60 YEARS

Organization of the Petroleum Exporting Countries

2020 World Oil Outlook 2045

2020
World Oil Outlook
2045

Organization of the Petroleum Exporting Countries

Digital access to the WOO: an interactive user experience 24/7

OPEC's World Oil Outlook (WOO) is part of the Organization's commitment to market stability. The publication is a means to highlight and further the understanding of the many possible future challenges and opportunities for the oil industry. It is also a channel to encourage dialogue, cooperation and transparency between OPEC and other stakeholders within the industry.

As part of OPEC's ongoing efforts to improve user experience of the WOO and provide data transparency, two digital interfaces are available: the OPEC WOO App and the interactive version of the WOO.

The OPEC WOO App provides increased access to the publication's vital analysis and energy-related data. It is ideal for energy professionals, oil industry stakeholders, policymakers, market analysts, academics and the media. The App's search engine enables users to easily find information, and its bookmarking function allows them to store and review their favourite articles. Its versatility also allows users to compare graphs and tables interactively, thereby maximizing information extraction and empowering users to undertake their own analysis.

The interactive version of the WOO also provides the possibility to download specific data and information, thereby enhancing user experience.

Available for Android and iOS

Download OPEC WOO App

Access the interactive version

OPEC is a permanent, intergovernmental organization, established in Baghdad, Iraq, on 10–14 September 1960. The Organization comprises 13 Members: Algeria, Angola, Republic of the Congo, Equatorial Guinea, Gabon, the Islamic Republic of Iran, Iraq, Kuwait, Libya, Nigeria, Saudi Arabia, the United Arab Emirates and Venezuela. The Organization has its headquarters in Vienna, Austria.

Helferstorferstrasse 17
A-1010 Vienna, Austria
www.opec.org

ISBN 978-3-9504890-0-2

Download: All the data presented in this Outlook is available at www.opec.org.

Acknowledgements

Secretary General, Chairman of the Editorial Board
Mohammad Sanusi Barkindo

Director, Research Division, Editor-in-Chief
Ayed S. Al-Qahtani

Head, Energy Studies Department, Editor
Abderrezak Benyoucef

Head, Public Relations & Information Department
Hasan Hafidh

Main contributors
Chapter 1: Key assumptions
Mohammad Alkazimi, Joerg Spitzy, Moufid Benmerabet, Roman Salo, Nadir Guerer, Irene Etiobhio, Jan Ban

Chapter 2: Energy demand
Erfan Vafaie Fard, Haris Aliefendic, Moufid Benmerabet, Mustapha Sugungun, Jan Ban, Julius Walker

Chapter 3: Oil demand
Jan Ban, Mustapha Sugungun, Moufid Benmerabet, Roman Salo

Chapter 4: Liquids supply
Julius Walker, Mohammad Alkazimi, Nadir Guerer

Chapter 5: Refining outlook
Haris Aliefendic, Moufid Benmerabet, Martin Tallett, Alanna Bock-Butler

Chapter 6: Oil movements
Haris Aliefendic, Martin Tallett, Alanna Bock-Butler

Chapter 7: Energy policy, climate change and sustainable development
Jan Ban, Eleni Kaditi, Daniel McKirdy, Irene Etiobhio

Chapter 8: Oil demand and supply uncertainties
Jan Ban, Julius Walker, Eleni Kaditi

The OPEC Secretariat is grateful for the kind contribution from the Gas Exporting Countries Forum (GECF), featured in Chapter 2

Other contributors
Behrooz Baikalizadeh, Boshra AlSeiari, Mohammad Zarie Zare, Mohamed Mekerba, Hossein Hassani, Hassan Balfakeih, Mohammad Ali Danesh, Yacine Sariahmed, Aziz Yahyai, Pantelis Christodoulides, Hannes Eichner, Roland Kammerer, Klaus Stoeger, Mohammad Sattar, Zairul Arifin, Mihni Mihnev, Justinas Pelenis

Editorial Team
Timothy Spence, James Griffin

Design & Production Team
Carola Bayer, Andrea Birnbach

Editorial support
Menhal Alamri, Daniel McKirdy, Angelika Hauser, Amani Shebaro

OPEC's Economic Commission Board (as of September 2020)
Achraf Benhassine, Ntika Mbiya Ricardo, Florencio Oyono Eneme Obono, Fernand Epigat, Afshin Javan, Mohammed Saadoon Mohsin, Mohammad Khuder Al-Shatti, Taher M.O. Najah, Mele Kyari, Esam Alkhalifa, Salem Hareb Al Mehairi, Ronny Romero

Contents

List of boxes

List of tables

List of figures

Foreword

This year's **World Oil Outlook (WOO)** is unlike any of its predecessors. When the groundwork for this **14th edition** of the publication began, we were just becoming aware of a limited outbreak of a new strain of coronavirus, **COVID-19**. Little did we know then that it would spread with unprecedented speed and force, causing unimaginable global humanitarian and economic consequences.

The pandemic's impact and resulting containment efforts precipitated one of the most tumultuous periods in the history of oil. The global industry faced an **existential threat**, especially in **April 2020**, when **oil demand** collapsed and storage capacity came dangerously close to being exhausted in some parts of the world.

Against this backdrop, producing the **WOO 2020** presented major challenges. Uncertainty about the pandemic's duration complicated the task of assessing its potential longer-term impact. With no modern parallel as a reference, it was difficult to take account of exceptional factors, including the worldwide grounding of **aviation** fleets and wholesale national **lockdowns**. The possibility of a 'new normal' in working and living patterns, and their potential to alter energy needs going forward, presented a further challenge.

Nonetheless, our researchers and analysts have produced a **comprehensive WOO** that explores the prospects for the global **economy**, **energy demand**, as well as oil **supply and demand** in the upstream and downstream sectors. Furthermore, the **WOO 2020** uses different scenarios and sensitivities to explore the implications of the pandemic across the board.

For the first time, the **WOO 2020** extends the outlook to **2045**, creating a new **Reference Case** for our projections. This provides the space to expand upon developments identified in past years, such as expectations for an evolutionary shift of economic and energy demand growth to **developing countries**, especially those in **Asia** and the **Middle East & Africa**.

With a longer perspective, we also see the growing importance of renewables and natural gas in meeting future demand. Nonetheless, **oil will continue to account for the largest share of the energy mix** by **2045**, providing a **stable foundation** for addressing global energy needs for years to come.

The **WOO 2020** assesses the **upstream**, **midstream** and **downstream investment** needs of the oil industry, especially in light of the setback caused by the pandemic-related market shock. Sustainable investment is vital to support the **technological innovations and capacity development** that will address the world's growing thirst for energy.

Climate and environmental policies will continue to shape the future of energy, which is why the **WOO** closely examines their potential impact on oil and other forms of energy in the coming years. Closely linked to **climate change** is the urgent need to close the **energy poverty** gap. **COVID-19** is a stark reminder of the need to find **inclusive** and **collaborative solutions** to these global challenges and to create a more resilient future for humankind.

Finally, this edition of the **WOO** coincides with two defining moments: the **60th anniversary of OPEC** and the **Organization's** pivotal leadership in response to the market shock stemming from **COVID-19**.

OPEC, together with the **non-OPEC** oil-producing countries in the **Declaration of Cooperation** (DoC), undertook the largest and longest production adjustments in the oil industry's history, initially amounting to nearly **10%** of global output. Building on more than three years of a tested and proven framework for cooperation, this bold and decisive action helped arrest the market's freefall, supported the draw-down of unsustainable inventory levels and boosted market confidence. Importantly, the DoC's response has provided a platform to support a **global economic recovery**.

In a year without precedent, we are very proud to bring you this exceptional edition of the **WOO** with the hope that it enriches the global energy **dialogue** and inspires **closer cooperation**. I would like to thank **OPEC's Member Countries** for their unfailing support in making this flagship annual publication possible. The entire staff of the **OPEC Secretariat** merit special recognition for researching, writing, producing and distributing the **WOO** under extraordinary circumstances.

As we turn an important page in our history, **OPEC's** commitment to securing an efficient, economic and steady supply of oil to consuming countries, and providing essential support to the global economy, is as unshakable today as it was when the **Organization** was founded **60 years** ago.

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 and is consistent with the July 2020 edition of OPEC's Monthly Oil Market Report (MOMR). The forecast period in this 14th edition of the Outlook was extended to 2045.

The outbreak of the COVID-19 pandemic resulted in the sharpest downturn in energy and oil demand in living memory

Since the publication of the WOO 2019 in November last year, the market has been transformed by the unprecedented scale and reach of the COVID-19 pandemic. What started at the beginning of this year as allegedly another SARS-like epidemic of 2003 to 2004 soon became a major pandemic, affecting countries around the globe and leading to the most severe economic downturn since the Great Depression in the 1930s.

OPEC and its partners in the DoC took the bold move to stabilize oil prices and to rebalance oil markets

Faced with the COVID-19 challenge, OPEC Member Countries and other participants in the Declaration of Cooperation (DoC) took the bold move in April 2020 to collectively adjust down production over a two-year period, starting with almost 10 million barrels per day (mb/d), or around 10% of global supply, which has helped put oil markets on a path to rebalance.

The COVID-19-induced recession and extension of the forecast period to 2045 have brought average long-term global GDP growth down to 2.9% p.a.

The overarching challenge of COVID-19 is expected to impair the growth rates in almost all economies over the medium-term. The average Organisation for Economic Co-operation and Development (OECD) growth rate will stand at 0.7% per annum (p.a.) in the period from 2019 to 2025, compared to the pre-COVID-19 projected growth level of 2.1% p.a.

For non-OECD countries, gross domestic product (GDP) is expected to grow by 3.4% p.a. on average during the same period, which is more than 1 percentage point (pp) lower compared to past projections. In the long-term, incremental GDP growth will be mainly driven by non-OECD countries. These countries are expected to grow by 3.7% p.a. on average between 2019 and 2045, largely on the back of improving labour productivity, even as the pace of GDP growth begins to slow.

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

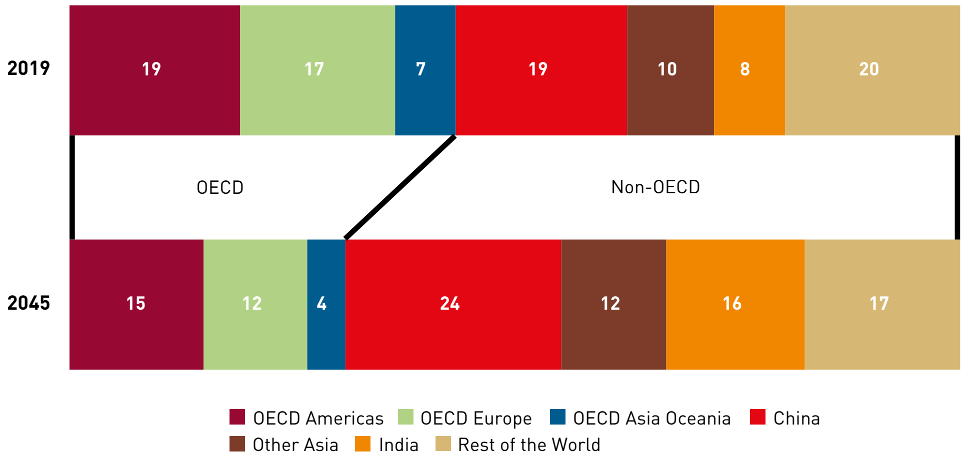
	2019–2025	2025–2035	2035–2045	2019–2045
OECD	0.7	1.9	1.9	1.6
Non-OECD	3.4	4.2	3.5	3.7
World	**2.3**	**3.3**	**3.0**	**2.9**

Source: OPEC.

The global economy in 2045 will be more than double the size it was in 2019

Global GDP is projected to rise from around $121 trillion in 2019 to more than $258 trillion in 2045 based on 2011 purchasing power parity (2011 PPP). China and India alone will account for 40% of global GDP in 2045. The share of OECD countries will decline to 31% in 2045 compared to around 43% in 2019. OECD Americas is forecast to remain the region with the highest GDP per

Distribution of the global economy in 2019 and 2045 %



Source: OPEC.

capita, followed by OECD Asia Oceania and OECD Europe. The lowest GDP per capita is expected for the regional grouping of the Middle East & Africa. This will be the only region where the average income is less than $10,000 (2011 PPP) in 2045.

The global population is expected to reach 9.5 billion by 2045

The global population is expected to increase by 1.7 billion throughout the forecast period, reaching 9.5 billion people by 2045 compared to around 7.7 billion in 2019. The disparity in population growth between the OECD and non-OECD is a major feature of these projections, as almost 96% of the growth is foreseen in non-OECD regions. The global working-age population (15–64) is estimated to grow by close to 1 billion over the period from 2019 to 2045. The share of the global working-age population is estimated to decline from 65% in 2019 to 63% in 2045. In addition, 66% of the world's population is projected to come from urban regions by 2045.

Policies relating to energy demand and supply are expected to become more stringent over the forecast period

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. While many countries are notionally signed up to a global, collective effort to combat climate change, the majority of policies relating to energy demand and supply will continue to be set and enforced at the national level, resulting in continued disparity in the scope of policy ambitions among countries and regions. This Outlook takes into account enacted policies in many countries, with a careful assessment of potential implications, as well as indicated targets of policymakers that signal the direction of future changes.

Technological advancements are set to shape the global energy landscape

Electricity generation, which currently relies heavily on fossil fuels, will see a rising penetration of renewable sources such as wind and solar. The development of blue hydrogen, which could be of interest for future oil applications, is also under way and is reliant on the expansion of carbon capture and storage (CCS) or carbon capture and utilization (CCU). For a more innovative approach to heating buildings and producing hot water for residential consumers, heat pumps offer an option.

Internal combustion engines (ICEs) will remain dominant in the road transportation sector for the foreseeable future. Nevertheless, electric mobility will gradually penetrate the car fleet to significant levels.

Despite the huge drop in 2020, global primary energy demand is forecast to continue growing in the medium- and long-term, increasing by 72 mboe/d in the period to 2045

Global primary energy demand is forecast to increase from 289 million barrels of oil equivalent per day (mboe/d) in 2019 to 361 mboe/d in 2045. This represents an average growth rate of 0.9% p.a. over the forecast period. In this period, energy demand in non-OECD countries is expected to increase by 76.5 mboe/d, while demand in the OECD is estimated to drop by around 4.4 mboe/d.

In this regard, India, China and other developing countries (DCs) with increasing populations and high economic growth play a key role in increasing energy demand while developed nations in the OECD are exerting more of their efforts on energy efficiency and low-carbon technologies. Consequently, nearly half of total energy demand growth is expected to come from India and China.

Total primary energy demand per region, 2019–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Share *%*	
	2019	2025	2030	2035	2040	2045	2019–2045	2019–2045	2019	2045
OECD	111.1	108.7	109.0	108.4	107.4	106.7	–4.4	–0.2	38.4	29.5
Non-OECD	178.1	194.3	212.9	229.8	244.9	254.6	76.5	1.4	61.6	70.5
World	**289.1**	**303.0**	**321.9**	**338.1**	**352.3**	**361.3**	**72.1**	**0.9**	**100.0**	**100.0**

Source: OPEC.

Oil will remain the fuel with the largest share of the global energy mix until 2045

Assuming that the COVID-19 pandemic is largely overcome by next year, oil demand is projected to partly recover in 2021. Healthy growth rates are expected especially over the medium-term horizon, resulting in oil demand reaching the level of 94.4 mboe/d in 2025 and further progressing to

Total primary energy demand by fuel type, 2019–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Fuel share *%*	
	2019	2025	2030	2035	2040	2045	2019–2045	2019–2045	2019	2045
Oil	91.0	94.4	97.7	99.3	99.7	99.5	8.5	0.3	31.5	27.5
Coal	77.1	75.1	75.1	74.3	72.8	71.0	–6.1	–0.3	26.7	19.7
Gas	66.9	69.8	76.2	82.2	87.3	91.2	24.3	1.2	23.1	25.3
Nuclear	14.4	16.1	17.5	19.1	20.8	22.1	7.7	1.7	5.0	6.1
Hydro	7.3	8.1	8.8	9.5	10.2	10.5	3.2	1.4	2.5	2.9
Biomass	26.4	28.9	31.0	32.9	34.6	35.5	9.1	1.2	9.1	9.8
Other renewables	6.0	10.6	15.5	20.8	26.8	31.4	25.4	6.6	2.1	8.7
Total	**289.1**	**303.0**	**321.9**	**338.1**	**352.3**	**361.3**	**72.1**	**0.9**	**100.0**	**100.0**

Source: OPEC.

99.5 mboe/d in 2045. In 2019, oil represented for more than 31% of global energy demand and is projected to remain the largest contributor to the energy mix to 2045, accounting for more than 27%, followed by gas (about 25%) and coal (almost 20%).

Natural gas will be the fastest-growing fossil fuel between 2019 and 2045

Global gas demand is expected to continue expanding as a result of rising levels of urbanization, growth in industrial demand and greater competitiveness over coal in the power generation mix. Global demand for gas is expected to increase from nearly 67 mboe/d in 2019 to 91 mboe/d in 2045, resulting in natural gas being the second-largest contributor to the primary energy mix.

Coal will be the only primary fuel for which demand declines between 2019 and 2045

Coal is currently still the second major fuel in the primary energy mix but it is losing its share to other energy sources. All over the globe, many coal-fired power plants are being displaced by renewables and gas. Demand for coal is projected to decline at the average rate of 0.3% p.a. within the 2019–2045 Outlook period. There are two main reasons for this change. The first is a result of shutdowns and replacement of coal-fired power plants in the OECD region. The second is the introduction of more energy-efficient technologies in developing regions as carbon abatement is prioritized. Despite the global decline, coal demand in India is expected to grow between 2019 and 2045 at a pace of 2.6% p.a. on average.

'Other renewables' retain the position of fastest growing source of energy in both relative and absolute terms

Between 2019 and 2045, 'other renewables' – combining mainly solar, wind and geothermal energy – will grow by 6.6% p.a. on average, which is significantly faster than any other source of energy. This will result in substantial growth in absolute terms for 'other renewables' of more than 25 mboe/d, which is more than the increase in demand for gas (24 mboe/d) over the same period.

Within the forecast period, growth in electricity generation is set to continue at rates much higher compared to overall primary energy demand

Rising electricity demand is the result of economic development, population growth and the expanding use of electricity in areas such as digitalization, cooling and transportation, as well as greater electricity access in developing regions. Primary energy demand is expected to increase at an average rate of 0.9% p.a. between 2019 and 2045 while, at the same time, electricity generation is expected to increase by 2.2% p.a. on average. In line with expectations for economic and population development, the majority of growth in power generation will come from developing countries.

Oil demand growth is expected to recover during the medium-term

After recovering from a turbulent 2020 in the medium-term, global oil demand is projected to continue growing at relatively high annual rates to reach a level of 103.7 mb/d by 2025. Annual increments will be relatively high, especially in 2022 and 2023, at 2.1 mb/d and 1.5 mb/d, respectively. There are two main reasons for this expectation. The first relates to a return to pre-COVID-19 economic growth rates during these years, especially in the major developing countries. The second is linked to demand 'catching up', especially in the sectors affected the most by restrictions during the COVID-19 crisis. These include the aviation, road transport and industry sectors. The rest of the medium-term will be marked by further 'normalization' of demand growth in which longer-term trends and factors will come to the forefront, leading towards moderate levels of annual incremental demand of slightly above 1 mb/d.

In the long-term, oil demand is projected to reach 109.1 mb/d by 2045

At the global level, oil demand is expected to increase by almost 10 mb/d over the long-term, rising from 99.7 mb/d in 2019 to 109.3 mb/d in 2040 and to 109.1 mb/d in 2045. This represents a downward revision of more than 1 mb/d compared to the 2040 levels projected in the WOO 2019. The more pronounced effect of the COVID-19 pandemic on oil demand in the OECD has further exacerbated the divergent trends between the OECD and non-OECD regions. OECD demand is expected to plateau around 47 mb/d between 2022 and 2025 before it starts a longer-term decline towards 35 mb/d by 2045.

In contrast, demand will continue growing 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 22.5 mb/d between 2019 and 2045, and reach 74.3 mb/d in 2045. The largest contributor to this incremental demand is anticipated to be India, adding some 6.3 mb/d between 2019 and 2045.

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

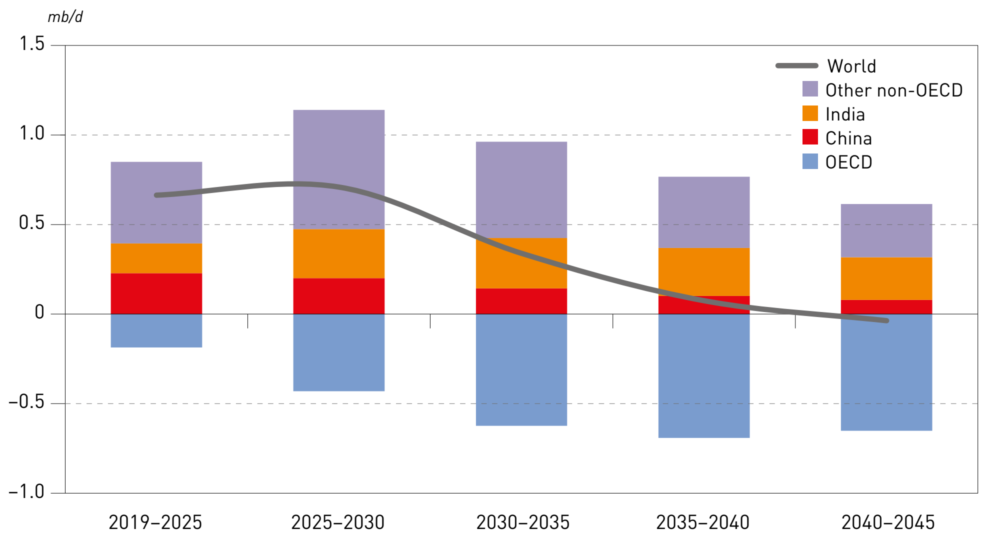
	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
OECD	47.9	43.0	46.8	44.6	41.5	38.0	34.8	–13.1
Non-OECD	51.8	47.8	56.9	62.6	67.4	71.2	74.3	22.5
World	**99.7**	**90.7**	**103.7**	**107.2**	**108.9**	**109.3**	**109.1**	**9.4**

Source: OPEC.

Global oil demand will plateau during the second half of the Outlook period

Considering strong fluctuations during the medium-term period, average incremental demand to 2025 is projected at 0.7 mb/d p.a. A comparable rate of growth is also expected in the period to 2030. This, however, will change quite significantly during the next five-year period as the decline

Average annual oil demand increments by region, 2019–2045



Source: OPEC.

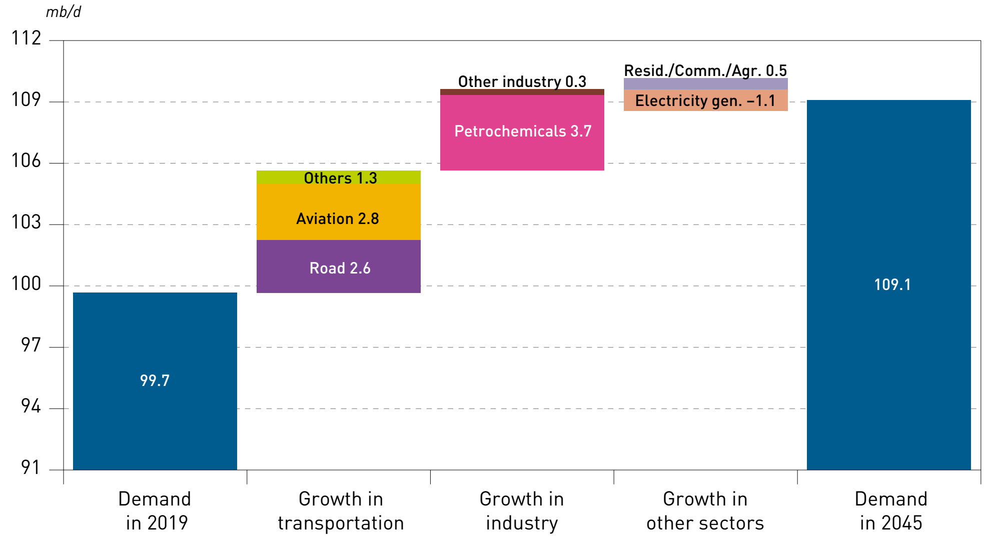
in the OECD will accelerate and demand growth in the non-OECD starts to decelerate. Global oil demand will grow at relatively healthy rates during the first part of the forecast period before demand begins to plateau over a relatively long period during the second half.

Oil demand in road transportation will continue to dominate the sectoral breakdown but the largest growth will come from petrochemicals

In 2019, road transportation represented 45% of global demand at 44.4 mb/d. Demand in this sector was hit hard in 2020 due to COVID-19 lockdowns, losing more than 4 mb/d compared to 2019. Over the medium- and long-term, however, oil demand in the road transportation sector is expected to continue growing and reach a level of 47 mb/d in 2045.

Oil demand in the aviation sector was most affected by COVID-19 restrictions in relative terms, declining by almost 50% during 2020 on an annual basis. Demand for aviation is projected to partly recover in 2021 and will continue growing thereafter, though it will likely only reach 2019 levels in 2023–2024. Despite this temporary decline, aviation demand is expected to grow significantly over the long-term. However, the petrochemical sector is projected to be the largest single contributor to incremental oil demand over the forecast period, growing by 3.7 mb/d.

Oil demand growth by sector



Source: OPEC.

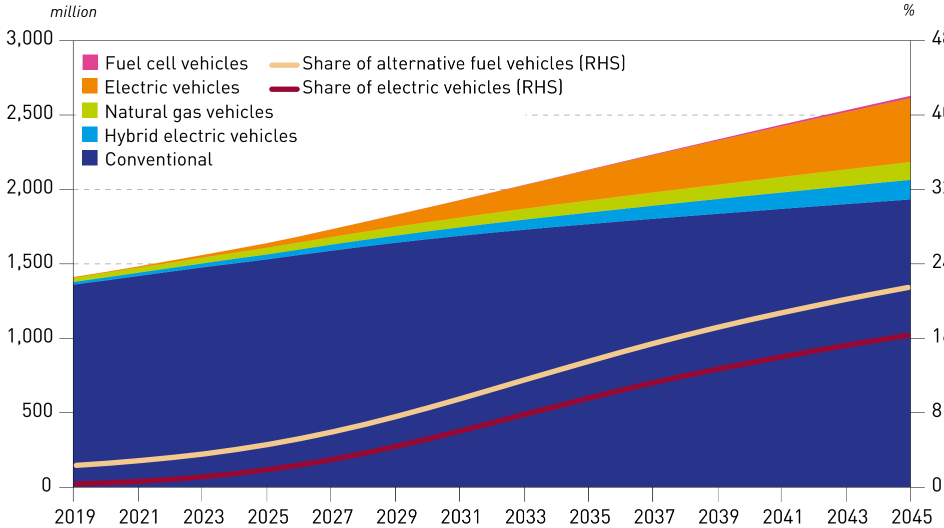
Rising penetration of alternative vehicles will limit oil demand growth in the road transportation sector

In the years to come, road transportation is forecast to witness a strong decoupling between oil demand on the one hand, and commercial transport services and the number of vehicles on the road on the other. This will primarily result from efficiency improvements driven by technological developments, the tightening of energy policies, and an increasing penetration of electric vehicles (EVs), natural gas vehicles (NGVs) and to some extent hydrogen-based vehicles.

Of the total of 2.6 billion vehicles on the road by 2045, around 430 million will be EVs, clearly constituting the second-largest group after internal combustion engine (ICE) vehicles. The share of EVs is projected to reach around 5% in 2030, 13% in 2040 and more than 16% in 2045. NGVs will number around 120 million by then but are overtaken by EVs around 2030.

Therefore, even as oil demand related to passenger cars grows at a healthy pace at the beginning of the forecast period, it starts to plateau within the next ten years and declines during the second part of the forecast period. This is mainly attributable to powertrain substitution and improving efficiency of passenger car fleets, factors that are present to a much lesser extent in the commercial vehicle segment. In the latter, continued GDP growth, especially in developing countries, will provide support for the ongoing expansion of the commercial vehicle fleet. This, in turn, will keep overall demand in the road transport sector at a relatively stable level of around 47 mb/d.

Composition of the global vehicle fleet, 2019–2045



Source: OPEC.

