WCSB	Western Canadian Sedimentary Basin
WHO	World Health Organization
WOO	World Oil Outlook (OPEC)
WTI	West Texas Intermediate
y-o-y	Year-on-year

Annex B
OPEC World Energy: definitions of regions

OECD

OECD Americas
Canada
Chile
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
Turkey
United Kingdom

OECD Asia Oceania
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
Colombia
Costa Rica
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

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
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
Eswatini
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
Angola
Republic of the Congo
Equatorial Guinea
Gabon
IR Iran
Iraq
Kuwait
Libya
Nigeria
Saudi Arabia
United Arab Emirates
Venezuela, Bolivarian Republic of

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

Annex C
World Oil Refining Logistics and Demand: definitions of regions

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, Bolivarian Republic of

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 the Congo
Côte d'Ivoire
Democratic Republic of the 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

A

Central African Republic
Chad
Comoros
Djibouti
Ethiopia
Eritrea
Gambia
Kenya
Lesotho
Madagascar
Malawi
Mauritius
Mayotte
Mozambique
Namibia
Réunion
Rwanda
Sao Tome and Principe
Seychelles
Somalia
South Africa
South Sudan
Sudan
Swatini
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
Turkey

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

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
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

Annex D
Major data sources

Accenture Consulting
Advanced Resources International Inc.
Africa Progress Panel
African Union
AG Energiebilanzen
Airbus
American Chemical Society (ACS)
American Petroleum Institute (API)
Argus Media
Asia-Pacific Economic Cooperation (APEC)
Baker Hughes
Barclays Research
Bloomberg
Boeing
BP Statistical Review of World Energy
Brazil, Ministry of Mines and Energy
Brookings Institute
Bunkerworld
Bureau of Labor Statistics (BLS)
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
East African Community
The Economist
Economist Intelligence Unit online database
Elsevier
Energy Research Institute of the Russian Academy of Sciences (ERI RAS)
Energy Intelligence Group
EnSys Energy & Systems, Inc
Equinor
Ernst & Young
EUREL
European Automotive Manufacturers Association
European Commission (EC)
European Council
European Environment Agency
Eurostat
Evaluate Energy
Financial Times
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
Institure for Essential Services Reform (IESR)
IMF, Direction of Trade Statistics
IMF, International Financial Statistics
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
Nexant
Norton Rose Fulbright
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
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
Smart Energy International
Society of Petroleum Engineers (SPE)
Stratas Advisors
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 Industrial Development Organization
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)
Verdict Media Limited
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
Xinhua

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