Non-OPEC liquids supply to recover from 2021

On the supply side, the impact of the COVID-19 pandemic, which resulted in a halving of oil prices, led to an historic downward production adjustment of nearly 10 mb/d by DoC participating countries. Production elsewhere was shut-in after it became uneconomic, including some 2–3 mb/d of US crude. These measures have helped to return stability to oil markets as they gradually rebalance.

Following an expected sharp decline of 3.3 mb/d in 2020, its first annual drop since 2016, non-OPEC liquids supply will grow modestly in 2021 and pick up momentum in the following years, thus increasing from 65 mb/d in 2019 to 70.7 mb/d in 2025. Medium-term recovery is driven mainly by Brazil, which grows by 1.7 mb/d, the US (+1.4 mb/d), Norway (+0.8 mb/d), Guyana (+0.7 mb/d) and Kazakhstan (+0.5 mb/d).

US tight oil will grow until around 2030, but not as much as previously expected

Despite being the most affected by shut-ins due to its inherent responsiveness to price, US tight oil is expected to recover quickly as market conditions improve, and will grow by 2.8 mb/d to 14.5 mb/d in the medium-term. It will continue to increase modestly thereafter, plateauing at 15.8 mb/d around 2030, but is not expected to reach heights projected in previous Outlooks.

Non-OPEC supply declines again in the long-term; OPEC liquids to fill the gap

Only a small number of non-OPEC producers show meaningful supply growth post-2025, including Canada, Qatar, Kazakhstan and Guyana. Most other non-OPEC producers see output stagnate or decline. As such, non-OPEC supply declines from a peak of 71.8 mb/d in 2027 to 65.4 mb/d by 2045, and thus is broadly flat when comparing 2019 and 2045. OPEC liquids will increase from 33.8 mb/d in 2019 to 43.9 mb/d in 2045, resulting in Member Countries' share of global liquids rising from 34% in 2019 to 40% in 2045.

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

	2019	2020	2025	2030	2035	2040	2045	Change 2019–2045
OECD	30.0	28.5	32.5	32.3	30.8	29.1	27.7	–2.3
of which: US	*18.4*	*17.0*	*19.8*	*20.3*	*19.1*	*17.7*	*16.6*	*–1.8*
of which: tight liquids	*11.7*	*10.9*	*14.5*	*15.8*	*15.4*	*14.3*	*13.3*	*1.6*
Non-OECD	32.8	31.2	35.9	36.7	36.5	35.7	34.7	2.0
Processing gains	2.3	2.1	2.4	2.6	2.7	2.8	3.0	0.7
Non-OPEC	**65.0**	**61.8**	**70.7**	**71.5**	**69.9**	**67.6**	**65.4**	**0.4**
of which: crude*	*45.9*	*43.5*	*50.0*	*48.9*	*46.0*	*43.0*	*40.3*	*–5.6*
NGLs	*10.5*	*10.3*	*11.3*	*12.5*	*13.0*	*13.2*	*13.2*	*2.7*
global biofuels	*2.5*	*2.3*	*2.8*	*3.1*	*3.3*	*3.5*	*3.6*	*1.0*
other liquids	*3.8*	*3.6*	*4.3*	*4.6*	*4.9*	*5.1*	*5.4*	*1.6*
Total OPEC liquids	**33.8**	**30.7**	**33.2**	**35.9**	**39.2**	**41.9**	**43.9**	**10.1**
World	**98.9**	**92.4**	**103.9**	**107.4**	**109.1**	**109.5**	**109.3**	**10.4**

* *The breakdown of non-OPEC supply does not include processing gains.*

Source: OPEC.

Cumulative oil-related investment requirements over the long-term will be $12.6 trillion

Possible downside risks to the global supply outlook could stem from reduced upstream investment, which is forecast to decline by over 30% in 2020, but will recover to 2019 levels by 2024/2025, according to Rystad Energy. To meet global oil demand, future upstream spending will need to average $380 billion p.a. over the long-term. Cumulatively, this means $9.9 trillion (in 2020 dollars) will be required. Added to $1.5 trillion for the downstream, and $1.2 trillion in the midstream, cumulative oil-related investment requirements over the long-term will be $12.6 trillion.

Distillation capacity additions during the medium-term reach 5.2 mb/d, mostly in the Middle East and Asia-Pacific

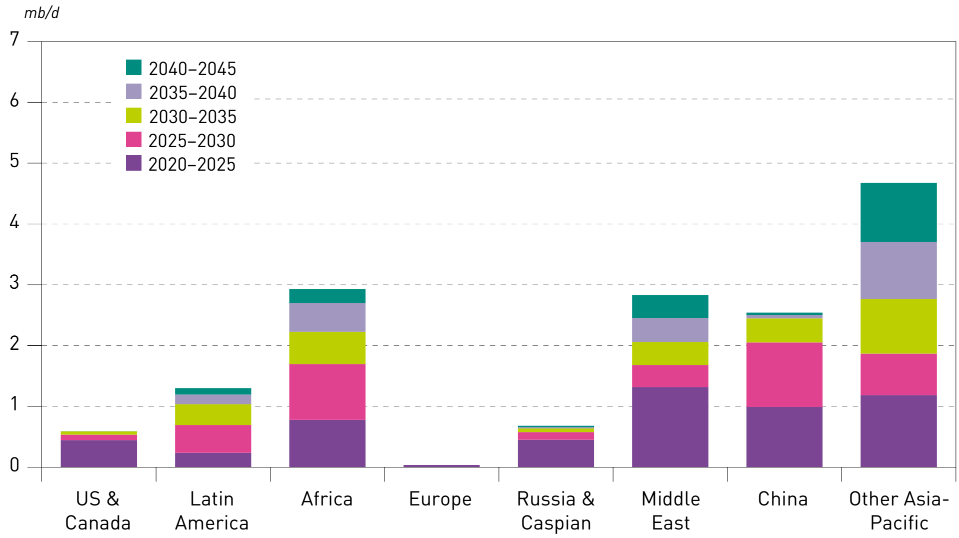
Around 3.8 mb/d of new refining capacity is projected to come online by 2022, with a significant slowdown in additions from 2023 onward. In 2025, expected additions are below 0.2 mb/d. Over 80% of additions by 2025 will be located in the Asia-Pacific (2.1 mb/d), the Middle East (1.3 mb/d) and Africa (0.8 mb/d), driven by oil demand growth and intentions to increase refined product exports.

Crude distillation capacity is expected to increase by 15.6 mb/d until 2045, with a significant slowdown in the rate of required additions

Following the slowdown of demand growth over the course of the forecast period, the annual rate of required additions drops to an average level of 350 thousand barrels per day (tb/d) between

2040 and 2045, down from 0.9 mb/d between 2020 and 2025. This Outlook confirms the trend of refining capacity increasingly migrating to new demand centres in developing countries. Additions of 13 mb/d will be located in the Asia-Pacific (7.2 mb/d), the Middle East (2.8 mb/d) and Africa (2.9 mb/d). At the same time, developed regions are likely to see only minor additions as demand in these regions declines. In terms of secondary capacity, around 7.9 mb/d of new conversions, 17.7 mb/d of desulphurization additions and 5 mb/d of octane units are projected to be commissioned between 2020 and 2045.

Distillation capacity additions, 2019–2045



Source: OPEC.

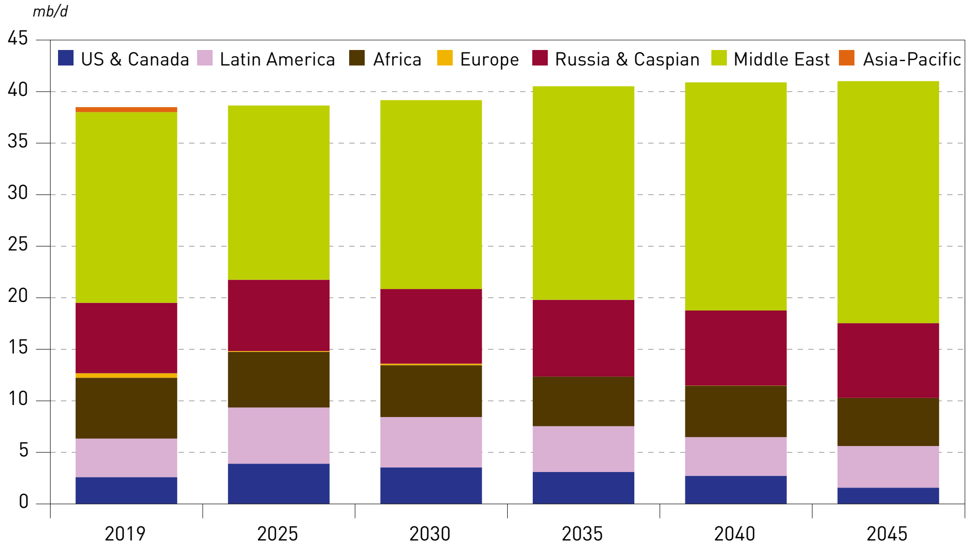
The sudden demand drop caused by the COVID-19 pandemic resulted in a market imbalance between available capacity and the call-on-refining

Relative to 2019, the required refining capacity is expected to plunge in 2020 due to the large demand drop. The resulting gap between potential (based on refinery additions) and required refining capacity is estimated at around 8.5 mb/d in 2020. The gap is projected to narrow to levels between 4 mb/d and 5 mb/d in 2021 and 2022, signalling a period of higher competition with subdued refining margins. In the long-term, the market imbalance is increasingly visible in developed regions with refinery utilization rates declining significantly. Consequently, closures of around 6 mb/d in the long-term (on top of assumed closures of 2.5 mb/d in the medium-term) are estimated as necessary, in order to stabilize utilization rates at levels around 80%.

Global crude and condensate trade between major regions remains stable between 2019 and 2030 at around 38.5 mb/d and increases gradually to 41 mb/d by 2045

Crude and condensate trade by 2030 is expected to be dominated by higher flows from the US & Canada as well as Latin America, in line with higher supply. At the same time, exports from Africa decline as domestic use of crude increases. Middle East exports drop from 18.5 mb/d in 2019 to below 17 mb/d in 2025 due to lower demand for OPEC liquids and higher domestic use, but recover by 2030. After 2030, crude and condensate flows from the Middle East increase to 23.5 mb/d in 2045, along with modest export growth from the Russia & Caspian region. Other regions are projected to see lower crude and condensate exports due to declining supply (e.g. the US) and higher domestic use (Latin America and Africa).

Global crude oil exports by origin, 2019–2045*



* *Only trade between major regions considered.*
Source: OPEC.

Asia-Pacific remains the most important crude oil importing region throughout the forecast period, with imports rising by more than 6 mb/d

Crude and condensate flows between the Middle East and Asia-Pacific remain the most important trade link, with volumes increasing from around 15 mb/d in 2019 to nearly 20 mb/d in 2045. However, other suppliers are expected to ship more volumes to the Asia-Pacific as well, such as the US & Canada, Latin America (especially between 2025 and 2035) and Russia & Caspian. The second most important importing region, Europe, is likely to see a significant drop in crude and condensate imports, declining from 10 mb/d in 2019 to around 7.5 mb/d in 2045, driven by shrinking demand and lower refinery throughputs.

International cooperation could allow a more coherent, balanced and integrated approach for realizing the Paris Agreement goals in the context of sustainable development

The Paris Agreement stipulates the relationship that climate change actions, responses and impacts could have with equitable access to sustainable development. Recognizing the specific needs and special circumstances of developing countries, the Agreement aims to strengthen the global response to the challenges of climate change by giving consideration to sustainable development and efforts to eradicate poverty. The COVID-19 pandemic makes this more urgent, especially in developing countries, which feel the effects acutely. For the world to emerge from this crisis, a surge in international solidarity and cooperation is needed to achieve a more sustainable, inclusive and resilient future. Energy access for all is an action area that could be leveraged to facilitate the coherent implementation of climate action and sustainable development objectives.

Enhanced collaboration and identification of mitigation options are vital to address the challenge of climate change

While countries strive to address the challenge of climate change, governments assess and implement different mitigation policies and measures. Analyses show that there is no one-size-fits-all approach to mitigating climate change. Energy-exporting developing countries are likely to experience significant socio-economic consequences due to mitigation action and response measures, particularly in those countries with limited access to financing and technology. In view of such vulnerabilities, it is essential to establish or restore the very foundations of resilience and stability in these societies, identifying mitigation options that could lead to 'win-win' solutions with environmental and socio-economic benefits while enhancing collaboration among countries.

Future oil demand and supply is clouded by many uncertainties

In addition to the challenge of climate change, the COVID-19 pandemic, the related economic crisis and changing consumer behaviour have added additional depth to existing uncertainties surrounding future prospects for oil demand and supply. Some of these are explored in detail in sensitivity cases developed in this Outlook. To address the issue of economic development, two alternative cases were considered, indicating that the range of oil demand in 2045 could be as wide as 8 mb/d. Moreover, adoption of more stringent energy policies and faster penetration of energy-efficient technologies could expand this range to 10 mb/d. On the supply side, broadly similar ranges of uncertainty with regard to medium- and long-term non-OPEC prospects result from sensitivities around the resource base, technology, the role of policy and upstream investment, in addition to paths for post-pandemic recovery.

Introduction

The year 2020 will be remembered primarily for the omnipresence, as well as unprecedented scale and reach, of the COVID-19 pandemic. From an energy point of view, the lockdown-induced economic recession has resulted in the sharpest downturn in energy and oil demand in living memory. Compared to 2019, oil demand is estimated to decline by 9 mb/d on an annual basis while demand in the second quarter of the year declined by more than 17 mb/d. As a result, oil markets plummeted, with Brent halving as the crisis unfolded. The US crude benchmark WTI made headlines when it plunged into negative territory on 20 April for the first time ever. This, however, was something of an anomaly related to the front-month futures contract's expiry that day, and not really reflective of oil market fundamentals.

Faced with this challenging environment, OPEC Member Countries and the other participants in the DoC took the bold move in April 2020 to collectively adjust down production by a record 9.7 mb/d, or around 10% of global supply. This action helped to stabilize the oil markets and set them on a path to rebalance over the course of the next few years, as the global economy recovers from its worst shock since the Great Depression of the 1930s. Other producers also contributed to the rebalancing, especially US shale producers as they were forced to shut-in as much as 2–3 mb/d of crude production in 2020.

Going forward, the big question hanging over energy and oil markets is to what extent there will be a longer-term impact on consumer behaviour and thus demand. Ongoing discussion centres around the impacts of more people working from home, thus reducing commutes; shifting consumer behaviour; and further adjustments in energy policies. International travel has been sharply curtailed, and many question whether business travel in particular will ever return to previous levels, even if leisure travel recovers. In line with the demand drop, the refining sector was also badly hit, with utilization rates dropping to historic lows. Therefore, a period of consolidation in the downstream sector seems unavoidable at the moment. At least until a vaccine against COVID-19 or effective treatments are developed, it is possible the world will remain in a state of partial emergency for a sustained period.

Moreover, given that some of the massive stimulus programmes announced to combat the impact of the COVID-19 pandemic are explicitly designed to target support for 'green' projects, renewables and the like, an acceleration of the energy transition is possible. Proposals announced by the EU and its Member States stand as an example.

At the same time, despite a dip in carbon dioxide (CO_2) and other emissions in 2020 due to much-reduced economic activity, efforts to reduce GHG emissions remain on a path that is far from sufficient to reach the goals of the Paris Agreement. Many argue that further regulatory efforts to this end should not take precedence over economic recovery and job creation.

Therefore, the outlook in the Reference Case in the WOO 2020 is for healthy demand for energy and oil in the long-term, as global economic recovery, creating and maintaining jobs, and avoiding widespread poverty are the highest priorities on the agendas of global political and business leaders. Certainly, OPEC Member Countries remain steadfast in their efforts to work towards stable and sustainable growth, stability in oil markets, a reduction of energy poverty and increased energy access for all.

As such, this year's Reference Case reflects and paints a picture of a world that continues to need and use oil, albeit with demand growing to modestly lower heights in the long-term than previously envisaged. Even rolling the outlook period forward to a new horizon of 2045 shows that oil will remain the single-largest source of energy for the world for decades to come.

To highlight the well-known challenges of making long-term forecasts, particularly at this uncertain juncture, the WOO 2020 also examines critical uncertainties related to demand for energy and oil, and shows some alternative trajectories shaped by policy choices, the economic outlook and potential environmental target-setting. On the supply side, the WOO 2020 reviews sensitivities surrounding the outlook for non-OPEC liquids supply, which faces significant challenges of its own.

Key assumptions

Key takeaways

- The global population is expected to increase by over 1.7 billion people, from around 7.7 billion in 2019 to almost 9.5 billion in 2045.
- The majority of this growth is forecast in developing countries, particularly in the Middle East & Africa, followed by Other Asia, OPEC and India. China's population is expected to stabilize at current levels, meaning India's population will exceed that of China's sometime towards the end of the current decade.
- The working-age population (15–64) is estimated to grow by 982 million over the long-term forecast period. The relative share of the working-age population in the world's total is expected to decline from 65% in 2019 to 63% in 2045.
- The global urbanization rate is forecast to increase from 56% in 2019 to 66% in 2045.
- Global GDP is forecast to shrink by almost 4% in 2020 due to the COVID-19 pandemic and the subsequent lockdown measures.
- A recovery in GDP growth will take place in 2021 and a healthy average GDP growth rate of 3.3% is forecast in the current decade from 2022 onwards.
- Global economic growth is expected to reach 3.4% at the end of the medium-term period in 2025.
- In the long-term, global GDP growth will decelerate and is forecast to fall to 2.7% in 2045.
- Based on 2011 PPP, global GDP is projected to rise from around $121 trillion in 2019 to more than $258 trillion in 2045.
- China and India alone will account for 40% of global GDP in 2045, whereas the Organisation for Economic Co-operation and Development (OECD) region will account for 31%.
- OECD Americas is forecast to remain the region with the highest GDP per capita during the entire forecast period whereas the Middle East & Africa will still have the lowest GDP per capita.
- 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.
- This Outlook assumes an evolutionary development of existing technology and pays close attention to the impact of advanced technology in the global energy business.
- Ongoing progress in robotics is significantly supporting the expansion of remote operation processes, contributing to rising efficiency, as well as overall safety improvements in the oil and energy industry.

This chapter explores different, yet important, key assumptions shaping the Reference Case presented throughout the WOO. It addresses projected variations in population and demographic trends, economic growth and relevant energy-related policies. Additionally, the chapter looks into potential technology and innovations that could impact energy supply and demand.

1.1 Population and demographics

The world is experiencing incremental population growth while at the same time ageing significantly. The overall trend varies from one region to another and various countries are at different stages of transition to low population growth. The Organisation for Economic Co-operation and Development (OECD) region and some developing countries have already experienced these changes, but the transition in many other regions is projected to commence in the near future. As an input to the WOO analysis, the major demographic elements – consisting of population growth rate, working population, urbanization and immigration – have been investigated in detail.

Based on projections from the United Nations Department of Economic and Social Affairs Population Division (UNDESA, 2019), the global population is expected to increase by over 1.7 billion from around 7.7 billion recorded in 2019 to 9.5 billion projected for 2045 (Table 1.1).

The disparity in population growth between OECD and non-OECD is quite prevalent as almost 96% of the growth is foreseen in non-OECD regions. Table 1.1 shows that the largest portion (45%) of this growth by 2045 will come from the Middle East & Africa (excluding OPEC countries), whereas Other Asia, India and OPEC will each contribute between 14% and 17%. In the OECD region, the growth in the period to 2045 will mostly come from OECD Americas.

Table 1.1
Population by region

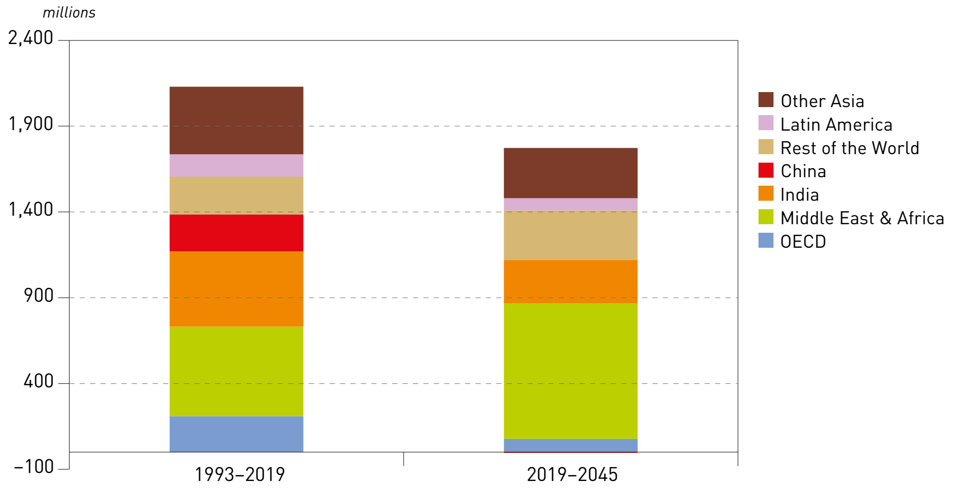
millions

	Levels							Growth
	2019	2020	2025	2030	2035	2040	2045	2019–2045
OECD Americas	516	520	537	554	570	583	594	78
OECD Europe	578	580	584	587	588	589	587	9
OECD Asia Oceania	217	217	217	215	213	210	207	–9
OECD	**1,311**	**1,317**	**1,338**	**1,356**	**1,371**	**1,382**	**1,388**	**78**
Latin America	470	474	493	509	523	534	542	72
Middle East & Africa	1,092	1,118	1,259	1,406	1,559	1,718	1,881	789
India	1,366	1,380	1,445	1,504	1,554	1,593	1,621	254
China	1,434	1,439	1,458	1,464	1,461	1,449	1,429	–4
Other Asia	1,204	1,218	1,289	1,352	1,408	1,456	1,496	293
OPEC	491	501	554	609	664	720	778	288
Russia	146	146	145	143	141	139	137	–9
Other Eurasia	198	198	201	203	204	205	206	9
Non-OECD	**6,400**	**6,475**	**6,844**	**7,190**	**7,513**	**7,814**	**8,091**	**1,691**
World	**7,711**	**7,792**	**8,181**	**8,545**	**8,885**	**9,196**	**9,479**	**1,769**

Source: United Nations (UN).

The regional population growth dynamics are shown in Figure 1.1. China's population will decline by four million between 2019 and 2045 whereas the observed growth for the previous 26 years (1993–2019) was 215 million, representing a turning point for China. This is the largest decrease in population growth among emerging economies. India, which added 439 million to the global population over the past 26 years, is assumed to see its growth contribution shrink to 254 million for the period from 2019 to 2045.

Figure 1.1
World population growth, 1993–2019 *versus* 2019–2045



Source: United Nations, OPEC.

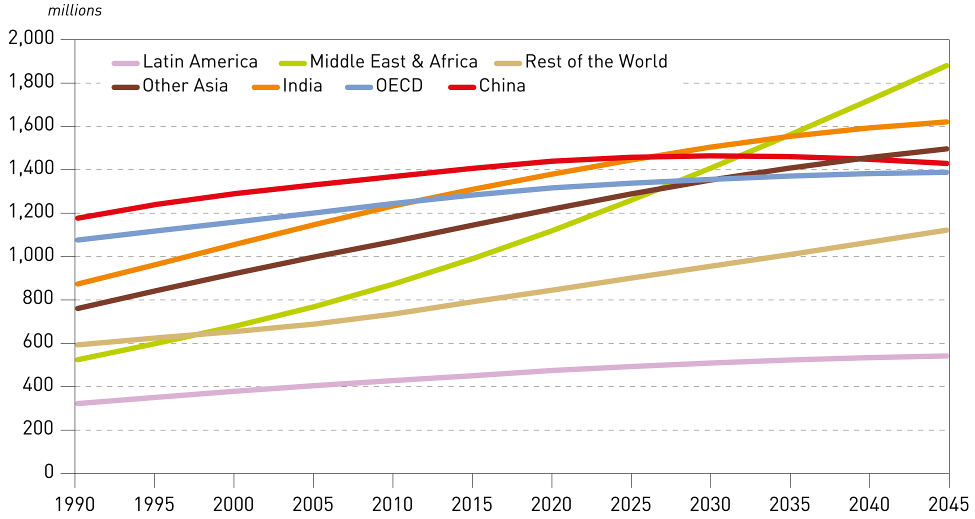
The population of the OECD is expected to grow by 78 million from 2019 to 2045, a much lower level than the 209 million observed from 1993 to 2019. The Middle East & Africa (excluding OPEC) region is currently experiencing a swift rate of population growth, with this trend expected to remain towards the end of the projection period. Notably, this is the only region that is expected to grow faster (adding 789 million people) in the period between 2019 and 2045, compared to the 522 million added in the 1993–2019 period. This development means the Middle East & Africa region will have the largest growth share of the world's population in 2045.

Looking at historical and projected trends, spanning from 1990 to 2045 (Figure 1.2), India's population will exceed that of China in the second half of the 2020s and is expected to have the second-largest regional share of the global population by 2045, after the Middle East & Africa. A similar change can be observed in the share of working-age population. In absolute terms, the Middle East & Africa (excluding OPEC) will see the largest population growth in the long-term.

The global working-age population (15–64) is estimated to grow by 981 million over the period from 2019 to 2045. The relative share of this global working-age population to the world's total population is estimated to decline from 65% in 2019 to 63% in 2045 (Table 1.2). This phenomenon is observed across all regions, albeit with different patterns and levels.

Notably, China's working-age population is expected to decline by 143 million people over the forecast period. This is consistent with China's observed growth rate dynamics. The Middle East & Africa, with around 552 million additional working-age people by 2045, compared to 2019, is anticipated to experience the highest growth, followed by India with around 192 million. The Middle

Figure 1.2
Population trends in developing Asia and Middle East & Africa, 1990–2045



Source: UN, OPEC.

East & Africa will provide more than two-thirds of the growth in the world's working-age population over the time period.

Consideration of urbanization trends is essential as these have profound implications on economic development, social issues and energy consumption. Moreover, urbanization is closely

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

millions

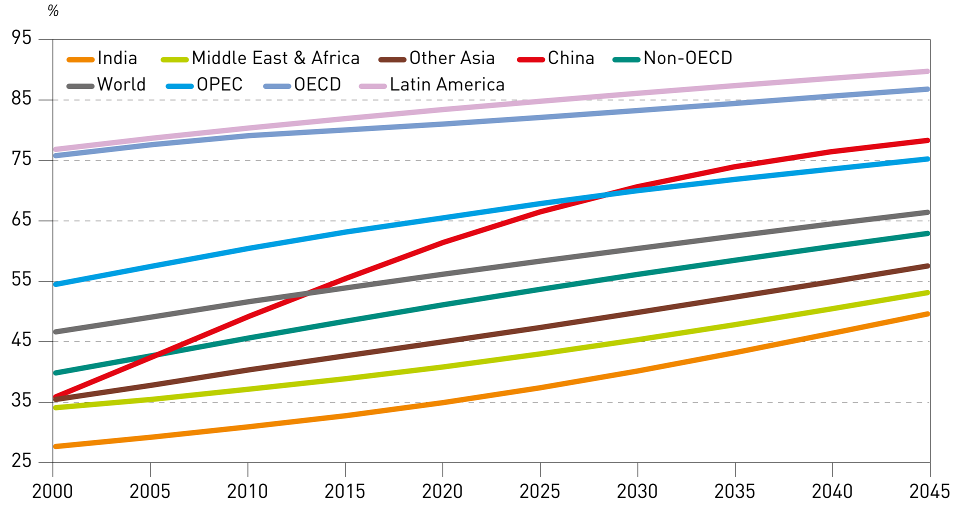
	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
OECD Americas	339	341	348	353	359	365	371	32
OECD Europe	374	374	370	364	357	349	342	–32
OECD Asia Oceania	137	136	133	130	125	118	113	–24
OECD	**850**	**851**	**851**	**847**	**841**	**833**	**826**	**–24**
Latin America	316	319	331	339	347	351	351	35
Middle East & Africa	618	636	730	833	943	1,056	1,170	552
India	916	928	986	1,029	1,064	1,091	1,108	192
China	1,014	1,012	1,007	986	943	898	871	–143
Other Asia	795	805	854	897	934	964	986	192
OPEC	295	301	336	374	412	448	483	187
Russia	97	97	93	90	90	89	86	–12
Other Eurasia	131	130	131	132	133	133	132	1
Non-OECD	**4,182**	**4,229**	**4,466**	**4,682**	**4,866**	**4,997**	**5,187**	**1,005**
World	**5,032**	**5,081**	**5,317**	**5,528**	**5,706**	**5,862**	**6,013**	**981**

Source: UN.

linked to better access to energy and is a factor for energy poverty alleviation. Urbanization in the WOO is expressed in terms of the urban rate, which underlines the level of the total population living in urban areas in percentage terms. Globally, more people live in urban areas than in rural areas, with almost 56% of the global population residing in urban areas in 2019. In 1950, 30% of the world's population was urban, and by 2045, 66% of the world's population is projected to be urban.

The Latin America and OECD regions are by far the most urbanized with more than 80% living in urban areas (Figure 1.3). Currently, the most urbanized regions are Latin America (83%), North America (82%), Europe (77%) and Oceania (68%).

Figure 1.3
Urbanization rate for selected regions, 2000–2045



Source: UN, OPEC.

The level of urbanization in Asia is now approximately 50%. OPEC Member Countries stand at a level above the current global average of around 65%. The Other Asia and Middle East & Africa regions are expected to experience a significant expansion in urbanization levels in the coming decades. Notably, India's urbanization rate has been the lowest, and although it is set to rise considerably in the coming decades, it is expected to remain regionally the lowest in 2045. Africa remains mostly rural, with 43% of its population living in urban areas.

China, in contrast, 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, albeit at a decelerating rate, to reach close to the global average in 2045.

Population movement is another element of the demographic variation on a regional basis. 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 in OECD areas and, to a much lesser extent, Russia. The OECD is projected to see an increasing migration rate by 2045 of around 4.7%, whereas the developing world is expected to see an outflow of population.

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.

1.2 Economic growth

1.2.1 Current situation and short-term growth

Global economic growth weakened to 2.9% in 2019. Growth had slowed down considerably in 4Q18, a momentum that carried over into 2019 and was impacted by the significant slowdown in global trade. Positively, there was an improvement at the end of 2019 with some spillover into 2020, fuelled by rising business sentiment amid hope that global trade would recover after the US and China reached a tentative agreement on trade matters. However, this tender pickup in sentiment was suddenly halted by COVID-19. While in January it was expected that COVID-19 would remain a local health issue in China, the very rapid global spread since then has caused a sharp downward revision in the global economic forecast.

Towards the end of 1Q20, global economic activity had almost come to a standstill and most major economies moved into a recession. More than two-thirds of the global economy was facing a lockdown in April, thus limiting economic activity. Since the pandemic started in China in 1Q20, the situation there has improved significantly, and lockdown measures implemented at the end of January and February were lifted by 2Q20. With the improving trend in COVID-19-related cases in April and May and unprecedented government-led stimulus measures, asset markets began to recover, reversing the downward trend that started in February. Markets started reflecting a more positive tone and provided some hope that the recovery would be swift and strong.

Lockdown measures in 1Q20 and 2Q20 severely disrupted the world's economic activity for several months. Global growth in 1H20 is estimated to have declined significantly, before recovering in 2H20, due to the easing of lockdown measures, rising consumer and business sentiment and supported by cyclical effects, especially pent-up demand in combination with unprecedented government-led stimulus. Based on these developments, global economic activity is forecast to decline by 3.7% in 2020.

Box 1.1

The COVID-19 shock and its unprecedented repercussions

The COVID-19 pandemic in 2020 precipitated an unprecedented health crisis and pushed the global economy into a deep recession. Public health measures put in place to contain the virus disrupted key economic sectors and caused widespread unemployment. As a consequence, the oil market experienced a historic shock that was sudden, extreme and global in scale.

Oil demand went into a freefall in many parts of the world. Moreover, intensified commodity volatility, especially in oil, caused prices to plunge to levels last seen in the late 1990s.

Stocks and equities nosedived as lockdowns began, and regained some ground as restrictions eased. Some key indexes, driven by the technology and health sectors, soared into record territory despite the lingering concerns about COVID-19. Many energy-related stocks, however, were hit in a manner not seen since the financial crisis of 2008/2009.

OPEC, together with other oil-producing countries participating in the DoC, acted decisively in April 2020 to address the huge imbalance in the global oil market. The DoC countries agreed to adjust downwards overall crude oil production in three phases over a period of two years, beginning with adjustments of 9.7 million barrels per day (mb/d) in May 2020 and ultimately reaching a planned 5.8 mb/d from January 2021 to April 2022. In a historic moment for the oil industry, the DoC committed to the largest and longest production adjustments, demonstrating the determination to make appropriate and collective decisions to help restore market confidence and stability.

The magnitude and severity of socio-economic implications of the pandemic, and the resulting extreme market volatility, has led to huge financial losses in the industry. The impact has drained oil revenues and jeopardized much-needed investment across the entire oil industry.

Despite the lingering uncertainties, there have been signs of the market rebalancing after the colossal 23 mb/d contraction in oil demand in April 2020 and the extreme volatility that was observed in the same month. However, with the massive and rapid build in stocks due to worldwide shutdowns, there is still a long way to go to eliminate the huge stock overhang and for the markets to return to balance and stability.

The process will be gradual and uneven among the sectors and products. Gasoline and diesel demand is likely to rebound faster than aviation fuels, but is not expected to reach pre-pandemic levels before the end of 2021, or even later, given significant uncertainties with regard to the global economic conditions, and persistently high and prolonged risks of further COVID-19 waves in the absence of a vaccination.

The pandemic also affected working practices and consumer preferences, leading to behavioural and lifestyle changes, plus a heightened risk of societal disruption. Containment measures, meanwhile, were a boon to digital infrastructure and new technology applications for remote working, virtual offices, online retail sales and services.

These changes are already paving the way for behavioural and structural shifts in the economy. They are also augmenting policy priorities related to economic resilience, sustainability, climate change and the energy transition.

In countering the COVID-19 shock, the G20 countries initiated fiscal and monetary stimulus packages of more than $20 trillion, including loan guarantees.

Some countries have used this opportunity to prioritize a 'green recovery' with sustainability criteria and targeted policy drives. In fact, the conditionality on sustainability and climate change issues is factored into recovery plans and stimulus packages, and in a few instances seek to avoid any delay in the transition to lower emissions. In the meantime, there is growing momentum in the investment community towards sustainable finance by including a sizeable portion of environmental, social and governance funds in their portfolios.

This shift has been accentuated in an environment of multiple uncertainties stemming from targeted investment choices, energy policy initiatives and societal changes that will increasingly influence the industry in meeting the future energy requirements while at the same time delivering environmentally benign products. In a post-COVID-19 era, oil companies could therefore have to address critical issues such as further improving their environmental credentials, diversifying their business models, and opting for the right economies of scale and advanced technology diffusion.

It is all the more critical under these extraordinary circumstances to deepen dialogue and strengthen broader cooperative efforts. Platforms such as the Charter of Cooperation (CoC) offer the opportunity to address and seek inclusive solutions to common challenges facing the petroleum industry in such a rapidly changing environment. These include the often interlinked challenges of climate change, the energy transition, investment and the creation of productive jobs.

COVID-19 has affected virtually all areas of the global economy. In contrast to other economic shocks, the global economy has witnessed a combined supply and a demand shock, together with disruptions in the financial markets. Moreover, the impact of COVID-19 came at a time of high global debt levels and ongoing challenges in world trade as well as in manufacturing, caused by slowing capital expenditure in some key economies and a global deceleration of the automotive industry.

The underlying key assumption for the 2020 gross domestic product (GDP) growth forecast is that after the significant decline in 1H20, the 2H20 recovery is anticipated to be noticeable, though not able to compensate for the extraordinarily large decline in 1H20. The 2H20 rebound is forecast to carry over into 2021, leading to economic growth of 4.7% in the coming year. The forecast for both 2020 and 2021 assumes that COVID-19 will largely be contained on a global level by 4Q20 and that no further significant issues will derail economic developments.

However, given surges of infections in some economies, and considering the numerous additional challenges facing the global economy – ranging from debt-related issues to ongoing US-centred trade-related issues – the forecast risk for both years is skewed to the downside. Upside potential does exist, primarily if a COVID-19 vaccine is developed or the virus is contained via other effective measures. Vital support to the global economic recovery will also come from the efforts of OPEC and non-OPEC nations in the Declaration of Cooperation (DoC) to help rebalance the oil market.

Global trade is forecast to pick up in 2H20 and in 2021, but remains burdened by US-centred trade disputes, especially with China. Moreover, the trend in domestic sourcing and the replacement of international supply chains by domestic businesses may dampen global trade to some extent. The important hospitality, travel and the leisure sectors are forecast to remain below 2019 activity, but are expected to recover by 20% in 2H20 and by around 10% in 2021. This will constitute an important element in the recovery. However, a global resurgence of the virus could cause a continuation of the malaise witnessed in 1H20.

Moreover, many uncertainties about key global trade issues remain unresolved. US-China trade tensions have risen recently after a brief thaw. There is still the possibility of US tariffs on imported cars and car parts, potentially negatively impacting some countries, especially Germany, South Korea and Japan. While the ratification of the US-Mexico-Canada Agreement, which replaced the North American Free Trade Agreement (NAFTA), was finalized in mid-2020, trade disputes with both Mexico and Canada remain. Existing sanctions on IR Iran, Venezuela and Russia are additional elements impacting the global economy and global trade in an already fragile time. Global exports account for around one-third of global GDP and constitute a vital part of the world's economy. A further disruption in global trade could have a negative impact on the short- and medium-term global economic growth forecast.

Unprecedented government-led fiscal and monetary stimulus measures are expected to provide support and help boost global consumption over the short- and medium-term. Based on OPEC Secretariat estimates, global measures in the form of fiscal and monetary stimulus, including guarantees, amount to more than $20 trillion, or almost a quarter of global GDP, and constitute the largest stimulus efforts ever undertaken.

The positive effects of these stimulus measures have already taken hold in various economies. Underlying economic indicators reflect a rebound, as do asset markets across the world and the important housing sector, which in G7 economies has seen some rebound in prices, sales and construction activity. The relatively accommodative monetary policy environment is forecast to continue, as long as inflation remains in check, a factor that is forecast to support medium-term growth developments as well. The fiscal side also will remain expansionary. However, as debt rises to peak levels, it remains to be seen at what magnitude this support will be continued.

Another important element has been the OPEC-led recovery in the oil market in 2020. OPEC's efforts, together with non-OPEC producers participating in the DoC, to help stabilize the oil market after a historically unbalanced 1Q20 has led to a rebalancing and a rising contribution from the oil sector to the global economic recovery.

This initiative was also endorsed by the G20 Energy Ministers' meeting in April, together with the G20's aim of supporting a stabilization of the oil market. Oil-producing economies, including large oil producers in the OECD such as the US and Canada, account for more than one-third of the global economy; hence stable income and investment into the energy sector remain vital for the global economy in the medium-term. This is forecast to be of benefit for producers and consuming nations alike, as a more balanced market provides consuming nations with a stable environment to make economic decisions.

1.2.2 Medium-term economic growth

The overarching issue of COVID-19 is forecast to impact growth rates in almost all economies over the medium-term. Hence global economic growth in the upcoming years has been revised down, compared to last year's edition of the World Oil Outlook (WOO). The first year of the medium-term period, 2021, is forecast to experience a strong recovery of 4.7% from the unprecedented global recession in 2020, when economic growth is forecast to decline by 3.7%.

Importantly, this recovery assumes that COVID-19 is contained by 4Q20 and while localized lockdowns may still become necessary, the economic impact of these measures will be limited. Consumer and business confidence levels are recovering and will normalize by the end of 2020. This will then lead to a considerable recovery in private household consumption, accompanied by rising investment activity in 2021. With this momentum, global trade is forecast to pick up by around 6% in the coming year.

After next year's recovery, growth will then retract to levels slightly above 3% before rising higher, with global economic growth expected to reach 3.4% at the end of the medium-term period in 2025. Last year's edition of the WOO also forecast that growth would reach 3.4% at the end of the medium-term period (then ending in 2024).

However, the forecast for 2024 in this year's Outlook is 0.1 pp lower. In both 2022 and 2023, global economic growth is forecast to be 0.2 pp below last year's forecast, as both years are expected to remain affected by structural shifts as a consequence of COVID-19. The hospitality, travel and leisure sectors are forecast to remain impacted and show a pattern of less dynamic growth than pre-COVID-19. This, in connection with a level shift in unemployment and relatively lower spending abilities, is forecast to lead to lower consumption and investment compared to the pre-COVID-19 world.

In addition, numerous uncertainties prevail. Not only could COVID-19 cause further economic disruptions over the coming years if the virus is not contained sufficiently, but the consequence of rising debt levels on both the sovereign and the private household side may lead to a rising number of defaults and/or a larger-than-anticipated slowdown in consumption and consequently investment. Moreover, trade-related issues may remain or even escalate along with re-emerging geopolitical conflicts and a continuation of social unrest in numerous countries, all of which could further dampen global economic growth.

Positively, a COVID-19 vaccine could lift consumer confidence and investment at a significantly higher rate than currently anticipated. This positive impact would be larger if it would materialize at the beginning of the medium-term forecast period. While less likely, it may turn out that

Table 1.4
Medium-term annual real GDP growth rate *% p.a.*

	2019	2020	2021	2022	2023	2024	2025	Average 2019–2025
OECD Americas	2.0	–5.4	4.0	1.7	1.9	2.0	2.3	1.0
OECD Europe	1.4	–7.6	4.2	1.4	1.5	1.6	1.8	0.4
OECD Asia Oceania	1.3	–3.9	3.6	1.1	1.2	1.3	1.3	0.7
OECD	**1.6**	**–6.1**	**4.0**	**1.5**	**1.6**	**1.7**	**1.9**	**0.7**
Latin America	1.1	–6.4	2.7	1.6	1.8	2.0	2.3	0.6
Middle East & Africa	2.8	–2.7	3.9	2.9	3.1	3.2	3.5	2.3
India	4.9	–2.5	6.8	6.2	6.3	6.4	6.5	4.9
China	6.1	1.3	6.9	5.8	5.5	5.2	5.0	4.9
Other Asia	4.1	–2.0	4.8	4.0	4.0	4.3	4.5	3.2
OPEC	–1.0	–5.8	2.3	2.1	2.3	2.5	2.8	1.0
Russia	1.3	–4.5	2.9	1.6	1.4	1.3	1.3	0.6
Other Eurasia	3.7	–4.3	4.4	2.4	2.5	2.6	2.8	1.7
Non-OECD	**3.8**	**–2.0**	**5.2**	**4.3**	**4.3**	**4.3**	**4.4**	**3.4**
World	**2.9**	**–3.7**	**4.7**	**3.1**	**3.2**	**3.3**	**3.4**	**2.3**

Source: OPEC.

consumers and businesses alike may better adjust to the new normal of a COVID-19 world and that consumption will continue with reduced physical interaction and will perform relatively better. The sectors that are beneficiaries of COVID-19, like healthcare, IT and communications, may outperform the ailing sectors of leisure, hospitality, travel and transportation at such a magnitude that they may lift growth higher than currently envisaged.

In summarizing the medium-term growth trend, most major economies and regions will not be able to recover to their ten-year average pre-COVID-19 level by the end of the forecast period in 2025. While the ten-year average in the years after the 2008 financial crisis reached an average global growth of 3.6%, world economic growth will stand at 3.4% in 2025.

Total **OECD** growth will stand at 1.9% in 2025, compared to the pre-COVID-19 growth level of 2.1%. This comes, however, after an unprecedented contraction of 6.1% in 2020 and an only partial recovery of 4% in 2021.

Especially **OECD Americas** will hold up well, closing the growth gap up to 2025, when growth will reach 2.3%, the pre-COVID-19 ten-year average. In OECD Americas, the US is forecast to lead the growth momentum in the medium-term. After the massive decline in all economies of OECD Americas, the recovery and momentum going forward should build on a rebound in labour markets, rising trade and a gradually improving commodities market, especially the oil market. Chile is also forecast to benefit from a general recovery in commodities exports, primarily its main export, copper. Growth is forecast to gradually accelerate towards the end of the medium-term period in line with an improving global economy. The rebound will be led by a recovery in consumption and investment, supported by an accommodative monetary policy and fiscal stimulus when necessary.

OECD Europe will see a more modest recovery up to the end of the forecast period, achieving growth of 1.8% in 2025, 0.1 pp below the pre-COVID-19 ten-year average. Supported by the stimulus measures of the European Commission, Member States and the European Central Bank, the negative economic impact of COVID-19 is forecast to be overcome to some extent in the medium-term. Fuelled especially by the major economies of Germany and France, growth is forecast to pick up again. This will also be accompanied by a general recovery of the global economy and an increase in global trade.

Brexit-related challenges and debt-related issues in other European Union (EU) economies, particularly Italy, may re-emerge but are forecast to be well contained. The forecast also assumes a gradual recovery in the car sector, which is especially important to Germany and to some extent also to France and Italy. However, given the COVID-19-related uncertainties, it remains to be seen if big-ticket item sales (such as vehicles) will recover as well as currently anticipated in the medium-term forecast.

In **OECD Asia Oceania**, the economy of Japan as well as that of neighbouring China, which are forecast to decelerate in the coming years, will provide strong guidance for the region's future growth. While the Japanese government together with the Bank of Japan (BoJ) introduced an enormous stimulus programme, accounting for more than 20% of its GDP, it is forecast that the Japanese economy will move back to its low-growth pattern after the stimulus efforts taper off in 2021.

The medium-term growth outlook in **developing 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 an expected improvement in commodities, which are the main export for a large majority of the major economies in these regional groups, growth will recover from their low levels especially after COVID-19. High population growth in these economies will be beneficial as well. Therefore, Latin America, Middle East & Africa and OPEC will achieve growth rates that are 0.1, 0.4 and 1.1 pp, respectively, above the pre-COVID-19 ten-year averages by the end of the forecast period in 2025.

In **Latin America**, a recovery is anticipated towards the end of the medium-term period. The recovery is not only from the low growth prior to COVID-19, but also from the large decline that the continent will experience in 2020. Almost every country in Latin America is affected at a significant level by COVID-19, but assuming that the pandemic will be contained by the end of 2020, a solid medium-term recovery could be seen. There are also challenges in the region's largest economies, with Argentina facing a severe recession and Brazil with its own domestic issues.

Yet a recovery in these economies is anticipated to lead the growth rebound. In Argentina, it remains to be seen how the debt restructuring efforts will play out and what impact this will have in future. In Brazil, a successful outcome of structural reforms over the coming years is forecast to add to the growth momentum. Another important assumption is the further improvement in the commodity markets, especially oil.

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 benefit in the medium-term from rising demand for commodities and growing regional domestic demand aided by the expansion of the middle class. A rebound in the global economy is forecast to lift foreign investment into the region. China's role as the region's major foreign investor and its need for natural resources will be of great importance as well.

However, the slowdown in China may be a challenge for the region, while countries' high sovereign debt obligations and debt servicing may be another constraint. The current forecast anticipates that geopolitical issues will not worsen in the region and remain manageable.

In contrast to the above regions, **China, India and Other Asia** will record lower growth in 2025 compared to the pre-COVID-19 ten-year average. China in particular is forecast to continue to slow down as the economy matures, with growth forecast at 5% in 2025 compared to its pre-COVID-19 ten-year average of 7.7%. India's growth will stand at 6.5% in 2025, below its pre-COVID-19 ten-year average of 7.1%. However, India's growth was already slowing down in 2019; hence this level can be seen as a successful rebound.

Other Asia also is forecast to stand somewhat below its pre-COVID-19 ten-year average of 4.9% at the end of the medium-term forecast period and is expected to achieve growth of 4.5% by 2025, but with rising momentum. These divergent trends in developing countries will lead the group to growth of 4.6% compared to 5.3% for the pre-COVID-19 ten-year average.

After the significant decline of **China**'s economy in 1Q20, the country managed a swift rebound, supported by government stimulus measures and containment of COVID-19. After expected higher growth in 2021, China is forecast to grow at a slower rate as its economy matures. In 2022, just after the stimulus-induced recovery in 2021, the economy is forecast to grow by less than 6%, a trend that is expected to continue up to the end of the medium-term forecast period, when growth will stand at 5% – still a relatively high rate.

An important element will be any developments on trade-related negotiations or outcomes with the US, which is China's most important trading partner. After agreement of the phase one deal in 2020, some trade-related challenges re-emerged, but the forecast assumes that no further friction in the trade relations will materialize in the medium-term.

Also, China's shifting focus from external trade and investments towards a more domestically oriented focus, led by private household consumption, will likely counterbalance some of the potential shortfall from external trade. An ongoing challenge will be to balance out the need for an economic rebound and the growing imbalances in the private sector – mainly in financial markets and the real estate market – while also reducing provincial government debt.

India's growth was significantly impaired in 2019, slowing to 4.9%, the lowest growth since the financial crisis of 2009. Growth in 4Q19, pre COVID-19, stood at only 4.1% y-o-y, hence the pandemic caught India at a time of already underlying growth challenges. These challenges, ranging from issues in the monetary transmission channel to slowing domestic demand, will need to be overcome quickly.

It is forecast that the major structural reforms of 2017 and 2018, and government-led stimulus measures in combination with a recovery in the global economy, will successfully provide a base for higher growth over the medium-term period. After a significant slowdown in 2020 amid the impact of COVID-19, the economy is forecast to expand by more than 6% for the rest of the medium-term period, with a slight accelerating trend after 2022.

Other Asia will be significantly affected by COVID-19 in 2020, with growth declining by 2% but recovering by 4.8% in 2021. There will be a level shift in growth over the medium-term when compared to growth rates before COVID-19. Growth will slightly appreciate towards the end of the medium-term period due to the domestic momentum in some of the region's dynamically growing economies. This will compensate for some of the slowdown these economies will face in trade with China.

OPEC, as a group, is facing a significant decline in 2020 before recovering in 2021. The recovery in Member Countries will very much be supported by the landmark 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.

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 rebalancing of the oil market, a very important element in leading to relatively stable medium-term growth. On the potential downside, Russia's economy remains hampered by sanctions. While Russia's GDP growth is forecast to decelerate slightly, driven in part by its declining population and resulting drop in consumer demand, Other Eurasia is forecast to grow more dynamically with an appreciating growth momentum towards the end of the forecast period.

With these counterbalancing trends, Eurasia is forecast to show growth of 2% in 2025, 0.5 pp below the pre-COVID-19 ten-year average. Russia is forecast to grow by 1.3% in 2025, 0.7 pp below the pre-COVID-19 ten-year average. Other Eurasia is forecast to grow by 2.8% in 2025, 0.4 pp below the pre-COVID-19 ten-year average.

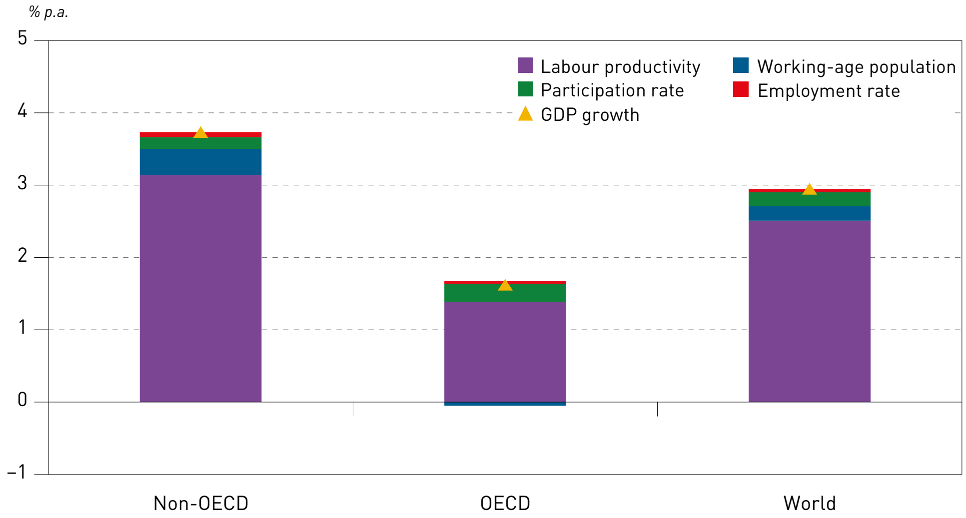
It is to be noted that these projections assume that fiscal stimulus measures will be maintained at the current level at least. While a further increase may materialize, it will likely be limited given the already very high sovereign debt and deficit levels in most major economies. Monetary stimulus measures are also forecast to continue, and while monetary policies could become even more accommodative, the effectiveness of such measures is forecast to be low, as can be seen in Japan, where the BoJ faces capacity constraints to increase its quantitative easing related to the purchase of capital market assets.

It also remains to be seen if, when, which and at what magnitude new taxes will be implemented or existing taxes increased. As the sovereigns will need to pay back their very high debt, this will be an important element to monitor.

1.2.3 Long-term economic growth

As per usual practice, the assumptions underlying the long-term economic growth developments are primarily based on productivity growth, demographic trends and developments in the labour market. Much of the growth expected throughout the forecast period will be determined by labour productivity, both at the regional and global level (Figure 1.4). Several economic regions and single economies will be affected by a decline in the working-age population. This is forecast to be the case in OECD Europe and OECD Asia Oceania, as well as in Russia and China. This dynamic will limit these economies' growth potential even as labour productivity increases.

Figure 1.4
Long-term GDP growth rates by components, 2019–2045



Source: OPEC.

In areas like the Middle East & Africa and OPEC, lower labour productivity will continue to be counterbalanced by the spillover into the labour market from rapidly expanding populations.

Global GDP growth between 2019 and 2045 is expected to increase at an average rate of 2.9% per annum (p.a.), which is lower than the WOO 2019 assumption. This is in large part due to the lower baseline in the near- and medium-term, which has been considerably impacted by COVID-19, and the expected after-effects of the crisis in the long-term, given the growth level change that is expected at the front end of the growth curve. Another element that has been considered is the trend of lower growth as developing economies, especially China and India, mature over the long-term.

The majority of the growth contribution through to 2045 will be driven by non-OECD countries, in line with assumptions of previous editions of this publication. These countries are expected to grow by 3.7% p.a. on average (Table 1.5), largely on the back of improving labour productivity even as the pace of GDP growth begins to slow.

India is expected to remain the fastest growing major developing country with average growth of 5.6% p.a., with growth front-loaded over the projection horizon in line with expected demographic trends. This is, however, much lower than in the WOO 2019, when India's long-term growth average stood at 6.3%. This strong downward shift in expectation is due to the much larger than anticipated underlying growth issues that India was facing before COVID-19, issues that are amplified by the COVID-19-related crisis.

As in previous editions of this publication, **China** is expected to have the second most rapidly growing major economy, with average growth of 3.9% p.a. over the whole period. Also, the underlying impact at the front-end of the growth curve in China, amid COVID-19, will be large, reflected in a

Table 1.5
Long-term annual real GDP growth rates

% p.a.

	2019–2025	2025–2035	2035–2045	2019–2045
OECD Americas	1.0	2.3	2.3	2.0
OECD Europe	0.4	1.7	1.6	1.4
OECD Asia Oceania	0.7	1.3	1.2	1.1
OECD	**0.7**	**1.9**	**1.9**	**1.6**
Latin America	0.6	2.3	2.3	1.9
Middle East & Africa	2.3	3.8	4.4	3.7
India	4.9	6.3	5.4	5.6
China	4.9	4.2	2.8	3.9
Other Asia	3.2	4.2	3.4	3.7
OPEC	1.0	3.0	3.1	2.6
Russia	0.6	1.5	1.3	1.2
Other Eurasia	1.7	2.8	2.2	2.3
Non-OECD	**3.4**	**4.2**	**3.5**	**3.7**
World	**2.3**	**3.3**	**3.0**	**2.9**

Source: OPEC.

0.7 percentage point downward shift from the number in the WOO 2019. This comes in combination with continued signals that China's economy is rapidly moving towards maturity and that it is expected that the growth rate will decelerate quickly, falling to an average 2.8% p.a. in the last five years of the forecast period.

Within the last decade of the forecast period, China will thus have been overtaken by the Middle East & Africa, OPEC, as well as **Other Asia**. In all these economies an expanding working-age population will contribute to faster economic growth when compared to China's ageing and gradually declining population. Economic growth in Other Asia is seen decelerating from 4.2% p.a. in the period of 2025 to 2035 to 3.4% p.a. in the last decade up to 2045, which is nonetheless still above the global average of 3%.

In the **Middle East & Africa**, growth is estimated to average 3.7% 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 the middle class with consequently rising consumption abilities. This is forecast to come in combination with improving commodity markets amid the global growth appreciation. There have been no material shifts in the assumptions regarding the region's productivity growth, which means that there is still significant potential that could materialize.

Labour productivity gains in **Russia** are expected to somewhat counterbalance unfavourable demographic changes and a reduction in the working-age population in the years up to 2035. Economic growth in Russia is thus expected to rise to 1.5% in the decade up to 2035, while the medium-term growth average is very much diluted by the impact of COVID-19. Russia is forecast to be supported by an improving commodity market in the long-term, with an emphasis on the crude oil market. However, the declining population will be the influential force in preventing growth from moving beyond the long-term average of around 1.2%. Elsewhere in Eurasia, marginal growth in the working-age population will help maintain GDP growth above 2% p.a. over the entire forecast period.

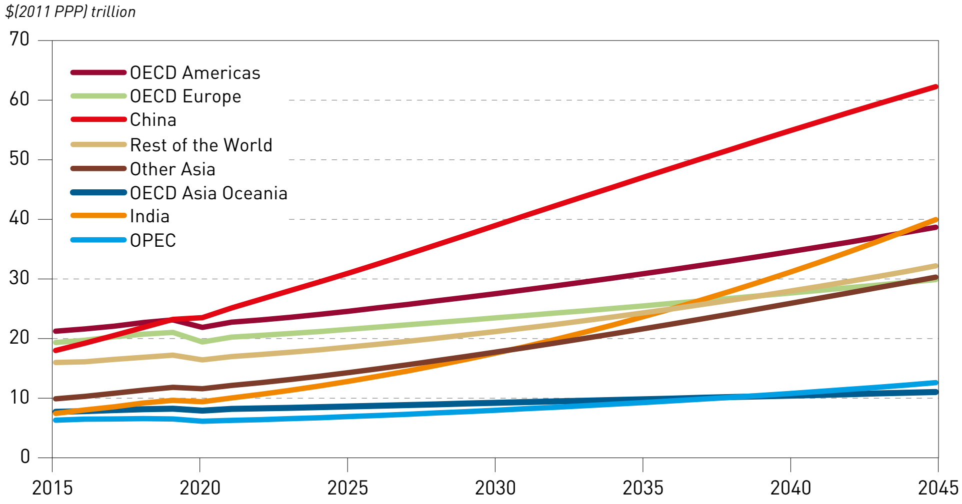
In addition to the ongoing structural issues in most of the economies in **Latin America**, COVID-19 had a significant impact on this group of countries. It remains to be seen, however, what the impact will be in the short- and medium-term. Argentina's ongoing financial issues are adding to the economic malaise of the continent as well. This, however, will build the base for growth appreciation in the long-term. Latin America was so much impaired before COVID-19 that it is first anticipated to witness a cyclical recovery. Secondly, it is forecast that the implementation of needed structural reforms will lead to economic improvements. As a result, Latin America will see relatively higher growth towards the back-end of the growth curve, when growth will stand at 2.3% on average.

Within the **OECD region**, economic growth is forecast to average 1.6% p.a. from 2019 to 2045. OECD Americas continues to lead the growth prospects with a stable economic outlook at 2% p.a., unchanged from last year's WOO, despite the major impact that COVID-19 had on the world. In the longer-term, immigration will help expand the workforce while labour productivity is expected to remain near current levels. In the other OECD regions, most particularly OECD Asia Oceania, smaller working-age populations will likely drive a deceleration of economic growth, down to 1.2% p.a. for the final years of the projection period. OECD Europe will also decelerate slightly, amid the population and working-age effects, showing growth of 1.4% in the long-term, but 1.6% for the final years of the forecast period.

The GDP growth figures assumed here imply that the global economy in 2045 will be double the size it was in 2019 (Figure 1.5). Based on 2011 purchasing power parity (2011 PPP), global GDP is projected to rise from around $121 trillion in 2019 to more than $258 trillion in 2045. Figure 1.6 indicates that China and India alone will account for 40% of global GDP in 2045, whereas the OECD will only account for 31%. In 2019, it was estimated that the OECD accounted for 43% of the global economy, with OECD Americas, OECD Europe and China all accounting for similar shares.

Despite large shifts at the regional level, the global economic picture does not see significant changes in 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

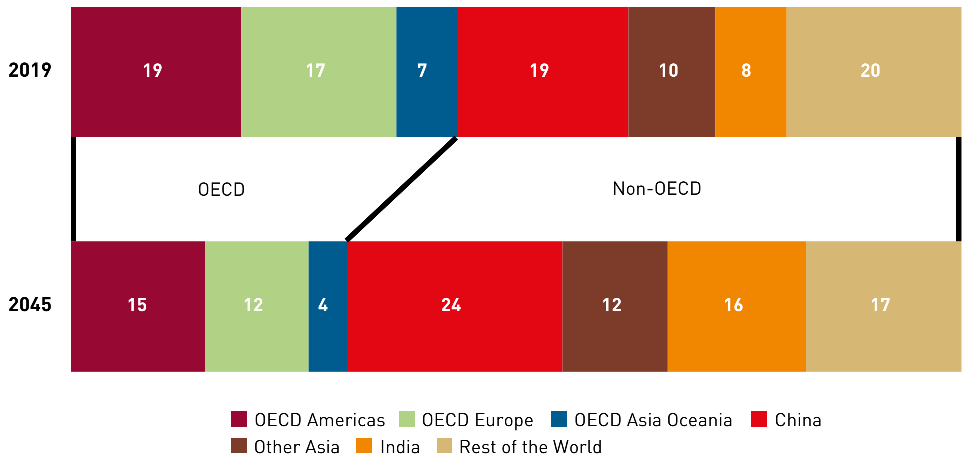
Figure 1.5
Size of major economies, 2015–2045



Source: OPEC.

Figure 1.6
Distribution of the global economy, 2019 and 2045

%

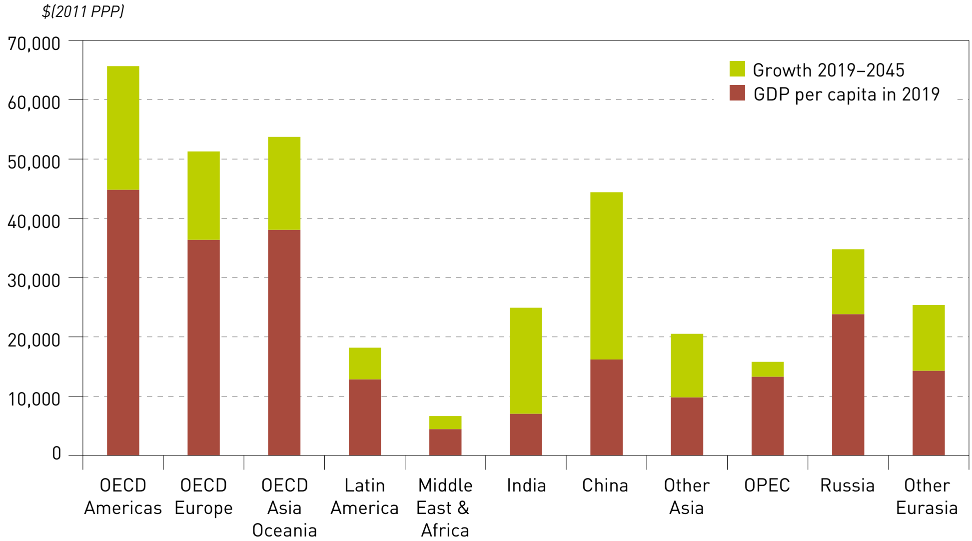


Source: OPEC.

(Figure 1.7). The regional grouping of Middle East & Africa will still have the lowest GDP per capita, and is expected to be the only region where the average income is less than $10,000 (2011 PPP) in 2045.

India and China are anticipated to see the biggest changes, with average income in China seen rising to close the gap with those of OECD countries and overtaking Russia. The global average income is projected to rise from $15,700 (2011 PPP) to more than $27,000 (2011 PPP) in 2045.

Figure 1.7
Real GDP per capita in 2019 and 2045



Source: OPEC.

1.3 Energy policies

Policies relating to energy demand and supply are, in general, expected to become more stringent over the forecast period. This is in line with the commitments made by many countries reflecting environmental concerns and as part of the Paris Agreement. Nonetheless, it is assumed that the majority of policies relating to energy demand and supply will continue to be set and enforced at the national level, resulting in continued disparity in the scope of policy ambitions. One exception to this is the EU, where an overarching policy acts as a framework for the national policies enacted by Member States. International bodies are also set to play a more important role with the establishment of new policies that cover global industries, such as the International Maritime Organization (IMO) and its recently adopted policy that limits SO_x emissions from the shipping industry.

Current and future energy policies will continue to shape energy demand in terms of both its absolute level and composition. Therefore, a critical assessment of likely implications of energy policies constitutes one of the key elements in making projections. Broadly, this Outlook takes into account enacted policies in most (certainly major) countries, as well as indicated targets of policymakers signalling the direction of future changes. While it is assumed that energy policies will further evolve over time, it is not taken for granted that all stated objectives and targets will be achieved. In other words, the viability and credibility of various targets and measures are considered before being incorporated into projections.

Moreover, it is important to emphasize that the policy provided in this section should by no means be considered as an exhaustive list of policies considered in this Outlook. On the contrary, it is just an update of recent changes in energy policies in major consuming countries. Besides recording these changes, they also serve as an indication of what is to be expected in the years to come.

US

Policy developments in the US are currently in a state of greater flux than in some other regions, given the complex dynamics between state-level and federal policy and the diverse priorities across the country. The easing of some long-standing environmental regulations may, to some extent, be considered favourable for increasing energy supply; however, as has long been the view in this series of Outlooks, it is economics which will dictate the trend of energy supply and demand. The proposed end to the moratorium on drilling in the Eastern Gulf of Mexico and the opening of some sections of the Arctic National Wildlife Refuge in Alaska could open a path to new oil and gas supply, but only if the projects are sufficiently profitable for developers. The same may be true for coal. While existing policies are being changed and some restrictions reduced, new coal plants could still be unprofitable in comparison to other fuel sources.

The outcome of the 2020 election will determine the fate of the corporate average fuel economy (CAFE) standards in the transportation sector and also, to a lesser extent, the Renewable Fuel Standards (RFS) programme. With regards to the latter, in May 2019, the US began to allow year-round sales of E15 gasoline (a mix of up to 15% ethanol); prior to this, it was not possible to sell E15 gasoline in certain regions during summer months due to a conflict with the Clean Air Act. On the issue of fuel efficiency, the National Highway Traffic Safety Administration (NHTSA) and the Environmental Protection Agency (EPA) established a fuel economy regulation programme called the One National Program Rule in 2019 and the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule, which is meant to amend and replace the CAFE standards. The new SAFE rule sets a 40.4 mpg target for new vehicles in 2026 – significantly reduced from the 54.5 mpg targeted for 2025 in the CAFE standards.

The One National Program Rule also proposes to withdraw California's waiver that allows the state to set its own GHG and Zero Emission Vehicle (ZEV) mandates – likely leading to lengthy legal disputes. However, California continues to push for more ambitious targets in renewable energy capacity, GHG emission reduction and ZEV uptake. Moreover, California's policies often have a wider impact as other states can and do follow the state's lead.

The second phase of GHG emissions and fuel efficiency standards for medium and heavy vehicles is set to begin for new vehicles in 2021. In conjunction with new technology, they could be the starting point for the relationship between freight demand and diesel demand in the transportation sector to decouple more markedly.

EU

The 2030 Climate and Energy Framework is the guideline for energy policy in the EU during the current decade. Adopted in 2014, and updated in 2018, it lays out targets and objectives for the period from 2021 to 2030. These include the reduction of GHG emissions to at least 40% below 1990 levels; increasing the share of renewables in the energy mix to at least 32%; and increasing energy efficiency by at least 32.5%. The Clean energy for all Europeans package, which was adopted in 2019, included a governance framework requiring each Member State to submit National Energy and Climate Plans (NECPs) by the end of 2019. These are currently under review.

At the beginning of 2020, the European Parliament endorsed the Commission's proposed European Green Deal, which lays out targets and policy objectives for the period to 2050. The primary target of the new framework is to reach zero net emissions of GHG in 2050. The Green Deal also sets a deadline of June 2021 to review and propose revisions to all relevant climate-related policy instruments, including the Emissions Trading System (ETS). A carbon border adjustment mechanism is also being drafted to prevent 'carbon leakage' as an alternative to existing measures already incorporated into the ETS.

The Industrial Emissions Directive, which entered into force in 2011, is the current instrument regulating emissions from the industrial sector. In March 2020, a European industrial strategy and a Circular Economy Action Plan proposal were unveiled which included pathways towards decarbonizing and modernizing energy-intensive industries. The updated Energy Efficiency Directive, which sets an energy efficiency target of 32.5% for 2030, needed to be transposed into national law by the end of June 2020.

In the power sector, a number of EU countries have pledged to phase out the use of coal, and the current policy in 26 of the 27 Member States is to have no new coal power plants start up after 2020. Some countries have also been accelerating plans to close their remaining coal plants: Portugal will likely complete this by 2021; France, Slovakia, the UK and Ireland will follow in the years after; and by the end of the decade, a majority of EU nations will have likely phased out coal from their energy mix.

The transportation sector has seen a spate of policies aimed towards reducing emission levels, such as the Fuel Quality Directive. An expected fleet-wide improvement in fuel efficiency will also be assisted by policies to increase the penetration of hybrid and fully electric vehicles (EVs) in different EU countries.

China

A major focus of Chinese policy over the past decade has been to improve and control air quality, with efforts in this regard affecting nearly all sectors. The Action Plan for Prevention and Control of Air Pollution, enacted in 2013 and followed up by a Three-Year Action Plan for 'Winning the Blue Sky Defence' in 2018, lays out strict guidelines for the power generation, transportation, residential and commercial, and industrial sectors, particularly in proximity to large urban areas.

China's 13th Five-Year Plan comes to an end in 2020 and the 14th Five-Year Plan will set out the high-level objectives for the country as it continues to develop its economy while addressing environmental concerns and the fallout of the COVID-19 pandemic. It is expected that a push for renewables will continue beyond the target of 15% of primary energy consumption from non-fossil fuel sources in the 13th Five-Year Plan. Air quality and energy efficiency targets will likely be expanded in scope and coverage. China also aims to reach a peak in carbon dioxide (CO_2) emissions around 2030 and the next five years will be critical for achieving this.

Furthermore, China has also been establishing its own Emissions Trading Scheme, which could quickly become the largest in the world. The scheme has been transitioning from its city-wide pilots to a nationwide system and will first include the power sector.

In the road transportation sector, China has been strengthening policies around fuel consumption and has implemented the China VI fuel standard. The country has also been reducing subsidies for new energy vehicles (NEVs) and 2019 saw a particularly large decrease from 2018 subsidy levels. As subsidies have decreased, the requirements of the NEV credit system will increase in 2020. Hence, manufacturers will have to produce more EVs to meet the government targets.

India

India has adopted a two-prong energy policy in recent years, trying to balance its main priorities of expanding energy access to a majority of the population and growing manufacturing sector while, at the same time, reducing its dependence on coal. The National Mission on Enhanced Energy Efficiency (NMEEE), one of eight operating under the umbrella of the National Action Plan on Climate Change, has been implementing initiatives to increase energy efficiency. The success of its Perform, Achieve and Trade initiative in its first three-year cycle, which ended in 2015, has led to the commencement of further cycles. The third (due to end in 2020) and the fourth (due to end in 2021) target reductions in energy consumption by 1.06 million tonnes of oil equivalent (mtoe) and 0.699 mtoe, respectively.

Support is also provided for the expansion of renewable electricity. India has targeted 175 GW of renewable energy capacity by 2022 while its longer-term ambition is to realize over 450 GW of capacity and has made available subsidies and tax incentives to help drive the increase.

The transportation sector has also seen policies geared towards reducing emissions by means of tightening fuel specifications. The Bureau of Indian Standards announced that it would leapfrog to Bharat Stage VI emission standards nationwide by April 2020, for both light-duty and heavy-duty vehicles – the 10 parts per million (ppm) sulphur limits had already been implemented in Delhi and major cities from April 2018. Up until April 2020, the nationwide sulphur limit was 50 ppm.

Regarding 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 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.

Other regions

Across the globe, energy policies of countries will relate to their own unique strengths and challenges. For example, Japan has been establishing policies related to the development of hydrogen in the long-term to help diversify away from the import of fossil fuel energy sources. Brazil will continue to make use of its vast hydro power resources while adding in more renewable sources of electricity in the coming decade. The country's huge biofuel production is linked with policies to require more biofuel use in the transportation sector.

When considering EVs, China, the US and the EU may be the biggest players in the market in absolute terms, but many other countries including Canada, South Korea, Chile and Japan have implemented or are pursuing policy measures that promote the uptake of EVs through higher efficiency standards or financial subsidies.

1.4 Technology and innovation

A close look at existing technology and potential advancements that are set to shape the energy landscape in the years to come is reflected in this chapter. Assumptions related to technology and its development and implementation are incorporated into the Reference Case. The WOO 2020 looks at different energy sectors with a focus on energy demand, as well as the energy transformation. The Outlook assumes the evolutionary development of existing technologies, taking into account potential further developments. The development and prospects of new technologies related to the global energy business will also be explored, including from a long-term perspective.

Road transportation

Internal combustion engines (ICEs) are the main mover for all road transport segments, whether for passenger or commercial vehicles. Since 1970, engineers have increased the efficiency of ICEs significantly and smaller passenger gasoline engines benefited the most. Nevertheless, larger stationary engines have remained the reference for several reasons, with the comparably low heat loss and the typically continuous operation with limited load changes being the two most important ones. This Outlook considers that ICEs will remain dominant for the foreseeable future, but does take into account the current developments and possible future advancements of electric mobility.

Except for gasoline and diesel, combustion engines may also use liquefied petroleum gas (LPG), compressed natural gas (CNG) or liquefied natural gas (LNG), hydrogen and biofuels. So far, one of the key alternative fuels for road transportation is natural gas for passenger vehicles, since natural gas has lower GHG and solid emissions than conventional fuels. This Outlook has, consequently, carefully considered the penetration of such natural gas vehicles.

Based on an overall cost analysis, commercial vehicles remain largely limited to diesel engines. Diesel remains the most economically attractive technology, especially for heavy trucks. Nevertheless, urban short-distance-only vehicles such as delivery trucks, garbage trucks and increasingly buses are starting to use battery-electric powertrains. A larger EV fleet share is anticipated in certain heavy-duty vehicle segments due to the growing desire to reach zero-emissions. However, it is more probable that LNG will lead the shift away from diesel fuel for heavy-duty vehicles.

Shared mobility, expedited by Internet-based systems, is growing swiftly especially in urban areas. Small electric scooter fleets are being deployed for (very) local travel without luggage.

Passenger vehicles are already taking advantage of powertrain electrification and in the case of battery electric vehicles (BEVs), completely electric operation. Future advances in electric mobility are closely linked to expectations and developments in battery technology. NMC (nickel manganese cobalt oxide) chemistry currently dominates EV battery technology. China has started developing a LFP (lithium iron phosphate) chemistry for its EV powertrains and Tesla (in the US) had selected NCA (lithium nickel cobalt aluminium oxide) batteries for their EVs. They are also both moving toward optimized NMC cathode chemistries.

The optimized chemistries reduce the use of costly cobalt and instead use more nickel and manganese. Solid-state materials for battery electrolytes (which improve safety by decreasing the risk of fire) are being developed and C-Si composite material for anodes is being pushed for future battery technologies. Battery cost reduction is still the most challenging element of EV uptake as it makes up a large part of the vehicle cost. However, with the increasing benefits of economies of scale and additional research efforts, the cell production cost objective of $100 per kilowatt hour (kWh) could be reached in the long-term, helping to increase the share of EVs in the fleet. The electrification trend will increasingly influence the overall automotive sector with powertrain electrification becoming more widespread, with more hybrid electric vehicles (HEV), as well as plug-in hybrid electric vehicles (PHEV).

The overall efficiency of an electric powertrain, including the battery, is already quite high – battery charging/discharging is above 96% and the efficiency of electric motors typically between 90% and 96% – so there is only limited potential for further improvement. Future batteries will be smaller and lighter, reducing the overall vehicle weight significantly and, consequently, the energy needed to propel the vehicle. This development pressures ICE manufacturers to design more fuel-efficient engines and reduce emissions. Although COVID-19 may have slightly deferred and altered this objective, the initiated momentum is poised to keep EV uptake moving forward.

Moreover, some policymakers are turning increasingly to the potential of hydrogen as an essential instrument for meeting new policy objectives. The European Green Deal foresees partnerships with industry and the EU Member States in supporting research and innovation on clean hydrogen. Yet, in order to become competitive, the price of green hydrogen has to be reduced dramatically, and there is currently an absence of infrastructure for transportation and storage. This Outlook assumes only a small transition in that direction, while fuel cells running on hydrogen are only considered as having an impact on the transportation sector in the distant future.

Air transportation

This year's COVID-19 pandemic will affect the demand for air transportation in the short- and medium-term. The latest projection shows that the effect of COVID-19 will depress this year's demand for passenger flights by half compared to 2019. The recovery will not be fast with air transportation likely only reaching 2019 levels in the period from 2022 to 2024. However, given the expansion of the global population and middle class, recent developments will have a less significant effect on aviation in the long run.

Each new generation of aircraft has shown roughly a 15% fuel efficiency improvement in comparison to the previous generation, with fleet renewal taking place every 20 years on average. Advances in jet engine technology account for the main share of efficiency gains so far.

Modern jet engines have reached a 50:1 compression ratio, which corresponds to a theoretical efficiency of about 80%. Further improvements can be expected from evolutionary developments such as jet engines with high and ultrahigh bypass ratios. However, at some point, they will also reach their limit, since the corresponding increase in engine size increases the weight and drag considerably. Revolutionary systems, such as open rotor and hybrid or electric propulsion, will reach global passenger aviation beyond the 2030s.

This should not be confused with the beginning of electrification in this sector, where small (one-to-two seat) aircraft equipped with electric motors running on battery power have already been developed. Several companies are currently developing so-called urban air taxis, such as vertical take-off and landing (VTOL) aircraft powered by electric motors for short-distance flights. According to the International Civil Aviation Organization (ICAO), there are four such projects: Lilium, City Airbus, Boeing Aurora eVTOL and Bye Aerospace Sun Flyer 2 had their first flights in 2019. However, there is a long way to go between one-to-four seat electric aircraft and regional single-aisle hybrid-electric aircraft, which are expected to enter into service only after 2030.

Overall in the future, it will become more challenging to achieve incremental improvements with existing tube and wing aircraft configurations. That is why more revolutionary design concepts and sustainable aviation fuels (SAF) are being considered as potential pathways for reaching emissions goals, such as carbon-neutral growth from 2020 and a reduction of net CO_2 emissions by 50% from 2005 levels by 2050 set by all stakeholders in the aviation industry.

It is anticipated that new aircraft designs – e.g. blended wing/body configurations (BWB) and strut-braced wing (SBW), which may enter into the industry after 2030 – will provide additional space for implementing next-generation technologies and alternative fuels. One of those advances could be boundary-layer ingestion (BLI), which reduces drag and the engines require less thrust resulting in lower fuel burn.

SAFs are used in commercial flights every day. Yet the volumes which are produced account for less than 1% of total jet fuel demand. In addition, SAFs are more expensive than hydrocarbon fuels, due to the relative immature economy of scale in comparison to conventional fuels. In order to improve this situation, more significant state support is required together with effective policy frameworks, as well as substantial investment. This Outlook takes into account this development, as well as the potential of future evolutionary engineering advances in the airline industry.

Improved flight management systems on the ground, together with advanced flight control, will allow more direct and, hence, efficient connections, also contributing to lower specific fuel consumption of airplanes.

Marine transport – the backbone of global business

The implementation of the IMO rules to limit marine fuel emissions to a maximum sulphur content of 0.5% resulted in a reduction of the demand for high-sulphur fuel oil (HSFO).

However, the effect of the COVID-19 pandemic has changed the regular landscape of marine fuel markets. For example, the pandemic has reduced the incentive for ship owners to install scrubbers, exhaust gas cleaning systems which help to comply with the IMO 2020 regulation even when running on HSFO due to the lower spread between the high and very low sulphur fuel oil (VLSFO) differential. On the back of weaker overall demand and international trade, ship owners were reported to be delaying or cancelling the installation of scrubbers.

The modern, large ICEs used in marine transportation are the most productive combustion engines, achieving efficiency rates above 50%. One way to improve fuel efficiency and reduce fuel costs is to use a waste heat recovery unit, which may add 10% of additional power to the main engine, which is typically used to operate auxiliary devices on board, though future improvements are limited.

In the long-term, LNG may play a much greater role as a marine fuel than it currently does. Most large marine engines can already be ordered as dual-fuel engines, which can use both fuel oil and LNG. LNG could in fact become the dominant fuel, especially for large ocean-going vessels. This would result in substantially lower CO_2 emissions compared to oil-based fuels.

Today, digitalization is penetrating all sectors, including marine transportation, which could potentially increase value along the transportation chain and improve fuel efficiency. For example, highly optimized cargo management systems have led to significant reductions in handling overhead. In future, further optimization can be expected – the introduction of artificial intelligence (AI) based on big data from a vast number of real-time connected transport means (warehouses, road, rail, domestic and international shipping) and participants (from individual workers to globalized freight forwarders and shipping companies).

Conventional and renewable power generation

Electricity generation, which relies heavily on fossil fuels, will see a rising penetration of renewable sources such as wind and solar. Renewables have been gradually making their way into the generation mix, displacing mostly coal- and natural gas-fired electricity generation.

Coal-fired power plants have matured and the efficiency advantage brought to the industry by using boilers with supercritical thermodynamics cycles has allowed efficiency to rise above 45%. This is important considering that, on average, global power plant efficiency is only slightly above 34%. In countries such as China, old and inefficient coal power and heat plants have been partly replaced with more efficient and centralized coal plants (so-called 'clean coal'). This approach increases overall efficiency, reduces fuel consumption and improves local air quality. However, the investment needed to run at higher temperatures mainly in ultra-supercritical pressure and temperature ranges is still and will remain prohibitive. The cost-effectiveness and efficiency that are currently attainable from conventional power generation are reaching their limits.

Some regions have seen increasing coal-to-gas switching based on economics and policy measures, which has led to declining CO_2 emissions. The recent decrease of CO_2 emissions from the power generation sector in the US can be attributed mostly to the increased use of natural gas, which was based on the relative competitiveness of gas compared to coal. The gas-powered combined cycle power plants (CCPPs) will remain by far the least CO_2-emitting fossil-fuelled power plants, an advantage which should not be underestimated as countries and regions look to tackle climate change at reasonable costs. In Europe, gas-fired generation is supported not only by the increasing competitiveness of gas but also by the EU ETS. Overall, the efficiency of state-of-the-art CCPPs can reach 70% (fuel-to-power) – significantly higher than supercritical coal power plants. On top of this, cogeneration (power and heat) is an important building block for improving power plant efficiencies, with gas-fired combined heat and power (CHP) plants potentially reaching overall efficiency of almost 90%.

On the other side of electricity production, low-emission production is driven by the increasing share of renewables – mainly wind and solar. The terms carbon-neutral power generation and renewables are used synonymously although power generation (and other energy use) may be carbon-neutral, but not necessarily renewable. The increased share of renewables in the power generation mix has also been driven by the aim to address security of supply by using domestic energy, and by the same token, broadening the primary energy base as a whole.

The development of new technologies and improvement of existing ones, encouraged by massive investment and often accompanied by substantial direct and indirect subsidies, has contributed to increasing the efficiency of PV cells or enlarging the range of useful wind speeds for wind turbines, for example. The financial backing of renewables has brought down their power generation costs rapidly and they are now competing with conventional means of electricity generation. These trends are likely to continue with the levelized costs of generation for wind and solar declining even more, making them more competitive relative to fossil fuel-based generation.

Energy storage technologies on a large enough scale are still a missing link to support the strong uptake of renewables, despite the substantial efforts to make advances in this area and 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-fuelled back-up plants. Various power-to-fuel (PtL) concepts propose to store renewable power as fuel for the use in combustion engines or fuel cells. However, they are 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 current high-voltage systems – from producing to consuming locations. This Outlook takes into account such secondary effects impacting the expansion of renewable power.

This lack of energy storage requires a higher rate of back-up power (mostly gas- and coal-based) to offset the intermittency of wind and solar power generation. Nevertheless, the lowered load factor of back-up power plants may considerably increase the average power costs for reliable and year-round power supply.

On the pathway to clean electricity, the development of blue hydrogen electricity generation, which could be of interest for future oil applications, is also under way and is reliant on the development of carbon capture and storage or utilization (CCS/CCU).

Refining systems have a traditional role in providing transportation fuels. Still, current developments, namely IMO regulations and carbon constraining policies, could see bottom-of-the-barrel fuels like fuel oil seek diverse outlets. Stable and favourable oil and carbon pricing could help the promotion and development of stationary fuel cells in a carbon-constrained pathway. Thermodynamic cycles using supercritical CO_2 also has potential in electricity application, though this is still at a conceptual stage.

Residential and industrial sectors

Residential and industrial consumers naturally account for a major share of global energy consumption. Stable heating is required for many purposes, including daily warming of buildings and providing hot water. Likewise, the industrial sector often consumes heat during the course of many production processes. Usually, this thermal heating is produced by the simple combustion of fuel, for instance, by burning heating oil or natural gas.

A more advanced concept is cogeneration, like CHP, where the thermal energy of the exhaust from combustion engines (e.g. gas turbines) is captured for further use. By using heat that would otherwise be lost, CHP can increase efficiencies in generation to over 80%, compared with 50% in the case of traditional technologies.

A wide range of energy sources is used to meet residential energy consumption. Heat pumps offer a more innovative approach to heating buildings and producing hot water for residential consumers. In simple terms, heat pumps transfer heat from one source to another location by electric or mechanical means. Moreover, heat pumps are also able to provide cooling. As technology matures, more intensive application of heat pumps in district and industrial heating can be expected.

Expanding urbanization and the evolution in economies from rural agriculture and low-level manufacturing towards service and high-level technological industries continuously raises the demand for air-conditioning systems. Furthermore, employee productivity significantly improves when they work in a comfortable environment and, thus, temperature and humidity have an essential role. It is not surprising that the power demand from air-conditioning (AC) systems continues to rise globally. In this regard, district cooling (DC) systems are gaining in popularity. DC is a relatively new and emerging segment and is similar to a district heating system.

Instead of heat, centralized DC provides chilled water through a network of pipelines to supply customers' AC systems. Typical DC consists of a chiller plant, network and consumer station/connector. Water from natural sources can be used as a source for chilling water. DC provides significant electricity economy, which may exceed 30% depending on the type of AC.

In the future, smart buildings will attempt to incorporate all of these processes. Advancing concepts such as optimized glazing, green facades and use of new insulation systems may further decrease the primary energy consumption of buildings. The idea of smart buildings can be integrated into smart cities, optimizing cooperation between individual elements to an unprecedented level of AI and big data application.

Technologies related to oil production

Ongoing technological developments in the area of directional drilling and hydraulic fracturing, combined with highly advanced digitalization (i.e. sensing and visualization methods), have contributed enormously to the transformation of oil production. Production costs have decreased significantly with potential for further improvements in future. However, tight oil and shale gas production still face challenges related to efforts to minimize their carbon footprint. The use of water, chemicals and proppants in hydraulic fracturing, as well as methane emissions and flaring of associated gas, are the main obstacles from an environmental perspective.

In regard to oil sands, *in situ* methods have already managed to reduce production costs and the environmental impact.

The development of CO_2 storage and its wider application in the oil and gas industry may assist in enhanced oil recovery (EOR) production methods and help to significantly reduce overall CO_2 emissions. The future of fossil fuels is closely related to the deployment of CCS/CCU. Ambitious climate change and environmental targets to address global warming will be nearly impossible to realize without greater CCS/CCU use. The development of direct air capture (DAC) may also enhance the role of oil and add to the longevity of fossil fuels and oil in particular.

IT, big data and AI

The rising penetration of digitalization supported by increases in computing power will also influence the energy sector. The capability to analyze data will continue to grow at a rapid pace (i.e. big data). When managed properly, it offers immense value and opportunity through improved knowledge and enhanced decision-making. Furthermore, cloud technologies, AI and machine learning, combined with unprecedented capabilities of a new generation mobile networks, will continue to reshape the energy business. Predictive analytics is one example. Its ability to make prompt decisions will help to reduce costs, from the size of spare parts inventories and planned periods of equipment-forced outages, to optimized processes.

When combined with ongoing progress in the robotics sector, further development and expansion of remote operation processes can be anticipated, contributing to rising efficiency, as well as overall safety in the industry.

Blockchain is another segment of data processing that is becoming increasingly important. This concept is far broader than cryptocurrency with which it is often associated. It has an inherently forward-oriented structure wherein approved actions cannot be reverted at a later stage (immutability of transactions), but only compensated for by a future action, making blockchain an interesting concept for accelerating international trade, for instance. There is significant potential for its use in the energy industry.

Energy demand

Key takeaways

- The COVID-19 pandemic and related economic crisis resulted in downward revisions to global energy demand.
- Global primary energy demand is forecast to increase from 289 mboe/d in 2019 to about 361 mboe/d in 2045 (0.9 % growth p.a.).
- From 2019 to 2045, energy demand in the non-OECD region increases by 76.5 mboe/d while demand in the OECD drops by around 4.4 mboe/d.
- Energy demand in India and China will increase by 2.8% and 0.9% p.a., respectively, which accounts for more than 50% of the energy demand growth in developing countries in the forecast period.
- Oil is expected to remain the dominant fuel, but with a lower share and still ahead of gas and coal.
- 'Other renewables' retain the position of the fastest growing fuel category in the long-term, growing by 6.6% p.a. between 2019 and 2045. This results in massive growth of nearly 25.4 mboe/d in absolute terms, ahead of the increase in demand for gas (24 mboe/d) over the same period.
- Coal is the only fuel recording a decline in demand (0.3% p.a.) between 2019 and 2045, basically as a result of the shutdown and replacement of coal-fired power plants in the OECD and the introduction of more energy-efficient technology in other regions to reduce the carbon footprint.
- Global demand for hydro and biomass is expected to expand by 3.2 mboe/d (1.4% p.a.) and 9.1 mboe/d (1.2% p.a.), respectively. Similar gradual growth is projected for nuclear, adding 7.7 mboe/d (1.7% p.a.) to demand from 2019 to 2045.
- The growth of electricity generation is set to continue at rates much higher relative to overall primary energy demand growth. This is linked to expanding energy access and utilization of electricity in different sectors (e.g. digitalization, cooling and transportation.)
- The expected overall annual increase in energy-related CO_2 emissions between 2019 and 2045 is 2.4 billion tonnes (bt). This represents growth of around 7%, which is less than one-third of the overall increase in energy demand.
- Energy consumption per capita in the non-OECD region will remain coupled with rapid economic growth. The OECD region, by contrast, is set to see energy consumption per capita continue to decline despite anticipated modest economic growth, in part owing to its more service-oriented economies.

The widespread impact of COVID-19 on nearly every economic sector will influence the future of primary energy demand in both the short- and medium-term. Lockdown measures taken to contain the pandemic disrupted mobility, industrial output and trade across the world, leading to significant energy demand decline in all regions. The resulting impact has the potential to redirect strategies related to the energy transition – a growing focus of public attention before the pandemic – and to reshape consumer behaviour, how businesses operate and decisions on energy investment. Each one of these factors has an influence on energy demand going forward.

COVID-19 is without question an urgent health and economic policy challenge with a corresponding impact on the energy sector, but it is not the sole influencer of future energy demand. Other factors are at play, including changes in demographics, advances in technology, plus government regulatory and environmental policies. The interplay of major energy-demand drivers affects regions differently and, therefore, a mix of energy options is needed – those that are accessible, economic and sustainable. While taking all these factors into consideration, this chapter shows that fossil fuels will retain their leading role in the primary energy mix throughout the outlook period (2019–2045). Furthermore, it elaborates on the development and demand for each source of energy in the medium- to long-term.

2.1 Major trends in energy demand

Oil demand in road transport and aviation were hit the hardest as mobility ground to a halt during the COVID-19 lockdowns. The slump in economic activity began in China and quickly spread to the other regions in the second quarter of 2020. At the time when China's economy began a gradual recovery and energy demand rose, energy demand declined in other major economies during consecutive lockdown periods. Industrial output in both developed and developing countries weakened due to the restrictions.

Despite the pandemic, the long-term energy trends highlighted in this Outlook largely remain the same as in previous editions, while demand contraction is chiefly noticeable in the short- and medium-term periods (Table 2.1). Major energy demand additions will come from developing countries with promising economic and population growth and increased urbanization. The low population growth in the OECD region, improving efficiency in all principal sectors and a shift towards renewable energy (with lower transformation losses compared to conventional electricity generation) are main precursors to declining primary energy demand in the region.

Since the energy mix is evolving towards a transition, the eventual course will mainly be shaped by the security of supply and deployment of enhanced efficiency solutions that drive sustainable energy at lower costs. The energy transition is driving changes in the energy mix towards low-carbon energy and economical alternatives. The shift in primary energy sources still reflects regional diversity and other factors, though the share of gas and renewables in the energy mix is growing steadily in almost all major regions.

The deployment of renewables is receiving increased attention due to their declining costs, especially in solar and wind energy devices and components. The cost aspect is also making renewables more competitive in the power sector. Electricity generation from renewables is rising steadily in most regions, including the previously low-solar deployment areas like the Middle East & Africa. The expansion of wind energy and solar installations in OECD Europe is replacing coal in power generation, while coal use is increasing mainly in India and Other Asia. This trending paradigm shift in direction fits with regional policies of the developed regions and their focus on reducing emissions and improving energy efficiency. The pathways to the transition differ at a regional level, with some regions emphasizing cleaner power generation and others cleaner transport.

The prospects for hydro and nuclear energy are on a different course. Hydro and nuclear energy are unarguably potent low-carbon power generation sources and, therefore, are important

Table 2.1
World primary energy demand by fuel type, 2019–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Fuel share *%*	
	2019	2025	2030	2035	2040	2045	2019–2045	2019–2045	2019	2045
Oil	91.0	94.4	97.7	99.3	99.7	99.5	8.5	0.3	31.5	27.5
Coal	77.1	75.1	75.1	74.3	72.8	71.0	–6.1	–0.3	26.7	19.7
Gas	66.9	69.8	76.2	82.2	87.3	91.2	24.3	1.2	23.1	25.3
Nuclear	14.4	16.1	17.5	19.1	20.8	22.1	7.7	1.7	5.0	6.1
Hydro	7.3	8.1	8.8	9.5	10.2	10.5	3.2	1.4	2.5	2.9
Biomass	26.4	28.9	31.0	32.9	34.6	35.5	9.1	1.2	9.1	9.8
Other renewables	6.0	10.6	15.5	20.8	26.8	31.4	25.4	6.6	2.1	8.7
Total	**289.1**	**303.0**	**321.9**	**338.1**	**352.3**	**361.3**	**72.1**	**0.9**	**100.0**	**100.0**

Source: OPEC.

components of the energy transition. However, the potential for additional hydropower generation is limited except in some developing economies as most water resources are already utilized and some waterways are designated for agricultural irrigation, especially in some arid regions. OECD regions have largely developed their hydroenergy capacity to the fullest and potential expansion is, therefore, limited.

As for nuclear power, there is expansion potential in China, India and Russia. OECD Europe, meanwhile, is retiring some of its older nuclear power facilities and phasing out others in favour of renewable electricity and also due to public concerns about nuclear reactors. Overall, intended new reactors for electricity generation are distributed unevenly across the regions, mainly in the non-OECD. As additional investment opportunities in nuclear generation are being explored to address rising electricity demand in the long run, safety regulations and operating cost implications are carefully considered.

While it is worth noting that transportation accounts for the largest share of oil use, the development and deployment of electric mobility has been growing for some time. Expansion of the EV market, however, is still dependent on further technological advancements, especially in battery energy density and fast charging, as well as the availability of subsidy regimes that have helped drive the EV market. Despite the growing popularity of EVs, current limitations on charging infrastructure, the limited driving range, high battery costs and dwindling subsidies in some markets impact growth. There are also environmental issues revolving around the production and eventual disposal of batteries.

This Outlook examines the preceding issues while incorporating the revised GDP growth expectations and the demand collapse related to COVID-19.

Global primary energy demand is set to increase from 289 mboe/d in 2019 to about 361 mboe/d in 2045, which represents average growth of 0.9 % p.a. for the long-term outlook to 2045. The individual energy source components and their growth are shown in Table 2.1. 'Other renewables' is the fastest growing fuel source and its growth has expanded from last year's Outlook, especially with the shift in the forecast period to 2045. This is a reflection of the existing energy transition push to introduce more clean energy sources into the mix, particularly in OECD countries.

Coal has the lowest rate of growth as coal-fired power plants are increasingly replaced by renewables and gas in OECD countries. Global demand for coal is projected to decline by –0.3% p.a. on average during the forecast period. This is largely due to the shutdown and replacement of coal-fired power plants in the OECD region and the introduction of more energy-efficient technology in developing regions as carbon abatement is prioritized. Gas demand grows in absolute terms by 24.3 mboe/d, representing a 1.2% p.a. growth rate. Oil is set to grow by 8.5 mboe/d or 0.3 % p.a. in the current forecast.

Nuclear and biomass are projected to grow by 7.7 mboe/d and 9.1 mboe/d, respectively, over the forecast period as new nuclear reactors come online and the use of biomass increases in energy-deficient regions with prospective population growth, and as advanced lignocellulosic biomass fuels are introduced in developed regions. Hydroenergy adds only about 3.2 mboe/d, which represents a 1.4 % p.a. growth as newer sources are added, mainly in developing regions with untapped water resources.

The pathway towards an energy transition and decarbonization necessitates the formulation of policies that encourage a shift to low-carbon fuels, often in tandem with efforts to significantly improve energy efficiency across sectors. Consequently, the shares of coal and oil drop by 7 percentage points (pp) and 4 pp, respectively, by 2045 compared to 2019. However, the share of gas in primary energy is set to grow by 1.9 pp, mainly in power generation and residential heating, and some transportation, while the 'other renewables' segment increases its share by 6.6 pp. Nonetheless, oil will continue to account for the largest share of the global energy mix for the outlook period.

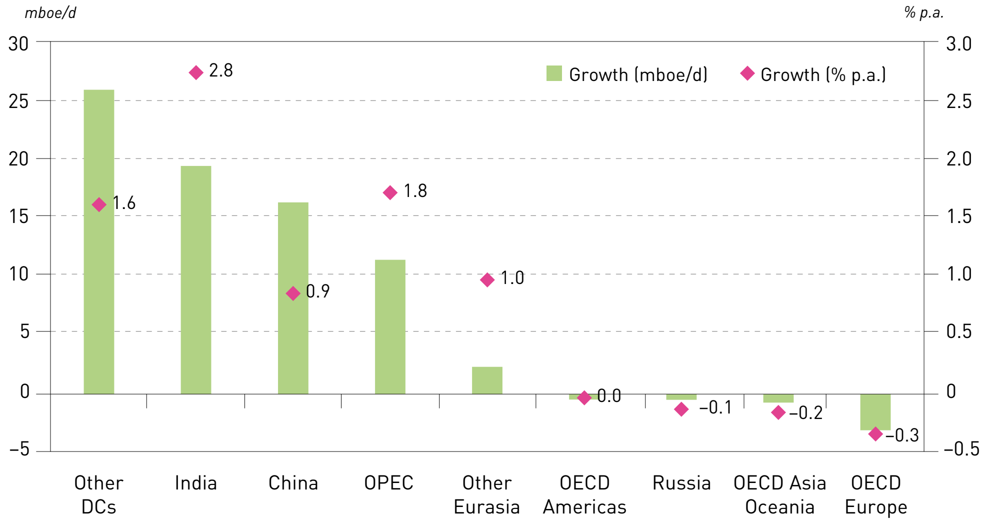
Major additions to primary energy demand still emanate from developing areas, specifically India, China and other non-OECD regions with the exceptions of Eurasia and Russia, which show limited and negative growth, respectively (Figure 2.1). Growth is primarily linked to rising populations and a higher standard of living that requires additional energy in line with increased urbanization and transport demand. Cumulatively, non-OECD regions, which are expected to require an additional 76.5 mboe/d, represent 70.5% of the global primary energy demand by 2045 (Table 2.2 and Figure 2.1).

Table 2.2
Total primary energy demand by region, 2019–2045

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2019	2025	2030	2035	2040	2045	2019–2045	2019–2045	2019	2045
OECD Americas	56.3	55.7	56.2	56.2	56.0	55.8	–0.5	0.0	19.5	15.5
OECD Europe	36.5	35.3	34.9	34.4	33.8	33.3	–3.1	–0.3	12.6	9.2
OECD Asia Oceania	18.3	17.7	17.8	17.8	17.6	17.5	–0.7	–0.2	6.3	4.9
OECD	**111.1**	**108.7**	**109.0**	**108.4**	**107.4**	**106.7**	**–4.4**	**–0.2**	**38.4**	**29.5**
China	65.6	71.5	75.8	78.6	80.6	82.3	16.7	0.9	22.7	22.8
India	18.9	22.2	26.6	31.1	35.2	38.8	19.8	2.8	6.5	10.7
OPEC	20.5	22.2	25.3	28.1	30.6	32.2	11.7	1.8	7.1	8.9
Other non-OECD	50.0	55.2	61.5	67.8	73.8	76.5	26.5	1.6	17.3	21.2
Russia	14.9	14.6	14.6	14.6	14.6	14.4	–0.5	–0.1	5.2	4.0
Other Eurasia	8.1	8.5	9.0	9.6	10.0	10.4	2.4	1.0	2.8	2.9
Non-OECD	**178.1**	**194.3**	**212.9**	**229.8**	**244.9**	**254.6**	**76.5**	**1.4**	**61.6**	**70.5**
World	**289.1**	**303.0**	**321.9**	**338.1**	**352.3**	**361.3**	**72.1**	**0.9**	**100.0**	**100.0**

Source: OPEC.

Figure 2.1
Growth in primary energy demand by region, 2019–2045

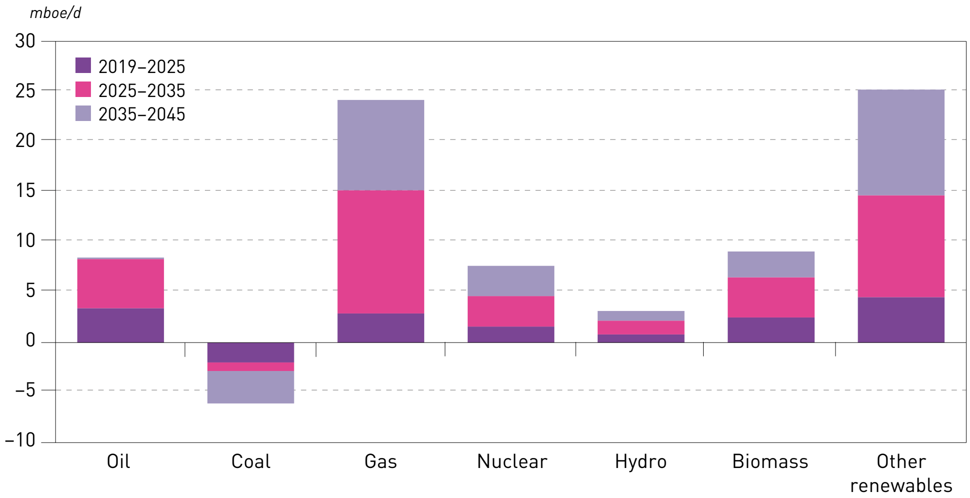


Source: OPEC.

In the period 2019–2045, primary energy demand growth in the OECD region is set to fall by 4.4 mboe/d or –0.2% p.a. on average, principally due to improving energy efficiency in major energy-intensive sectors and also declining consumption of coal and oil.

As demand for gas rises rapidly, it partly compensates the declining share of coal that is displaced by 'other renewables', mainly in power generation. Lower gas prices serve as a springboard for increasing demand in some major energy-intensive regions. While the percentage share of coal, and to a lesser extent oil, in the energy mix will decline, rising gas demand means that these three fuels by 2045 are forecast to constitute 72.5% of the global energy mix, an 8.8 pp decline from 2019.

Figure 2.2
Growth in primary energy demand by fuel type, 2019–2045



Source: OPEC.

Box 2.1

Evolving strategies of major energy companies

The COVID-19 pandemic, and its resulting effects on oil and energy markets, are reinvigorating discussions about the long-term energy future. Several factors are prompting this debate, such as lower oil prices, uncertainty as to how quickly oil demand will recover, discussions of energy-related policy measures, and stimulus packages that are tied not only to economic recovery, but also green energy incentives. The increased uncertainty as to what this energy future might look like has been pointed out several times in the WOO 2020.

It is evident there is a wide range of long-term views taken by various international oil companies (IOCs) and national oil companies (NOCs). Simply put, these span from bold claims that peak oil demand may already be here, resulting in a desire to diversify towards becoming an 'integrated energy company' (some European IOCs), to an insistence that oil markets will recover cyclically from this crisis, as they always have, and corresponding bets on further long-term growth for oil (US majors). In between sit some of the major NOCs, which are vertically integrating and diversifying, even while confident they can benefit from their lower cost base (and often strong domestic market) for years to come.

When picking apart these different visions, there are various driving factors. In the short-term, the immediate impact of the pandemic has been to sharply pressure prices and eat away at oil demand. As a direct impact, quarterly results released by large publicly-traded oil companies at the end of the second quarter of 2020 were generally dismal, showing hefty losses, particularly for those without a strong trading arm.

Share values of many IOCs have declined sharply this year. ExxonMobil, once the world's largest company, made headlines in August when it dropped out of the Dow Jones Industrial Average index of major US companies. Western oil majors have also written off a record chunk of assets, wiping tens of billions of dollars from their balance sheets, and in many cases launched major asset divestment efforts.

The fact that IOCs feel compelled to sell off significant assets also plays into the so-called stranded assets argument that certain oil fields might be uneconomic to develop. This argument, which was initially made by environmentalists, has now been picked up by some investors. However, while it has led to greater transparency – a welcome outcome – it has rarely included a comprehensive or holistic view of long-term global energy needs.

Reputational risk is also now increasingly being discussed in boardrooms, amid growing awareness of the potential ramifications of climate change. Some investors, previously used to having a solid stock of dividend-paying energy company shares in their portfolio, now view these companies as not nearly as attractive as start-ups with new, more nimble models, nor as stably profitable as the new tech behemoths. Oil companies' combined share in the S&P 500 now makes up around 4%, compared to 16% in 2008.

In the context of a broader discussion about climate change, oil and energy companies' long-term strategies are being questioned. This discussion also feeds into the one about whether hauling the world out of recession and a return to growth may accelerate the fledgling energy transition, and in which way.

Some of the most striking headlines recently were generated by BP's announcement that it intends to reduce its oil and gas production by 1 mboe/d, or some 40% over the next decade, while increasing investments in low-carbon technologies by a factor of ten, to around $5 billion per year in the same time frame. By 2050, the company is aiming to have net zero emissions. BP clearly sees future potential for oil and gas, but increasingly in combination with renewables, battery storage and hydrogen – what it is calling 'integrated energy solutions'. In mid-September, BP also released its annual long-term Energy Outlook, which even in its most optimistic scenario sees oil demand at best recovering to pre-COVID levels in the medium-term, seemingly supporting its new business strategy.

By and large, other European IOCs are setting themselves on similar trajectories, notably Shell, Total and Eni. These companies adopted strategies they believe will reap benefits from a more imminent energy transition.

By contrast, the two largest US-based IOCs, ExxonMobil and Chevron, remain more steadfast in their belief that oil demand will recover from what they see as a cycle of boom and bust – albeit a much more extreme one due to the pandemic-induced circumstances. Both have also been forced to shed upstream assets, but strikingly ExxonMobil has not written down any assets due to the lower price outlook. It is also evident that both are planning to continue to invest in upstream capacity, though not as much as previously envisaged given events in 2020, a sign of their more positive outlook for oil in the long-term energy mix. Additionally, both appear to remain more committed to the downstream, including petrochemicals, than some European majors, and neither has made significant investments in renewables.

Somewhere in between stand a few of the large NOCs, including some from OPEC Member Countries. One that stands out due to its size is Saudi Aramco (though many of its efforts are true of others). It is clearly determined to continue investing in oil, including in the upstream, midstream and downstream. Yet it is also committed to diversifying energy sources and production, not least to free up more oil for export. Hence, it and others are developing domestic sources of gas, and neighbouring United Arab Emirates (UAE) has recently commissioned its first nuclear power station. Saudi Arabia, the UAE and others are developing renewables, which in the region often means solar power.

NOCs like Saudi Aramco are also investing heavily in petrochemical capacity – for example, it purchased 70% of SABIC – as well as crude-to-chemicals and downstream capacity, including overseas. Saudi Aramco is also at the cutting edge when it comes to research into new technologies, such as hydrogen and various options for carbon capture, utilization and storage (CCUS). Besides simply collecting and reinjecting CO_2, which is widely used to extend the life of oil fields, the company is researching methods to convert CO_2 directly into chemicals and even fuels, or to capture it in materials, for instance cement. Such efforts would of course serve to extend oil's relevance if in essence it becomes a low- or even zero-carbon energy source. These are all part of the company's wider strategy related to the circular carbon economy (CCE) (Box 7.1).

It begs the question: what do we make of these divergent long-term strategies? Clearly, there is some degree of correlation between oil prices and new initiatives. Some 20 years ago, in a period of lower oil prices, BP unveiled its 'Beyond Petroleum' campaign, with partly similar goals to diversify away from oil and towards a broader renewable energy portfolio. Other companies have tried similar things. The fact that it is mostly European IOCs that are redirecting interest and investments towards renewables suggests that there is a 'cultural' element to their thinking. Perhaps this is more influenced by domestic debates, and also the realization that Europe by and large will see oil demand decline as it pursues greener policy initiatives set by both national governments and the EU.

In contrast, US IOCs and NOCs currently have less domestic pressure, and NOCs in emerging economies are more cognizant of the role they will have to play in meeting rising energy needs as their economies grow. Moreover, a period of lower oil prices could incentivize stronger demand growth again, as it has done in the past. One thing most IOCs arguably have in common is increasing difficulties to replace reserves, given lower prices, curbs on exploration budgets, investor pressure and environmental concerns.

The WOO 2020 projects that oil will be needed for years to come, and even if demand plateaus in the long-term, it will remain a key fixture in the energy mix. In any case, low-cost producers, including many OPEC NOCs, will continue to play an all-important role in supplying oil to the world, even in a future in which oil demand no longer grows, or even declines.

Only time will tell which vision of our common energy future is correct, or whether there are many pathways.

2.2 Energy demand by region

Primary energy demand varies from region to region. OECD countries, with somewhat advanced levels of energy-efficient industrialization and saturated transport, will experience less demand growth. Conversely, the non-OECD regions that lead in population growth and urbanization require more energy for corresponding economic activities. Consequently, as energy demand grows, regions will exhibit differing energy mixes that match their requirements and ensure supply security. Therefore, regional and country-level energy demand variations are subject to a diversity of factors such as demographic growth, energy policies and economic development.

In the **OECD** countries, oil and gas combined constituted two-thirds of the energy mix in 2019 and the shares of the other sources are shown in Table 2.3. This illustration also shows the declining growth of oil in the energy mix for the forecast period (2019–2045), which is mainly associated with efficiency gains and fuel substitution, especially in the industrial and transport sectors. However, natural gas' role as a share of the OECD energy mix grows for power generation and residential use. At the end of the outlook period, the combined shares of the two major fuels drops to 58.8 % of the energy mix as they approach convergence.

Table 2.3
OECD primary energy demand by fuel type, 2019–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Fuel share *%*	
	2019	2025	2030	2035	2040	2045	2019–2045	2019–2045	2019	2045
Oil	41.4	40.2	38.2	35.4	32.3	29.3	–12.1	–1.3	37.3	27.5
Coal	17.0	14.0	12.7	11.5	10.5	9.6	–7.4	–2.2	15.3	9.0
Gas	30.4	30.0	31.0	32.0	32.8	33.4	3.0	0.4	27.4	31.3
Nuclear	10.3	10.2	10.4	10.7	10.8	10.9	0.6	0.2	9.3	10.2
Hydro	2.5	2.6	2.7	2.8	2.9	2.9	0.5	0.7	2.2	2.8
Biomass	6.6	7.3	7.9	8.6	9.1	9.6	3.0	1.5	6.0	9.0
Other renewables	2.9	4.4	5.9	7.4	9.1	10.8	7.9	5.2	2.6	10.1
Total	**111.1**	**108.7**	**109.0**	**108.4**	**107.4**	**106.7**	**–4.4**	**–0.2**	**100.0**	**100.0**

Source: OPEC.

Energy use in OECD regions declines at the end of the outlook period as the countries deploy more efficient and low-emission energy technology solutions that conserve energy in the industrial, residential and transportation sectors. In addition, the lower population growth rate, energy use saturation (mainly in the transport sector) and relatively low GDP growth contribute to the energy demand decline of 0.2 % p.a. within the forecast period (2019–2045).

In the **non-OECD** region the energy mix and demand situation differs widely from the developed regions. Energy growth is dictated by the expanding population and accompanying urbanization. The energy demand of non-OECD countries is spearheaded by India and China, which are the leaders in final energy consumption.

The non-OECD energy mix also is dominated by fossil fuels (Table 2.4), the combined shares of which constituted 82.1% in 2019, dropping to 74.4% at the end of the forecast period. Even though both oil and gas register appreciable growth, of 20.6 and 21.3 mboe/d, respectively, the expansion of nuclear and 'other renewables' affects the combined shares of the fossil fuels. Non-OECD primary energy demand grows, on average, at the rate of 1.4 % p.a. for the forecast period 2019–2045. As the energy demand of non-OECD countries is dominated by India and China, the Outlook takes a close look at the energy mix of these energy demand-growth behemoths. The primary energy demand outlook by fuel for China and India are displayed in Table 2.5 and Table 2.6, respectively.

Table 2.4
Non-OECD countries primary energy demand by fuel type, 2019–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Fuel share *%*	
	2019	2025	2030	2035	2040	2045	2019–2045	2019–2045	2019	2045
Oil	49.5	54.2	59.5	63.9	67.4	70.1	20.6	1.3	27.8	27.6
Coal	60.1	61.1	62.5	62.7	62.3	61.4	1.3	0.1	33.8	24.1
Gas	36.5	39.9	45.1	50.2	54.6	57.8	21.3	1.8	20.5	22.7
Nuclear	4.2	5.8	7.1	8.4	10.0	11.2	7.0	3.9	2.3	4.4
Hydro	4.8	5.5	6.1	6.7	7.3	7.5	2.7	1.7	2.7	3.0
Biomass	19.8	21.6	23.1	24.4	25.5	25.9	6.1	1.0	11.1	10.2
Other renewables	3.1	6.1	9.5	13.3	17.8	20.6	17.4	7.5	1.8	8.1
Total	**178.1**	**194.3**	**212.9**	**229.8**	**244.9**	**254.6**	**76.5**	**1.4**	**100.0**	**100.0**

Source: OPEC.

China's primary energy demand is projected to grow by 0.9% p.a., thereby continuing to account for over 20% of the total global energy demand during the forecast period of the Outlook. As the country evolves, with ambitious policies supporting emission abatement, transport electrification and less energy-intensive industries, the energy mix follows this trend too. The country, therefore, requires the mobilization of all energy sources to reach these aspirations, especially with the need to generate more electricity to support growing urbanization and mobility. Coal has been dominant in China for security of supply considerations and exceeded 60% of the country's energy mix in 2019. However, the share of coal drops at the end of the projection to 41.7%, mainly as super-critical coal-fired plants reach the limit of their efficiency, and are displaced by more efficient lower-emission combined-cycle gas turbines. Consequently, coal is set to decline by 0.6% p.a. during the forecast period.

Gas demand in China is set to grow by 5.5 mboe/d in the 2019–2045 period, almost double that of the corresponding oil demand growth. Closely following gas, nuclear and 'other renewables' will

Table 2.5
China primary energy demand by fuel type, 2019–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Fuel share *%*	
	2019	2025	2030	2035	2040	2045	2019–2045	2019–2045	2019	2045
Oil	12.5	13.6	14.5	15.0	15.4	15.7	3.2	0.9	19.0	19.0
Coal	40.3	40.1	39.4	37.9	36.1	34.3	–6.0	–0.6	61.3	41.7
Gas	5.0	6.6	8.0	9.2	10.1	10.5	5.5	2.9	7.6	12.8
Nuclear	1.7	3.0	3.8	4.6	5.6	6.5	4.8	5.2	2.7	7.9
Hydro	2.1	2.3	2.4	2.6	2.7	2.9	0.8	1.3	3.1	3.5
Biomass	2.4	2.8	3.2	3.6	3.9	4.1	1.8	2.2	3.6	5.0
Other renewables	1.7	3.2	4.4	5.6	6.8	8.3	6.5	6.2	2.7	10.1
Total	**65.6**	**71.5**	**75.8**	**78.6**	**80.6**	**82.3**	**16.7**	**0.9**	**100.0**	**100.0**

Source: OPEC.

also play equally significant roles in the future energy mix of China. Combined demand growth of 11.3 mboe/d is expected for these fuels by 2045. While starting from a low base, 'other renewables' and nuclear show the highest growth rate of all fuel sources.

China's demand for oil grows at 0.9% p.a., adding in absolute terms about 3.2 mboe/d. Other fuels that witness slight incremental growth in the energy mix are hydro (1.3% p.a.) and biomass (2.2% p.a.), whose combined growth is set at 2.6 mboe/d.

India's primary energy sources, in contrast to China's, are more flexible and diversified (Table 2.6). Fossil fuels currently constitute more than 75% of the energy mix, which still falls below the level of China. At 45.6%, India had less coal in the energy mix than China in 2019. Indian coal production is forecast to grow at a healthy rate, mainly utilized in power generation and the rail transportation sub-sector. India's coal demand is projected to grow at 2.6% p.a. as the population, urbanization rate and infrastructure expand. India is set to see coal demand increase up to about 8 mboe/d within the forecast period. Other fossil fuels grow in the Indian energy mix as well.

Table 2.6
India primary energy demand by fuel type, 2019–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Fuel share *%*	
	2019	2025	2030	2035	2040	2045	2019–2045	2019–2045	2019	2045
Oil	4.7	5.7	7.0	8.3	9.6	10.7	6.0	3.2	24.8	27.6
Coal	8.6	9.9	11.7	13.6	15.3	16.6	8.0	2.6	45.6	42.9
Gas	1.1	1.4	1.9	2.4	2.8	3.2	2.1	4.1	5.9	8.2
Nuclear	0.3	0.4	0.6	0.8	0.9	1.2	0.9	6.0	1.3	3.0
Hydro	0.3	0.3	0.4	0.5	0.5	0.6	0.3	3.1	1.4	1.5
Biomass	3.8	4.0	4.1	4.2	4.2	4.2	0.4	0.4	19.9	10.7
Other renewables	0.2	0.5	0.9	1.4	1.8	2.3	2.1	10.1	1.0	6.0
Total	**18.9**	**22.2**	**26.6**	**31.1**	**35.2**	**38.8**	**19.8**	**2.8**	**100.0**	**100.0**

Source: OPEC.

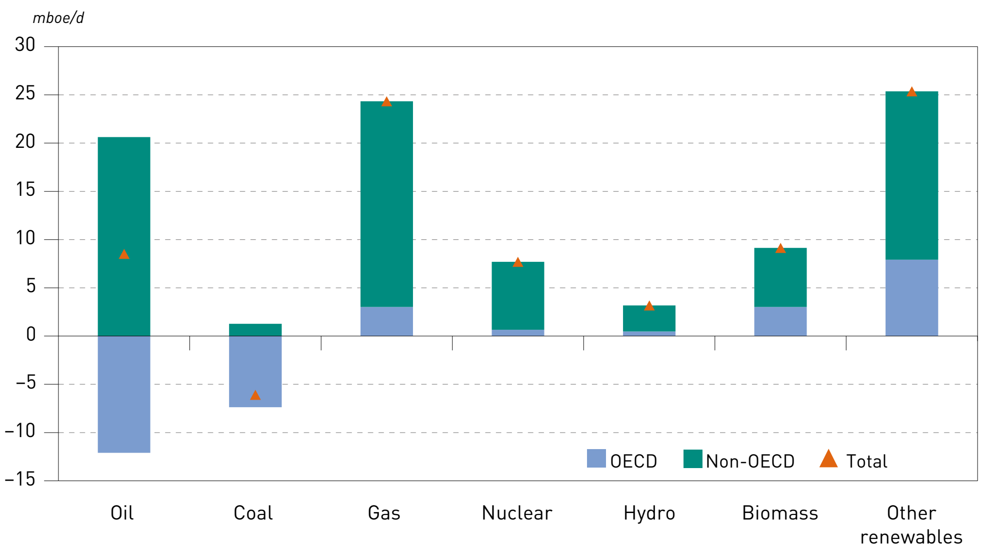
India's oil demand continues to grow at a steady rate, adding 6 mboe/d by the end of the projection. Gas demand and growth supersede other fossil fuels, despite starting at a low base level. Gas is projected to grow in the energy mix at 4.1% p.a. within the outlook period as India deploys gas in electricity generation to complement coal and renewable sources. This Outlook foresees the continued growth of gas in the power generation sector and in the transportation sector as CNG infrastructure and the distribution network improve. Natural gas is set to grow by over 2 mboe/d, which would represent about an 8% share in the energy mix by 2045.

As renewable energy use in India continues to increase, further growth is supported by policies and the removal of constraints for additional investment. In the medium-term, solar and wind energy are set to add about 60 GW of electricity capacity. In the long run, the transition to clean energy sources will accelerate with renewables accounting for about 6% of the energy mix by the end of the outlook period. The outlook does not foresee significant capacity additions from hydroenergy. The share of hydroenergy in the mix is set to increase by a mere 0.1 pp from the current share of 1.4%. Nuclear and biomass combined are projected to introduce an additional 1.3 mboe/d of primary energy demand growth in India by 2045.

In order to illustrate regional disparities in projected primary energy growth, Figure 2.3 depicts the growth demand by fuel type in OECD and non-OECD regions. While oil and gas constitute the bedrock of energy demand growth in the non-OECD region due to population expansion and urbanization, the OECD region is primarily increasing capacity in low-emission renewables, especially for electricity generation. At the end of the forecast period, the OECD is set to add about 8 mboe/d from 'other renewables' sources despite the total energy demand decline of about 0.2% p.a. on average within the outlook period. Nonetheless, oil and gas still contribute almost 59% to the OECD energy mix by 2045. No significant hydro and nuclear additions in the OECD are expected at the end of the projection as both sources combined contribute a growth of 0.9 mboe/d, largely attributable to the attainment of the hydropower threshold and retirement of some nuclear plants in Europe.

In non-OECD countries, oil, gas and 'other renewables' dominate the growth arena as the three energy sources combined constitute 80% of the growth, which in absolute terms translates to 59.4

Figure 2.3
Growth in energy demand by fuel type and region, 2019–2045



Source: OPEC.

mboe/d. Note that unlike in the OECD, all energy sources in developing countries register growth, each at different levels with gas alone adding about 21.3 mboe/d. However, 'other renewables' is the fastest growing and is projected to increase 7.5 % p.a. for the period 2019–2045. Additionally, demand for nuclear is projected to grow at 3.9 % p.a., mainly in China, making it the second fastest growing fuel source in the region. At 0.1 % p.a., coal is the fuel source with the slowest growth in the non-OECD energy mix due to pollution abatement in major cities and fuel substitution with cleaner energy sources, as well as the introduction of enhanced coal-fired technology.

2.3 Energy demand by fuel

2.3.1 Oil

It is important to note that the figures shown in this Chapter are not directly comparable to those shown in other chapters. There are two main reasons for this. First of all, Chapter 2 uses energy equivalent units (mboe/d) to allow for a comparison between the different fuel types. In other chapters, oil is expressed in volumetric units (or mb/d).

Secondly, the definition of oil in Chapter 2 is different from that used in Chapters 3 through 8. While Chapter 2 deals with primary energy sources, other chapters consider the outlooks for all liquid fuels. In that sense, in this chapter biofuels are 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 subsequent chapters. 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.

At the global level, the demand for oil-based products is set to increase in the long-term from around 91 mboe/d in 2019 to 99.5 mboe/d in 2045. This represents an overall increase of around 8.5 mboe/d over the forecast period (Table 2.7). However, this overall increase masks significant changes in the oil demand trajectory which will take place with respect to both regional development and the passage of time. Although not visible in the table, the largest change ever experienced in oil demand took place in the second quarter of 2020 as a result of the worldwide lockdown measures and lower economic activity caused by the COVID-19 pandemic. On an annual basis, oil demand will decline by around 8.5 mboe/d in 2020 compared to 2019 levels.

Under the assumption that the COVID-19 pandemic will be broadly contained in the course of 2020, oil demand is expected to recover in 2021 and 2022, and will continue growing in the years thereafter. Healthy demand growth rates are expected, especially over the medium-term horizon, with oil demand reaching 94.4 mboe/d in 2025. Moderate growth is also projected for another decade before demand starts plateauing for the rest of the forecast period.

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 period. In 2019, oil provided more than 31% of global energy requirements. This share will gradually decline to below 30% by 2035 and further to almost 27% by 2045. Nevertheless, this will still be higher than the share of any other source of energy. Moreover, oil will also keep its place among major contributors to incremental energy demand between 2019 and 2045. Measured on an energy content basis, the oil demand increase of 8.5 mboe/d will be the third largest increment, just after 'other renewables' and natural gas. The details and major drivers for this demand path, such as developments in the road transport sector, aviation and petrochemicals, are discussed extensively in Chapter 3 (Oil demand).

Turning to the trends at the regional level, there is a stark contrast between expected developments in the OECD and non-OECD countries. Future oil demand growth will be almost exclusively driven by non-OECD countries in which demand will increase by almost 21 mboe/d between 2019 and 2045.

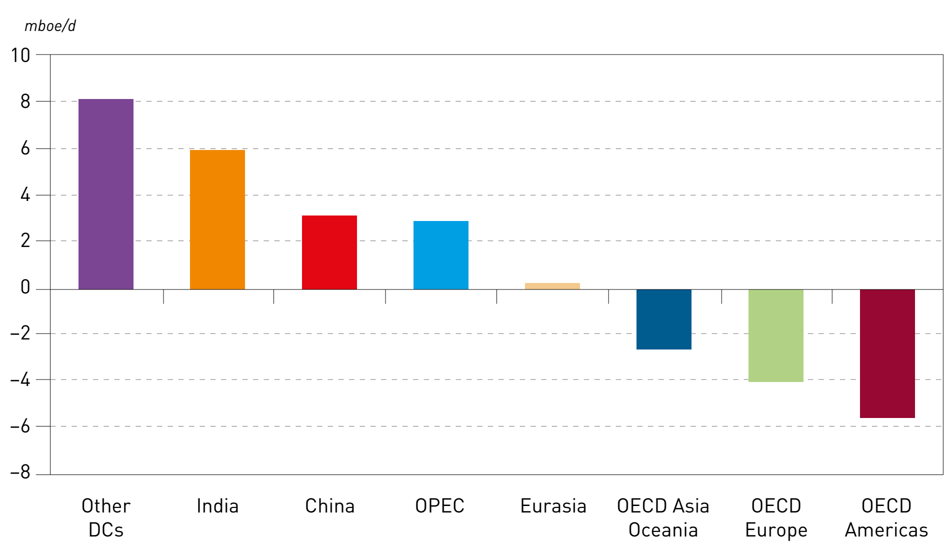
Table 2.7
Oil demand by region, 2019–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Share *%*	
	2019	2025	2030	2035	2040	2045	2019–2045	2019–2045	2019	2045
OECD Americas	21.3	21.3	20.4	19.0	17.3	15.7	–5.5	–1.2	23.4	15.8
OECD Europe	12.8	12.2	11.4	10.6	9.7	8.9	–4.0	–1.4	14.1	8.9
OECD Asia Oceania	7.4	6.8	6.3	5.8	5.3	4.8	–2.6	–1.7	8.1	4.8
OECD	**41.4**	**40.2**	**38.2**	**35.4**	**32.3**	**29.3**	**–12.1**	**–1.3**	**45.6**	**29.5**
China	12.5	13.6	14.5	15.0	15.4	15.7	3.2	0.9	13.7	15.7
India	4.7	5.7	7.0	8.3	9.6	10.7	6.0	3.2	5.2	10.8
OPEC	8.4	9.2	10.2	10.9	11.3	11.3	2.9	1.2	9.2	11.4
Other DCs	18.7	20.2	22.2	24.0	25.5	26.9	8.2	1.4	20.5	27.0
Russia	3.3	3.5	3.6	3.6	3.5	3.4	0.1	0.1	3.7	3.4
Other Eurasia	2.0	2.0	2.1	2.2	2.2	2.2	0.2	0.4	2.1	2.2
Non-OECD	**49.5**	**54.2**	**59.5**	**63.9**	**67.4**	**70.1**	**20.6**	**1.3**	**54.4**	**70.5**
World	**91.0**	**94.4**	**97.7**	**99.3**	**99.7**	**99.5**	**8.5**	**0.3**	**100.0**	**100.0**

Source: OPEC.

Driven by an expanding middle class, high population growth rates and stronger economic potential, the largest part of this growth will come from developing countries, led by India and China (Figure 2.4). India especially has emerged at the forefront of countries with growing oil demand due to extending the time horizon of this Outlook to 2045. This is because oil demand in India, similar to several other developing countries, especially those in Africa, will still be on a growth trajectory during the

Figure 2.4
Incremental oil demand by region, 2019–2045



Source: OPEC.

second part of the forecast period, whereas demand in other large non-OECD countries, such as China, Russia and Brazil, will be maturing or even declining.

In contrast to these countries, oil demand in the OECD declines significantly in the period to 2045. Demand in this group of countries will likely experience a short period of growth while recovering from the COVID-19 crisis before entering a long period of slow but steady decline. The largest demand decline (5.5 mboe/d between 2019 and 2045) is projected for OECD Americas, although in relative terms, demand is expected to drop in OECD Asia Oceania much faster than in OECD Americas. Somewhere in between is the projected demand decline in OECD Europe, which in absolute terms will be at around 4 mboe/d. This represents an average annual decline of around 1.4% over the entire forecast period.

2.3.2 Coal

Coal is the largest and most accessible source of electricity generation worldwide considering its reliable nature as a base load fuel with a low cost. It is estimated that global coal-based electricity generation has doubled since the 1990s, mainly driven by a growth in industrialization and electrification in developing nations. The largest recoverable reserves are mainly located in the US, China, Australia, Russia, India, Germany, Ukraine and South Africa while major production of the resource takes place in China, the US, India, Russia, Australia and Indonesia.

Rapid growth in the Chinese economy and demand for coal was the key driver of the large demand increase for both thermal and metallurgical coal, while policy measures and investment to boost the share of renewables and gas pushed down demand growth for coal globally.

China at the moment accounts for half of annual coal production globally and the fuel has a more than 60% share of the country's total energy demand. Therefore, it is still a decisive source of energy and is positioned at the heart of China's giant steel and cement industries. Nonetheless, inefficient production processes in many coal mines and significantly increasing environmental regulation have resulted in the country's coal output shrinking in recent years.

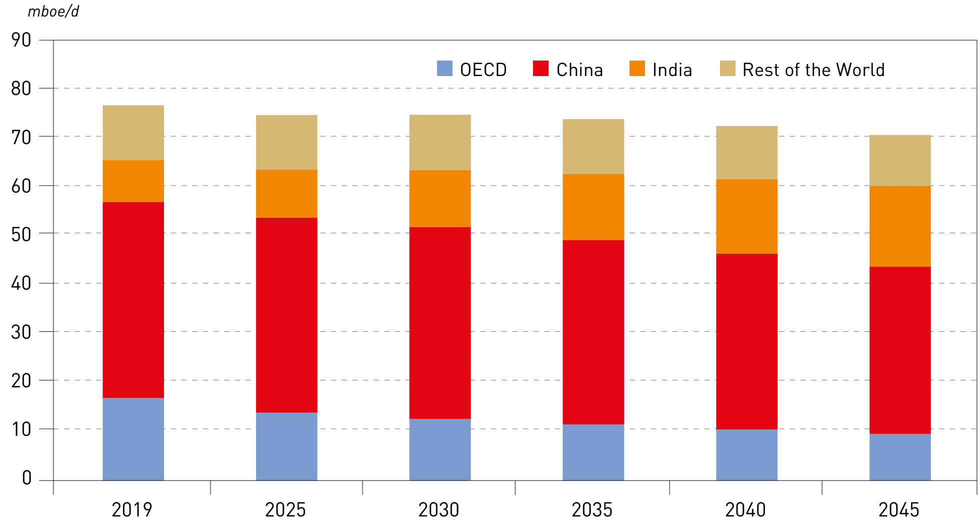
Australia is currently the biggest coal exporter to China, followed by Indonesia and Russia and China is still the prime customer for coal in the seaborne market. This dynamic is expected to continue in the decades ahead. However, expected lower economic growth and changes in government policies will impact supply and demand dynamics so that coal's share in the country's energy mix is projected to decline.

Therefore, it is expected that demand for coal in China will drop by 0.6% p.a. between 2019 and 2045, and this will remove around 6 mboe/d of coal demand. In 2020, coal consumption has fallen in some major power plants while the outbreak of COVID-19 also affected the country's economy and reduced power demand in the short-term. China, therefore, is likely to import less thermal coal in the medium-term while the prospect of tighter supplies from some countries (e.g. Australia and Indonesia) is also likely to impact prices and market conditions in the medium-term.

The COVID-19 pandemic also lowered the demand for coking coal in India and Europe and this opens new room for heavy industries in China to take advantage of the crisis. This assumes that COVID-19 will be brought under control earlier in China and production will return to normal levels before other countries. But there is considerable doubt over whether the market will act and rebalance in the medium term.

Indonesia is one of the world's largest producers and exporters of coal. Its coal industry consists of a few large producers alongside many small miners, especially in Sumatra and Kalimantan.

Figure 2.5
Coal demand by major region, 2019–2045



Source: OPEC.

In the long-term, Indonesia's domestic consumption is forecast to increase as power generation capacity is added to support the country's energy plan. Meanwhile, some big players have lost their interest in investing more in such a low-priced commodity. In combination with the country's plan to supply around one-third of its energy mix using coal, export tariffs may discourage the expansion of Indonesian exports in the medium- to long-term.

Another major coal producer, Australia, is an exporter of both thermal and metallurgical coal and accounts for 20% and 50%, respectively, of these global markets. Total domestic coal production in Australia has almost doubled since the 1990s and the country is considered the world's biggest coal exporter. Coal is now the main fuel source for electricity generation in Australia and accounts for around 60% of the power supply of the country. However, environmental concerns are limiting new investment and expansion.

Despite the drop in the demand forecast in China, the main importer of Australian coal, it is projected that overall demand for Australian coal will stay strong, at least in the medium-term. This is due to the high quality of its thermal coal and demand growth in India and some other developing countries.

At the same time, it is estimated that market oversupply, low prices and high production costs could hinder the expansion of coal production in Australia. The same constraints in past years have kept new investment in the coal sector at a level that only allows for sustainable production rather than major expansion. Meanwhile, domestic coal consumption is declining because of competition from natural gas and renewables. This will release more capacity for coal exports to India and Southeast Asia.

India is the second largest importer of coal after China and is significantly dependent on the fuel to support economic growth and to increase electricity access. The share of coal in India's energy mix exceeds 45% and the construction of more coal-fired power plants is planned alongside the diversification of India's energy portfolio using renewables and nuclear energy. However, these plans are under threat from the COVID-19 pandemic, which has hit manufacturing and has put further pressure on the economy.

India is highly dependent on Chinese technology and suppliers to develop its coal power plants. Almost half of its coal power generation capacity and some of the plants under construction are sourced from China. As a result, any long disruptions in the supply chain of equipment and logistics amid the COVID-19 pandemic could delay several energy projects that are under construction in India.

Despite short-term disruptions, coal demand in India is expected to grow between 2019 and 2045 at a pace of 2.6% p.a. This will nearly double the demand for coal in the forecast period but the faster development of gas, nuclear and 'other renewables' means that coal's contribution to the total energy demand of India will not increase.

Coal demand in Europe has been on a downward trajectory for some years and this is likely to continue over the forecast period. In the medium-term it is expected that coal demand in OECD Europe will fall below 4 mboe/d and will reach around 1.5 mboe/d by 2045. This indicates a 4.5% p.a. decline in demand for coal in this region as a result of lower energy intensity, as well as intensive substitution of coal by renewables and gas, partly driven by policy to phase out coal power plants.

In the US, generation of power from coal has been declining since 2001 and the market capitalization of major coal companies in the country has also been in decline. The enormous energy demand decline related to COVID-19 not only threatened the supply of coal, but compounded the financial health of coal companies, further increasing the risk of bankruptcy.

Even before the COVID-19 pandemic, some coal companies had filed for Chapter 11 bankruptcy protection. The growth of gas and renewables means coal will be pushed out more rapidly from the US energy mix despite efforts by the current administration to support the coal industry. Coal demand in OECD Americas is expected to decrease by 1.8% p.a. and its share in the region's total energy demand is expected to drop by nearly 3 pp between 2019 and 2045. Hence, the reduction in

Table 2.8
Coal demand by region, 2019–2045

	Levels mboe/d						Growth mboe/d	Growth % p.a.	Share %	
	2019	2025	2030	2035	2040	2045	2019–2045	2019–2045	2019	2045
OECD Americas	7.1	5.9	5.4	5.1	4.7	4.4	–2.7	–1.8	9.2	6.2
OECD Europe	5.0	3.7	3.0	2.4	1.9	1.5	–3.5	–4.5	6.5	2.1
OECD Asia Oceania	4.9	4.4	4.2	4.0	3.8	3.7	–1.2	–1.1	6.3	5.2
OECD	**17.0**	**14.0**	**12.7**	**11.5**	**10.5**	**9.6**	**–7.4**	**–2.2**	**22.0**	**13.5**
China	40.3	40.1	39.4	37.9	36.1	34.3	–6.0	–0.6	52.2	48.3
India	8.6	9.9	11.7	13.6	15.3	16.6	8.0	2.6	11.2	23.4
OPEC	0.1	0.1	0.1	0.1	0.1	0.1	0.0	–0.6	0.1	0.1
Other DCs	7.1	7.2	7.4	7.4	7.3	7.0	–0.1	–0.1	9.2	9.9
Russia	2.3	2.2	2.1	2.0	1.9	1.7	–0.6	–1.1	3.0	2.4
Other Eurasia	1.7	1.8	1.8	1.8	1.7	1.6	–0.1	–0.2	2.2	2.3
Non-OECD	**60.1**	**61.1**	**62.5**	**62.7**	**62.3**	**61.4**	**1.3**	**0.1**	**78.0**	**86.5**
World	**77.1**	**75.1**	**75.1**	**74.3**	**72.8**	**71.0**	**–6.1**	**–0.3**	**100.0**	**100.0**

Source: OPEC.

investment for new coal plants has been an ongoing factor for the past few years while the pandemic also reduced short-term demand for coal.

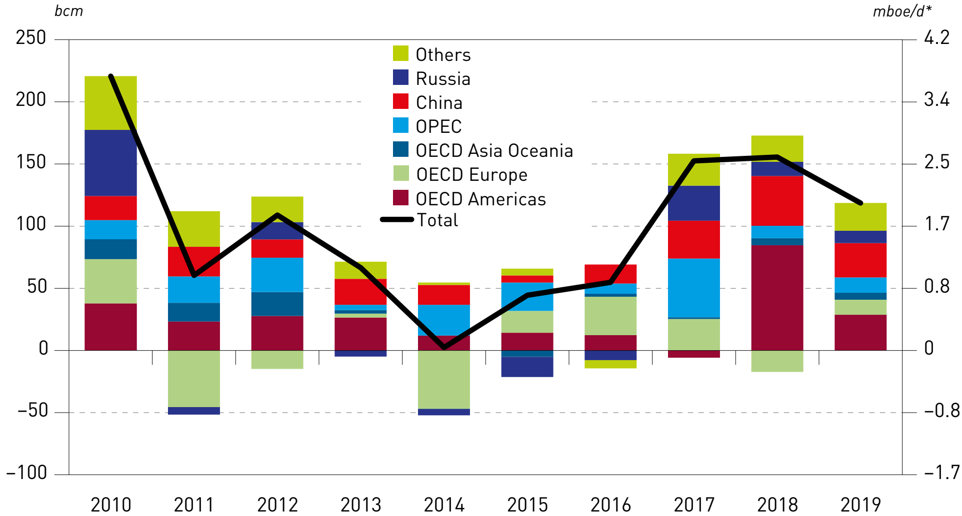
Elsewhere, economic uncertainty related to COVID-19 may encourage China, India and some other countries to adjust their strategies and benefit longer from cheap coal to help their economies recover from the pandemic's impact. However, such a decision would come with financial risks due to the low profitability of coal power plants, carbon price increases and power price reductions because of the lower energy demand projected after COVID-19.

The global demand for coal is projected to shrink by 6.1 mboe/d between 2019 and 2045 and this translates into a 0.3% p.a. decline in this period. The current global share of coal in the overall energy demand mix will drop to below 20% by the end of forecast period.

2.3.3 Natural gas

Natural gas demand increased in 2019 by around 3% or 120 bcm (2 mboe/d) y-o-y, driven by regional markets such as the US and China with growth of around 26 bcm (0.45 mboe/d) y-o-y each. Demand in other regions also increased, including OPEC, Russia and OECD Europe, totalling some 30 bcm (0.5 mboe/d). The increases came despite pressure from lower demand from the heating sector in the Northern Hemisphere during the last two winters. The 2019 gas demand increment is somewhat lower compared to levels seen 2017 and 2018 (Figure 2.6), mostly due to lower growth in the US and China.

Figure 2.6
Global gas demand growth, 2010–2019



* *Net calorific value.*

Source: OPEC.

Following the outbreak of COVID-19 in early 2020, gas demand plunged in line with the lockdown policies implemented in many countries. According to preliminary estimates for 2020, global gas demand could be around 4–5% lower relative to 2019, though this is also subject to weather patterns. The decline in the first half of 2020 demand resulted in a price collapse with Asian prices at parity with Henry Hub, while European spot prices even fell below Henry Hub indices during May and June 2020. Prices have recovered somewhat in Q320, but underlying uncertainties related to demand developments after the COVID-19 shock remain.

Collapsing price levels in major consuming markets in Europe and Asia, and consequently negative export margins for LNG, led to cancellations of spot LNG cargoes (predominantly from the US, but also other exporting countries) in the first half of 2020. This, in turn, led to strong capex cuts and delays of several LNG projects, not only in the US but also Canada, Russia and other countries (Box 2.1). Furthermore, pipeline gas exports from incumbent suppliers such as Russia also declined significantly during the first half of 2020.

Record-low prices and rising availability of LNG supplies, however, improved the position of gas compared to other fuels such as coal. In other words, gas became more competitive in the power generation system of major regions, including the US, Europe and China. Some gas-fired power plants in Europe (e.g. the Irsching CCGT in Germany), which were previously mothballed due to high gas prices, are scheduled to be put back online, thus increasing demand for cheap gas in the power generation sector. In the US, another significant portion of coal-fired generation was replaced by gas during 2019. According to Energy Information Administration (EIA) data, natural gas accounted for 38.5% of the power generation mix, significantly higher than the 23.5% accounted for by coal-fired generation. In 2015 shares of coal- and gas-fired generation were both around 33%.

Box 2.2

LNG prospects in the post-COVID-19 era

prepared by the Gas Exporting Countries Forum (GECF) Secretariat

COVID-19 stopped the erstwhile growing gas demand in its tracks and drove a substantial gas oversupply in the face of paralyzed industrial and commercial activities in economies of all sizes. Even before COVID-19 ravaged the world, this supply deluge existed due to a particularly massive build-up of new LNG capacities, especially in the US.

Gas companies responded by reducing natural gas and LNG supplies to avoid flooding the market and producing at negative margins. Supply reductions have been carried out in some cases through unplanned maintenance and, in others, shut-ins of gas assets, including LNG plants. Some companies decided to postpone their LNG deliveries while others offered supply flexibility to customers.

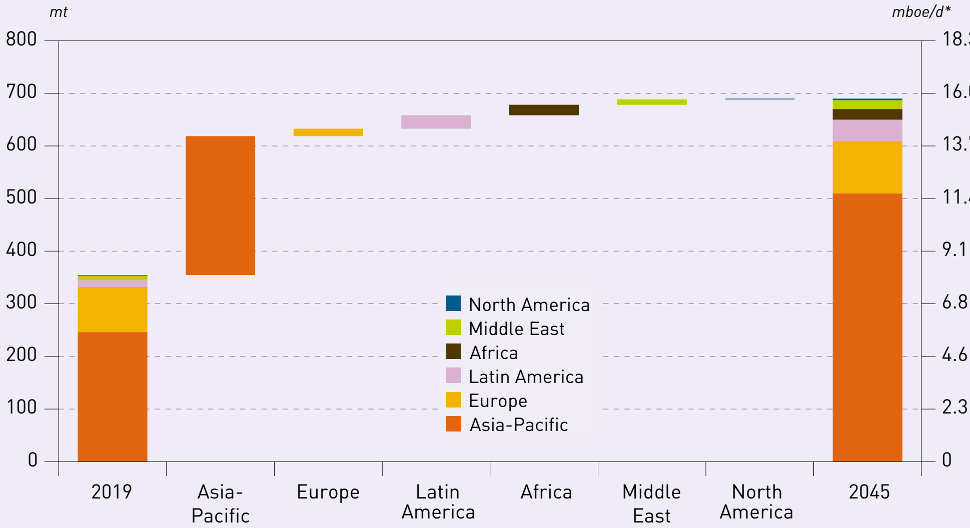
As with other energy resources, the future of LNG supply and demand will be affected by the pace of the global economic recovery, demand growth, and the execution of announced projects along the LNG value-chain – for instance in regasification and liquefaction LNG projects. Furthermore, more time is needed to assess the kinds of post-pandemic energy policy developments that will influence the future of LNG.

Several policy drivers will contribute to supporting the progress of LNG in different markets over the mid- to long-term. For the Asia-Pacific region, policy support for LNG import infrastructure and gas network integration will be instrumental in scaling up LNG imports, especially where a low gas-price environment increases the attractiveness of LNG. China, India and countries such as Thailand and Singapore have achieved progress in terms of promoting market liberalization and market price mechanisms, allowing third-party access to LNG terminals and facilitating LNG trade. In South Korea, a new policy offers support to LNG at the expense of coal and nuclear energy. The appetite for LNG is also increasing in several countries in the region where domestic production is reaching maturity and even experiencing a decline, such as Pakistan, the Philippines and Viet Nam.

In Europe, LNG is promoted as a source of supply diversification under the EU strategy for LNG and gas storage, which was adopted in October 2016. LNG is also a viable option in Latin America, Africa and the Middle East, offering countries in these regions the flexibility to overcome the lack of pipeline infrastructure and manage fluctuations of their domestic gas production.

Over the outlook period, LNG demand is expected to grow from 355 million tonnes (mt) in 2019 to 690 mt in 2045 (Figure 1). The number of importers is projected to rise, with many countries forming so-called niche markets, typically with LNG imports below 3 million tonnes per annum (mtpa). While 44 countries import LNG at present, the number of LNG-importing countries could reach more than 50 by 2045.

Figure 1
Global LNG imports by region, 2019–2045



* *Net calorific value.*
Source: Source: GECF Secretariat based on data from the GECF Global Gas Model (GGM) 2020.

In terms of regional breakdown, the Asia-Pacific will remain in the lead when it comes to LNG demand as more countries start importing and some existing importers ramp up purchases. Overall, Asia-Pacific consumers will require around 510 mt in 2045, compared to 246 mt in 2019. It is assumed that China will become the leading LNG importer in the world, increasing its demand from 62 mt in 2019 to more than 110 mt in 2045. India, with its anticipated huge investments in infrastructure and plans to more than double the share of natural gas in the energy mix, is expected to see LNG demand rise from 24 mt to above 70 mt of LNG over the forecast period.

Japan and South Korea will continue to be very attractive markets as gas is considered to be the main alternative to coal and nuclear. However, the two countries will take different paths: the demand decline in Japan will be offset by growth in South Korea as coal-fired and nuclear power plants are retired. Together, these two countries will consume around 120 mt in 2045, which almost corresponds to the 2019 level. Other Asian nations will also contribute to demand growth. For example, Bangladesh has insignificant LNG imports at present (4.1 mt in 2019) but is expected to increase its LNG imports to 35 mt in 2045 due to steadily declining indigenous gas production.

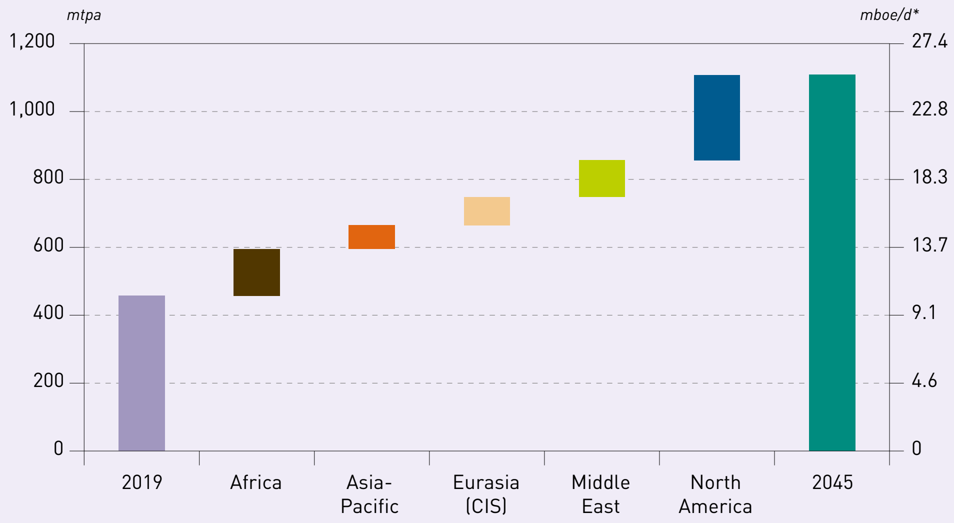
Europe, which has mainly been a residual market for LNG, is expected to add import volumes in line with declining domestic supplies and possibly lower imports of pipeline gas from other regions. LNG imports are forecast to grow from 86 mt in 2019 to around 100 mt in 2045. Latin America is an emerging LNG market with imports expected to rise substantially from 14.3 mt in 2019 to approximately 40 mt by 2045. A lack of pipeline interconnections in the region will spur LNG demand, including LNG-to-power projects.

On the LNG supply side, five new liquefaction plants with a total nameplate capacity of 19.7 mt began operating in 2019, including four onshore facilities (16.1 mt in the US and 3.6 mt in Australia). In addition, exports started from small-scale liquefaction plants in Russia and Argentina with a capacity of 0.66 mt and 0.5 mt, respectively. Consequently, at the end of 2019, global LNG liquefaction capacity reached 427 mt.

According to long-term projections from the GECF, more greenfield liquefaction projects have the potential to come online and add a whopping 650 mtpa between 2020 and 2045. These include projects currently under construction or reaching a final investment decision, proposed and stalled projects, and those at different stages of preliminary front-end engineering design. The majority are in North America with 250 mtpa capacity, of which the US accounts for 140 mtpa with support from shale gas developments. Africa, with 137 mtpa liquefaction capacity potential, could emerge as a key LNG production region. Should African LNG projects materialize, new exporters, such as Mozambique, with around 80 mtpa liquefaction capacity projects, will join the LNG exporters club. Russia currently has liquefaction capacity of 28 mtpa, and with a further 83 mtpa potential, will remain one of the top global LNG suppliers.

Assuming all these projects eventually materialize, the expansion of global LNG capacity could outpace growth in demand and lead to a fall in the average capacity utilization rate of

Figure 2
Global LNG liquefaction capacity in 2019 and 2045



* *Net calorific value.*

Source: GECF Secretariat based on data from the GECF GGM 2020.

LNG operations and extend the expected period of marked oversupply. This oversupply could hurt the economics of the new projects and may lead to longer payback times on investment, particularly for the more costly projects. On the other hand, it will amplify the competitiveness of LNG and enable the industry to capture further demand growth potential, especially in the Asian power generation sector.

Gas demand in **China** also rose in 2019 though significantly less relative to the 2018 increase. Gas demand was supported by rising urbanization and industrial use. However, the policy-related shift to gas in the power generation sector showed the first signs of softening and that the country may also support centralized coal-fired power plants (so called 'clean coal') as alternative to gas-fired generation.

In the medium- to long-term, global gas demand is expected to continue increasing in line with rising levels of urbanization and gasification, growing industrial demand, as well as improving competitiveness against coal in the power generation mix. However, several countries and regions are increasingly exploring alternative options, which may replace a portion of gas demand. This is predominantly green gas such as biomethane, as well as green hydrogen, which could take a share of the gas market in the long-term. However, these alternatives are still largely dependent on governmental support including required infrastructure investments. Furthermore, the rising share of renewables (predominantly solar and wind) in the power generation mix could also have a negative impact on the role of gas in power generation in the medium- and long-term. Finally, due to the drop of gas consumption in 2020, it is estimated that a portion of demand will be lost relative to previous expectations. All these factors result in a slightly lower gas demand in the long-term relative to last year's projection.

Consequently, the Reference Case sees gas demand increasing from around 67 mboe/d in 2019 to around 91 mboe/d in 2045. The incremental demand of around 24.3 mboe/d is unevenly distributed, a the share of more than 95% accounted for by developing countries. Eurasia is likely to see only a minor increase in the long-term, mostly in countries outside Russia. Natural gas demand in the OECD region is set to increase marginally throughout the forecast period, although with sub-regional differences.

The largest gas demand growth is expected in **China**, from around 5 mboe/d in 2019 to almost 10.5 mboe/d in 2045. Urbanization rates in China are still rising, leading to the increasing need for incremental volumes of gas in the residential and commercial sector throughout the projection period. Furthermore, gas demand from the industrial sector is expected to increase in line with the rising GDP and shift away from coal. Finally, the power and heat-generation sector is also likely to see rising volumes of gas usage, though the incremental rates are likely to be slower relative to recent years. The major reason for this is governmental support for so-called 'clean coal', i.e. centralized and efficient coal power plants for electricity and heat generation. This, in turn, means a somewhat milder push for a coal-to-gas switch in the country relative to 2017, when the government decided to close a large number of small and inefficient coal-fired heat and power plants mostly in the northeast of the county.

India will also be a significant contributor to incremental gas demand with an increase of around 2.1 mboe/d, to reach levels of around 3.2 mboe/d in 2040. The Indian government promotes the use of gas in the residential and commercial sector, in line with the rising gasification rates in the country. Furthermore, the government sees large potential for the use of gas in the transportation sector, thus significantly expanding its network of CNG stations throughout the country.

OPEC countries are also increasingly shifting towards natural gas for power generation and industrial use, as well as water desalination. The availability of resources will help these countries to diversify their energy and power mix and reduce oil consumption in the power generation sector. Several countries have stated their readiness to increase their focus on gas production and increase LNG imports. Consequently, OPEC gas consumption is expected to increase from around 9 mboe/d to almost 13 mboe/d in 2045.

The **Other developing countries** group includes a large number of nations in the Asia-Pacific, Africa and Latin America. With continuous economic development and expansion of gas use in the residential and commercial sector (including the switch from biomass), gas demand is expected to increase by around 10.5 mboe/d, reaching more than 20.5 mboe/d in 2045. The growth is also based on domestic resources in some of these countries including Brazil, Qatar, Indonesia and Egypt.

Demand in the OECD region increases marginally between 2019 and 2045 as the market is rather saturated and energy polices in some countries are shifting away from natural gas. **OECD Americas** is the only sub-region which shows growth in line with the availability of price-competitive gas resources. Gas has successfully replaced the large share of coal in the power generation mix, a trend that is likely to continue in the future. Although the Affordable Clean Energy rule, issued by the Environmental Protection Agency (EPA) in 2019, sees a place for coal in the power generation mix, natural gas is expected to remain competitive against coal in the coming years. Consequently, gas demand is expected to reach levels of around 20.5 mboe/d, up by 2.7 mboe/d relative to 2019.

In **OECD Europe**, gas demand is expected to increase marginally by 2045 to reach 9.1 mboe/d. While gas is expected to profit from the coal-to-gas switch in this region, some policies are clearly targeted at reducing the use of natural gas. These include the increasing focus on renewables in the power generation mix, energy efficiency measures and the replacement of natural gas with alternatives such as biogas and/or green hydrogen. The stimulus packages following the COVID-19 crisis will be decisive for the future of gas in OECD Europe and non-OECD EU members.

In **OECD Asia Oceania**, natural gas consumption is set to decline from 3.8 mboe/d in 2019 to 3.5 mboe/d in 2025, in line with the expected restart of nuclear units in Japan. After 2025, gas demand

Table 2.9
Natural gas demand by region, 2019–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Shares *%*	
	2019	2025	2030	2035	2040	2045	2019–2045	2019–2045	2019	2045
OECD Americas	17.8	17.8	18.6	19.4	20.0	20.5	2.7	0.6	26.6	22.5
OECD Europe	8.8	8.7	8.8	9.0	9.0	9.1	0.3	0.1	13.2	9.9
OECD Asia Oceania	3.8	3.5	3.6	3.7	3.8	3.8	0.0	0.0	5.7	4.2
OECD	**30.4**	**30.0**	**31.0**	**32.0**	**32.8**	**33.4**	**3.0**	**0.4**	**45.4**	**36.6**
China	5.0	6.6	8.0	9.2	10.1	10.5	5.5	2.9	7.5	11.5
India	1.1	1.4	1.9	2.4	2.8	3.2	2.1	4.1	1.7	3.5
OPEC	9.3	9.7	10.9	11.8	12.4	12.7	3.5	1.2	13.9	14.0
Other DCs	10.2	11.5	13.6	15.9	18.3	20.5	10.4	2.7	15.2	22.5
Russia	7.7	7.2	7.0	6.9	6.7	6.4	–1.2	–0.7	11.5	7.1
Other Eurasia	3.3	3.4	3.7	4.0	4.2	4.4	1.1	1.1	4.9	4.8
Non-OECD	**36.5**	**39.9**	**45.1**	**50.2**	**54.6**	**57.8**	**21.3**	**1.8**	**54.6**	**63.4**
World	**66.9**	**69.8**	**76.2**	**82.2**	**87.3**	**91.2**	**24.3**	**1.2**	**100.0**	**100.0**

Source: OPEC.

is set to increase marginally, in line with economic development and the replacement of coal in several countries such as South Korea and Australia. According to recent announcements, South Korea plans to shut more than 15 GW of coal-fired capacity by the mid-2030s, converting some of these capacities to gas.

Finally, in **Eurasia**, gas demand is set to increase somewhat, mostly in countries outside Russia. The major driver is the power generation sector and industrial use related to economic development. Russia's gas demand is expected to decline by around 1 mboe/d between 2019 and 2045 in line with efforts to increase the efficiency of gas usage. Overall, the gas demand is projected at just below 11 mboe/d in 2045, at similar levels compared to 2019.

2.3.4 Nuclear

For many decades nuclear power has been an effective source of electricity generation and is considered one of the pillars in the national energy security planning of several nations. The expansion of nuclear power capacity is supported by population growth, urbanization trends and the increased demand for electricity in many countries. Despite these support factors, larger capital investment for construction, technology, safety and maintenance costs are some essential factors that need to be considered during the policymaking process, along with public perceptions of nuclear energy.

According to the International Atomic Energy Agency (IAEA), 54 reactors are under construction mainly in Asia, Europe, the Middle East, Latin America and North America. Most are pressurized light-water moderated and cooled reactors (PWR) and are estimated to add 58 GW to the global nuclear power capacity.

In contrast to expansion activities, political and social considerations have led to permanent closure of some nuclear plants, particularly in the US, Europe and Japan. Some countries have chosen not to replace older reactors. Operations of nuclear power plants in some countries were stopped because of declining demand during COVID-19 lockdowns, especially in cases where they were not major suppliers of electricity. According to the World Nuclear Association, nuclear electricity demand declined sharply in Ukraine and South Africa and some plants went offline or reduced production. In China power output was reduced and some new plants faced construction delays due to disruptions in the supply chain.

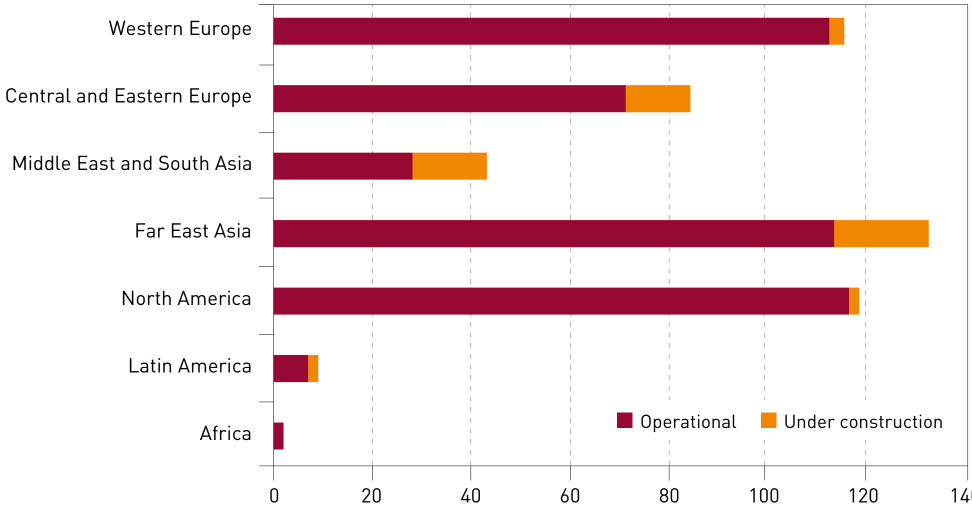
Simultaneously, uranium mining was temporarily stopped or slowed down in some of the main sites such as Kazatomprom (Kazakhstan), Cigar Lake (Canada), as well as mines in the US, Europe, South Africa and Namibia. Some investment in new project construction, maintenance and repair, and safety enhancements of nuclear plants were delayed by the pandemic. Such delays have been reported in the UK, US, China, India, the Czech Republic, Japan and Bulgaria.

Reports also indicate that there was up to a 20% fall in electricity demand forecast for France due to the economic slowdown. Therefore, the company Électricité de France (EDF) reduced its estimates for annual nuclear output to approximately 300 TWh in 2020, and to 330 to 360 TWh for both 2021 and 2022, according to *World Nuclear News*.

This critical situation resulted in a number of major players in the European nuclear industry asking the EU to unify its nuclear policies to encourage greater investment in the sector post-COVID-19, according to *Power Technology.*

IAEA statistics show that there are currently 441 nuclear reactors operating in 30 countries, with total capacity of over 390 GW. Europe, Asia and North America are the regions with the most operating nuclear plants. Concurrently, the US, Europe and Japan have the highest number of permanently shut-down nuclear reactors. The majority of planned and under-construction nuclear power plants are located in Asia (mainly China and India), the UAE, South Korea and Russia.

Figure 2.7
Number of nuclear reactors by region, 2020

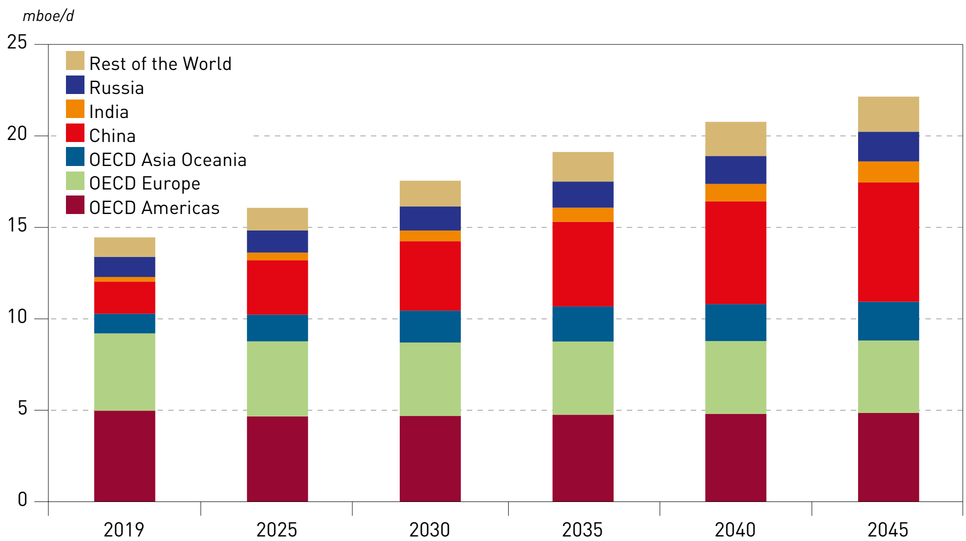


Source: IAEA.

Among the OECD regions and over the long-term forecast period, OECD Asia-Oceania is leading the expansion in nuclear power with nearly a 2.6% growth rate anticipated from 2019 to 2045. This will result in a 7% increase in the contribution of nuclear energy to the total energy demand of this region.

Demand for nuclear energy in OECD Europe is anticipated to slow by 0.3% p.a. in the projection period while no growth is estimated for OECD Americas. Indeed, the gradual retirement, cancellation of construction and phase out of nuclear plants is expected to continue in these regions while most European countries are shifting away from any new investment in nuclear power. For instance the UK, Spain, Germany, Sweden, Belgium and Switzerland have already phased out

Figure 2.8
Nuclear energy demand by major region, 2019–2045



Source: OPEC.

some nuclear reactors while Italy, Austria and Portugal are unlikely to have any nuclear power plants in the future. In contrast, 13 nuclear reactors are under construction in North America and Central and Eastern Europe with these expected to produce around 13 GW of power.

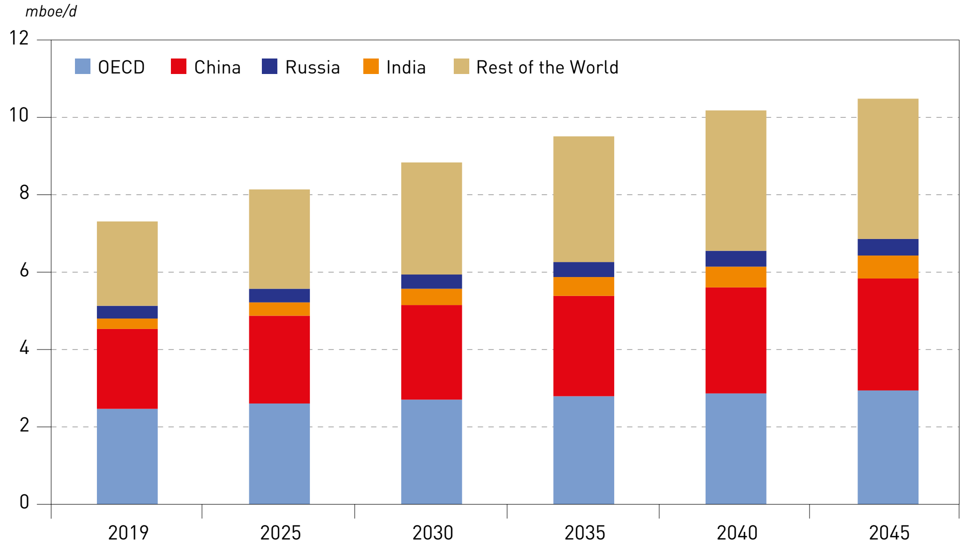
China and India are expected to experience the largest global growth in nuclear demand from 2019 to 2045. As a result, nuclear power will be the second fastest growing non-fossil fuel source of energy in both countries behind 'other renewables'. However, in absolute terms additional

Table 2.10
Nuclear demand by region, 2019–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Share *%*	
	2019	**2025**	**2030**	**2035**	**2040**	**2045**	**2019–2045**	**2019–2045**	**2019**	**2045**
OECD Americas	5.0	4.7	4.7	4.8	4.8	4.9	–0.1	–0.1	34.5	21.9
OECD Europe	4.2	4.1	4.0	4.0	4.0	4.0	–0.3	–0.3	29.2	17.9
OECD Asia Oceania	1.1	1.5	1.7	1.9	2.0	2.1	1.0	2.6	7.5	9.6
OECD	**10.3**	**10.2**	**10.4**	**10.7**	**10.8**	**10.9**	**0.6**	**0.2**	**71.2**	**49.4**
China	1.7	3.0	3.8	4.6	5.6	6.5	4.8	5.2	12.1	29.4
India	0.3	0.4	0.6	0.8	0.9	1.2	0.9	6.0	1.7	5.2
OPEC	0.1	0.1	0.2	0.3	0.4	0.6	0.6	9.0	0.5	2.8
Other DCs	0.4	0.4	0.4	0.5	0.5	0.3	0.0	–0.4	2.5	1.5
Russia	1.1	1.2	1.3	1.4	1.5	1.6	0.5	1.5	7.6	7.3
Other Eurasia	0.6	0.7	0.8	0.8	0.9	1.0	0.3	1.7	4.3	4.4
Non-OECD	**4.2**	**5.8**	**7.1**	**8.4**	**10.0**	**11.2**	**7.0**	**3.9**	**28.8**	**50.6**
World	**14.4**	**16.1**	**17.5**	**19.1**	**20.8**	**22.1**	**7.7**	**1.7**	**100.0**	**100.0**

Source: OPEC.

Figure 2.9
Hydro demand by major region, 2019–2045



Source: OPEC.

demand for nuclear in China (4.8 mboe/d) will be much higher than India (0.9 mboe/d). Demand for nuclear energy in Russia is also estimated to increase by 0.5 mboe/d over the forecast period. Russia currently has four reactors under construction with a combined capacity of 4.5 GW.

Over the long-term forecast period, the relative share of nuclear power in the global energy mix is estimated to rise to 6.1% in 2045, albeit policies geared towards this source of energy are different in each country.

2.3.5 Hydro

Harnessing the energy of moving water is a reliable, clean and efficient source of power generation and most of its technology is mature. Modern hydro turbines are able to convert up to 90% of the available energy into electricity. Therefore, the development of small and large hydropower plants is in the interest of many countries but is technically limited to the availability of water resources and sufficient rainfall.

Hydro is now considered as the largest global source of clean power generation, but it is also a fact that hydro plants are very dependent on weather conditions and are also disruptive for the environment and upstream and downstream residents. In some cases these negative impacts can outweigh the benefits of hydropower when it comes to achieving carbon-reduction goals.

Among all countries, China, India and some other developing countries are investing heavily in hydro projects while within the OECD, except in countries such as Norway and Austria, there is no expectation for significant growth in demand for hydro.

More detailed analysis indicates that China continues to account for the largest share of newly installed hydropower capacity and demand for hydro in this country is anticipated to grow by 1.3% p.a. from 2019 to 2045. Demand advances for hydro in India within this forecast period and the rate of growth is estimated to be more than 3% p.a. albeit from a low base. During this time period Eurasia will experience 1.2% growth p.a. while hydro demand in Russia is not expected to expand by more than 1% p.a. At the same time, untapped hydropower capacity in Africa and Latin America is expected to be developed more rapidly.

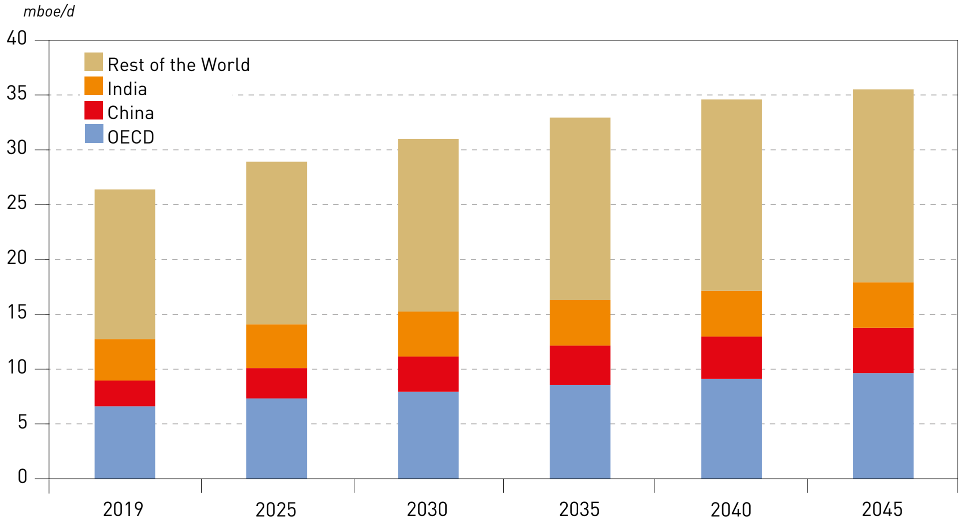
Pandemic lockdowns, which led to remote working and disruptions in supply chains, had a serious impact on the hydro industry. The situation caused suspensions, delays and financial setbacks for many projects, for instance in India, China, Albania and Chile. The huge temporary reduction in electricity demand in countries like China, India and Brazil also created challenges for hydropower plants. However, thanks to the special flexibility of hydropower stations, they were able to ramp up promptly to meet the demand growth as economies recovered.

The post-COVID-19 picture for the global development of hydro and other sources of energy is mixed, however. In the long-term, demand for hydro is expected to grow steadily but slowly considering the technical and financial limitations, as well as the complexity of exploring for new water resources. This will result in the relative share of hydro in global energy demand increasing slightly to close to 3% by 2045, the smallest contribution among all energy sources.

2.3.6 Biomass

With further developments in the advanced use of biomass (such as cellulosic biofuels, biogas and heating chips), global demand for biomass energy continues to grow correspondingly to match these additional uses. Globally, biomass energy is forecast to increase by 9.1 mboe/d in 2045 (Table 2.11). A major component of that addition (about 66%) is from non-OECD countries where traditional usage of biomass for cooking and residential heating persists combined with the expansion of biomass use for electricity generation and biogas/biofuels production. China

Figure 2.10
Biomass demand by major region, 2019–2045



Source: OPEC.

Table 2.11
Biomass demand by major region, 2019–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Share *%*	
	2019	**2025**	**2030**	**2035**	**2040**	**2045**	**2019–2045**	**2019–2045**	**2019**	**2045**
OECD Americas	2.7	3.0	3.2	3.4	3.7	3.9	1.2	1.4	10.4	11.1
OECD Europe	3.3	3.7	4.0	4.4	4.6	4.9	1.6	1.5	12.4	13.7
OECD Asia Oceania	0.6	0.7	0.7	0.8	0.8	0.8	0.2	1.4	2.2	2.3
OECD	**6.6**	**7.3**	**7.9**	**8.6**	**9.1**	**9.6**	**3.0**	**1.5**	**25.0**	**27.1**
China	2.4	2.8	3.2	3.6	3.9	4.1	1.8	2.2	8.9	11.6
India	3.8	4.0	4.1	4.2	4.2	4.2	0.4	0.4	14.3	11.7
OPEC	2.4	2.6	2.7	2.8	2.8	2.9	0.5	0.7	9.3	8.2
Other DCs	10.8	11.8	12.6	13.3	14.0	14.0	3.2	1.0	40.9	39.4
Russia	0.2	0.2	0.2	0.2	0.2	0.3	0.1	2.0	0.6	0.8
Other Eurasia	0.3	0.3	0.3	0.3	0.4	0.4	0.1	1.6	1.0	1.1
Non-OECD	**19.8**	**21.6**	**23.1**	**24.4**	**25.5**	**25.9**	**6.1**	**1.0**	**75.0**	**72.9**
World	**26.4**	**28.9**	**31.0**	**32.9**	**34.6**	**35.5**	**9.1**	**1.2**	**100.0**	**100.0**

Source: OPEC.

uses biomass for heating, steam generation and biogas production. Biomass accounted for 12.6% of the energy mix of non-OECD countries in 2019 and this is set to decrease to 11% in 2045. This decline is mainly attributed to the reduction of energy poverty in Sub-Saharan Africa and also improved energy access via electrification in the Indian subcontinent, which reduces traditional biomass use for cooking and heating. In absolute terms, non-OECD biomass demand grows to 25.9 mboe/d by 2045 from the current 19.8 mboe/d, and this additional demand comes from biofuels, electricity generation and other bioenergy use.

The **OECD** deploys biomass resources in the transportation sector where it is converted to conventional and advanced biofuels, especially in the US under the Renewable Fuel Standard (RFS) policy. OECD Europe utilizes biomass mainly for heating and co-generation of electricity with other fuels and for the production of bio-methane. Biomass processing for heat and electricity generation in the OECD region also involves the application of bioenergy with carbon capture and storage (BECCS) technology as a pathway to carbon neutrality. Traditional direct use of biomass for cooking and home heating in the OECD is very limited as the region has several energy sources at its disposal for residential use.

In contrast to **non-OECD** countries, the share of biomass energy in the OECD region's energy mix is set to increase from 6.6% in 2019 to 9.6% by 2045. For the period of this projection, the OECD is set to add 3 mboe/d. Most of this addition is for the deployment of bioenergy solutions and partly for the production of clean fuels (biofuels). Biomass is set to grow at 1.5% p.a. in the OECD, higher than in developing economies. Overall, biomass energy contributed 9.1% to the global primary energy mix in 2019 and is set to increase to 9.8% (35.5 mboe/d) in 2045.

2.3.7 'Other renewables'

Global investment in new renewable energy capacity has been increasing in previous years and installed solar power capacity additions were more than any other source in 2019. Over the past few years, technological advancements, economies of scale in production and improved efficiency and supply chain management resulted in a massive improvement in the cost competitiveness of renewables with the levelized cost of energy declining significantly. Among the many countries which are developing renewable energy projects, China and India are two major markets and key drivers of growth in Asia.

Following the lockdowns, however, most mass production was shut down and issues were raised along the whole supply chain of the renewables industry sector. Many power producers faced a drop in demand from different sectors (e.g. services and manufacturing plants) leading to a cash flow reduction while they also struggled with a workforce shortage (technicians and contractors) due to quarantine measures and international travel restrictions.

India has ambitious plans to expand the use of renewables to meet demand growth for electricity in the industrial, residential and service sectors and also to help the country cut its heavy dependence on coal. However, a large part of India's electricity-generation capacity is dependent on Chinese technology. Many suppliers for projects that are under construction are from China and nearly 80% of solar modules, for instance, are sourced from China. Several of the top ten solar PV manufacturers – such as Trina, Jinko Solar, Risen Energy and JA Solar – are based in China and work with Indian companies to construct new plants. Due to COVID-19 and the suspension of many industrial production activities, several renewables projects in India are at risk of running behind schedule and face delays in commercial deliveries from Chinese companies.

In India the demand growth rate for 'other renewables' is anticipated to be around 10% p.a. within the projection period and its share of the total energy mix of the country increases to 4% at the end of this period. It is expected that 2.1 mboe/d will be added to the current demand for 'other renewables' in the country, which mainly comes from planned solar and wind projects. However, grid connectivity and the transmission of electricity over long distances are considered challenges for the Indian government to overcome.

Globally, the most significant newly added capacity for 'other renewables' is expected to come from China. The enthusiasm for renewable forms of energy is in line with the country's emission-reduction policies and is supported by cost reduction, efficiency enhancements and advanced technologies in the country's renewable energy industry.

'Other renewables', especially wind and solar, represented more than 2.1% of total energy demand in 2019. The unprecedented power demand drop during the COVID-19 outbreak, as a result of lockdowns and the stagnation of industrial and commercial activity, created even more competition among the different power supply resources in this country. As a result, demand for nuclear, thermal and hydropower generation dropped in first two months of the 2020 lockdown, while solar and wind power generation was relatively unaffected.

However, some producers of solar components (e.g. cells and modules) that are based in China faced severe disruption and, at the time of writing, were still operating with limited capacities. For China and the rest of the world, this means a supply interruption for renewables projects under construction. This is nevertheless likely to be managed in the short-term by negotiations and rescheduling of some affected projects when production and deliveries resume.

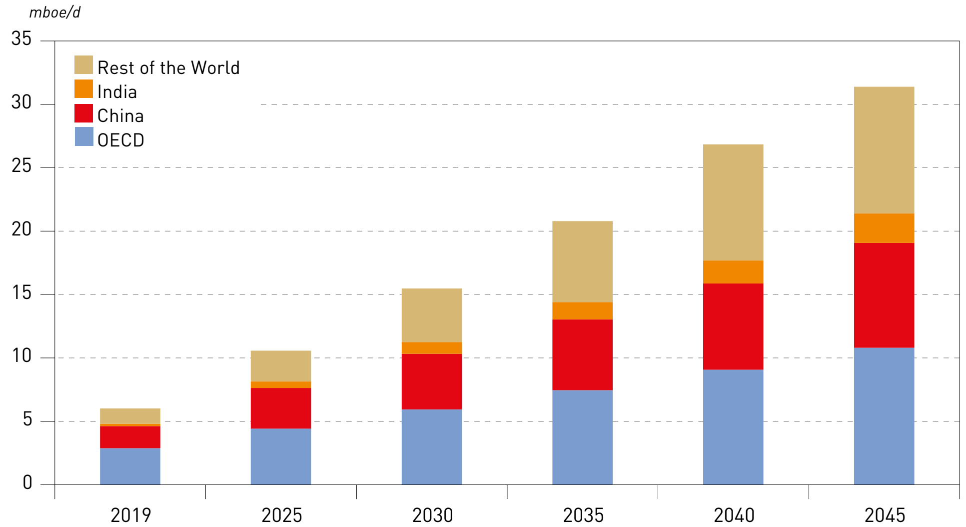
China is and will remain, within the projection period, the largest producer of electricity worldwide. However, economic growth, the main driver of the demand increase for electricity, has recently slowed and the country is more in favour of service-sector expansions that are less energy intensive.

Demand for 'other renewables' in China is expected to increase by 6.2% p.a. within the projection period. This will result in an additional 6.5 mboe/d of demand for 'other renewables' in 2045 and the share of renewables will reach above 10% from nearly 1.7% in 2019.

According to Bloomberg NEF, China's investments in renewable energy in 2019 declined and the solar sector was the hardest hit by this fall in investments. On the other hand, investments in renewables reached a record level in the US as projects were rushed ahead of impending deadlines. The US renewables industry is concerned about the approaching time limits set under the investment tax credit (ITC), which was initially approved by Congress in 2015 for a five-year period to make renewable energy more affordable.

These tax credits encouraged the massive expansion of solar capacity, but developers must begin and finish construction within a certain deadline in order to benefit from ITCs. However, taking

Figure 2.11
'Other renewables' demand by major region, 2019–2045



Source: OPEC.

advantage of this in the last year has been challenging as projects are currently under pressure due to disruptions related to COVID-19. There is ongoing lobbying to extend these deadlines to allow more time and flexibility.

Overall, it is expected that demand growth of renewables will continue within the medium- and long-term in OECD Americas. Demand for 'other renewables' is forecast to increase by 5.8% p.a. between 2019 and 2045. In this period the share of 'other renewables' in the energy mix of the region will increase from 1.9% to 8.5%.

Generation of clean electricity in OECD Europe will expand substantially until 2045 and renewables are at the centre of almost every energy-related policy within the EU. Nevertheless, there are challenges related to long-term funding, grid connectivity and capacity enhancement. According to the latest data, 12 of the 27 Member States have now reached their individual targets for 2020 and five countries are very close to doing so.

However, some countries like the Netherlands, Malta, Luxemburg, Belgium, Ireland, Poland and Slovakia are struggling to meet the 2020 targets and the European Commission is in the process of evaluating clean energy plans of each Member State against its target for 2030. They are also discussing the use of legislation to ensure members contribute to the overall EU long-term objectives.

Average demand growth for 'other renewables' in OECD Europe between 2019 and 2045 is projected to be approximately 4.0% p.a., which is much less than the rate in OECD Asia Oceania (6.7% p.a.).

Within the EU's COVID-19 recovery strategy, renewable energy projects are recognized as pillars of EU prosperity and resilience. In particular, a new Strategic Investment Facility was introduced to generate investments of up to €150 billion for boosting the resilience of strategic sectors, notably those linked to the green and digital transition.

Another interesting trend is that major oil companies, which had already invested in some renewable projects, are expected to allocate record investment in clean energy within the next few years.

Table 2.12
'Other renewables' demand by region, 2019–2045

	Levels *mboe/d*						Growth *mboe/d*	Growth *% p.a.*	Share *%*	
	2019	**2025**	**2030**	**2035**	**2040**	**2045**	**2019–2045**	**2019–2045**	**2019**	**2045**
OECD Americas	1.1	1.7	2.4	3.1	3.8	4.7	3.6	5.8	18.2	15.0
OECD Europe	1.4	2.0	2.6	3.1	3.6	4.0	2.6	4.1	23.3	12.8
OECD Asia Oceania	0.4	0.7	1.0	1.3	1.7	2.1	1.7	6.7	6.2	6.5
OECD	**2.9**	**4.4**	**5.9**	**7.4**	**9.1**	**10.8**	**7.9**	**5.2**	**47.7**	**34.4**
China	1.7	3.2	4.4	5.6	6.8	8.3	6.5	6.2	28.9	26.4
India	0.2	0.5	0.9	1.4	1.8	2.3	2.1	10.1	3.2	7.4
OPEC	0.0	0.3	1.1	2.0	3.2	4.1	4.1	25.6	0.2	13.1
Other DCs	1.2	2.0	2.9	4.0	5.2	4.7	3.6	5.5	19.3	15.0
Russia	0.0	0.0	0.1	0.2	0.3	0.5	0.5	18.6	0.1	1.6
Other Eurasia	0.0	0.1	0.1	0.2	0.4	0.7	0.6	11.9	0.6	2.1
Non-OECD	**3.1**	**6.1**	**9.5**	**13.3**	**17.8**	**20.6**	**17.4**	**7.5**	**52.3**	**65.6**
World	**6.0**	**10.6**	**15.5**	**20.8**	**26.8**	**31.4**	**25.4**	**6.6**	**100.0**	**100.0**

Source: OPEC.

The European companies BP, Total and Shell, as well as some US rivals, are leading this race in the transition of their portfolios to low carbon energy. These include deals for clean power generation, technology development and storage capacity enhancements.

In Russia hydro represents nearly all of its clean energy capacity while the country has not yet explored most of its potential for 'other renewables', mainly located in less populated parts of the country. However, the draft Energy Strategy of Russia for the period up to 2035 projects a nearly 5% share of renewables in final energy consumption. This will require more investment in technology and subsidization of renewable energy projects by Russian companies. At the moment most of the wind and solar power projects in Russia are designed by foreign companies from China, Italy and Germany.

It is anticipated that Russia will experience a nearly 18% p.a. growth in demand for 'other renewables' in the projection period, though this is from a base of near zero.

Africa is adding new capacity from solar, wind and geothermal to tap some of its vast available resources and pursue electrification programmes in several countries.

Despite this, funding, subsidies and effective policy design and implementation are challenges for many countries in this region. To accelerate the development of renewables in Africa, several regional initiatives – such as the West Africa Clean Energy Corridor, Pan-Arab Clean Energy Initiative (PACE) and Entrepreneurship Support Facility – are already in place. In light of this, Morocco, Egypt, South Africa and Mauritania have taken steps to benefit from power generated by renewables.

'Other renewables' are being promoted in developing countries with a significant growth rate of 7.3% between 2019 and 2045, increasing their share from 2% to 8.4% by the end of projection period.

The full impact of the COVID-19 crisis on the renewable energy sector is difficult to predict. However, what is clear is that supply shortages, price inflation, delays in tenders and funding uncertainties pose challenges for projects in the early stages of financing and procurement. According to Wood Mackenzie, the number of global solar and energy storage installations in 2020 is expected to drop by nearly 20% compared to pre-COVID-19 projections. Over the long-term, however, it is expected that the share of 'other renewables' will rise to 9.2%, resulting in global demand growth of nearly 7% p.a. Despite the immediate impact of COVID-19, all regions will be pursuing the development of cleaner sources of energy going forward.

2.4 Trends in the electricity sector

This section provides information about recent global and regional trends in electricity generation. It also highlights important issues related to the transformation of power generation systems and points out major challenges to future development. Finally, this section provides a high-level long-term outlook for power generation in the Reference Case. These projections are in line with the expectations for primary energy demand shown in the previous sections and take into account Reference Case assumptions on economic and population development, technology and energy policy. It is important to note that all figures presented are for so-called gross power generation, which includes final electricity consumption, own consumption, as well as transmission and distribution losses.

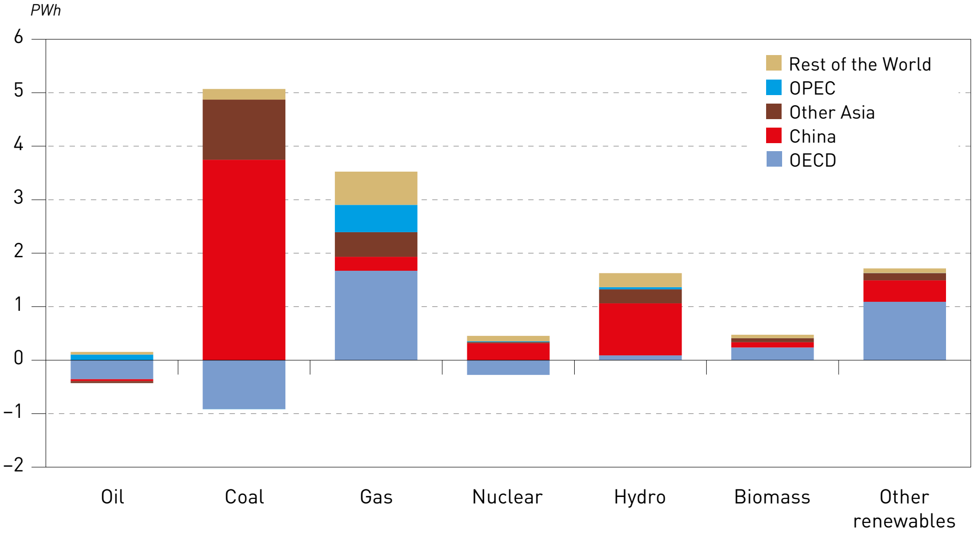
Historically, the power generation sector has been dominated by fossil fuels (mostly coal and gas but also oil in some countries). Nuclear and hydro also account for significant shares of total power generation, especially in specific countries (e.g. nuclear in France, hydro in Norway and Austria). In recent years the penetration of 'other renewables' (mostly wind and solar) has been observed and they now account for a considerable share of the generation mix of some countries. For instance, renewables accounted for almost 40% of the generation mix in Germany in 2019, up from levels below 15% in 2007, according to AG Energiebilanzen e.V.

Global power generation has risen significantly since 2000, from around 15.5 petawatt-hours (PWh) in 2000 to almost 27 PWh in 2019, an increase of around 75%. The increase was registered in all major regions, led by Asia, which accounted for almost 70% of the increase. China was by far the largest single contributor, accounting for around 50% of global power generation growth.

In terms of fuel mix (Figure 2.12), significant electricity generation increments came from coal and gas, which rose by around 4.1 PWh and 3.5 PWh, respectively, from 2000 to 2019. 'Other renewables' (mostly wind and solar) and hydro followed, rising by 1.7 PWh and 1.6 PWh, respectively, still significantly lower compared to coal and gas in the same period. Oil was the only fuel which declined in the generation mix, falling by some 270 terawatt hours (TWh), which is due to efforts of several countries (including some OPEC Member Countries) to switch from oil to other fuels – mostly natural gas but also 'other renewables' – for electricity production.

Needless to say, the picture looks different on the regional level (Figure 2.12). Expansion in coal-fired generation occurred largely in developing countries, mostly in Asia, with China accounting for a large share. China alone expanded coal-fired generation by around 3.7 PWh in the period from 2000 to 2019. At the same time, developed countries managed to reduce coal-fired generation in the range of 1 PWh (mostly the US and some European countries), partly due to availability of competitive gas supplies and policies targeting the closure of old and inefficient coal plants.

Figure 2.12
Electricity generation growth by fuel and region, 2000–2019



Source: IEA and OPEC.

Regarding gas-fired generation, increases were recorded in all major regions led by the OECD (+1.7 PWh), followed by OPEC countries (+0.5 PWh) and Asia (+0.7 PWh). The position of gas in the generation mix has significantly improved in recent years, given the increasing availability of relatively cheap gas (especially in the US), as well as due to energy policies seeking to reduce CO_2 emissions and improve local air quality through the use of less polluting fuels.

Regarding 'other renewables', generation in the OECD region increased by more than 1 PWh, mostly due to governmental support (e.g. feed-in tariffs and other instruments). At the same time, China and India added around 0.5 and 0.1 PWh, respectively, of generation from 'other renewables'. Hydropower also saw strong additions between 2000 and 2019, also led by China (almost 1 PWh) and followed by other developing regions.

The growth in hydro generation in developing regions was partly supported by the construction of giant power complexes such as the Three Gorges Dam in China with its installed capacity of around 22 GW. Nuclear-based power generation, meanwhile, increased by less than 0.2 PWh, which is the result of generation increases in China (+0.3 PWh), Russia and OECD Americas, which offset declines in Japan (after the Fukushima disaster) and OECD Europe (mostly because of the decommissioning of old plants).

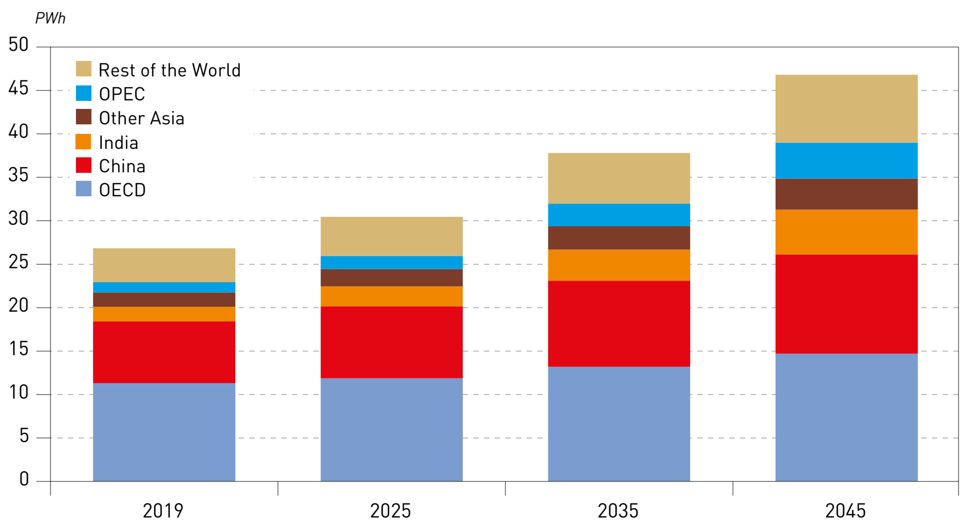
Finally, the share of fossil fuels in the global power generation mix remained unchanged between 2000 and 2019 at around 65%. The share of renewables (including hydro, 'other renewables' and biomass) increased from 19% in 2000 to 25% in 2019, mainly due to the growth of wind and solar. However, mostly due to shutdowns after the Fukushima disaster and consequent closures in other countries such as Germany, the share of nuclear declined from 17% in 2000 to just 10% in 2019.

Going forward, the growth of electricity generation is set to continue at rates much higher relative to overall primary energy demand growth. Rising electricity demand is the result of economic development, population growth and the expanding use of electricity in sectors such as digitalization, cooling and transportation, as well as rising energy access in some regions. In the Reference Case, primary energy demand is expected to increase at an average rate of just below 1% between 2019 and 2045, while at the same time electricity generation is expected to increase by 2.2%. In line with expectations on economic and population development, the majority of growth in power generation will come from developing countries.

However, the development of the generation mix is likely to look different from what has been observed since the beginning of this century. More pressure on coal is expected with a significant push for renewables, nuclear power and natural gas. There are several reasons for this. Energy policies at the global and local levels strongly support low-carbon generation such as wind and solar. Energy policies have been and will remain the major drivers in setting the framework for the development of the power system.

Many countries are expected to continue supporting renewables (wind, solar and hydro) through government support schemes such as feed-in-tariffs, but also to actively influence the generation

Figure 2.13
Electricity generation by region, 2019–2045



Source: OPEC.

mix as has been the case in China and Germany which have closed some coal power plants. Some approaches also seek to provide a competitive advantage to fuels with a lower carbon footprint such as the EU ETS, which increases the competitiveness of gas against coal in the generation mix in EU countries.

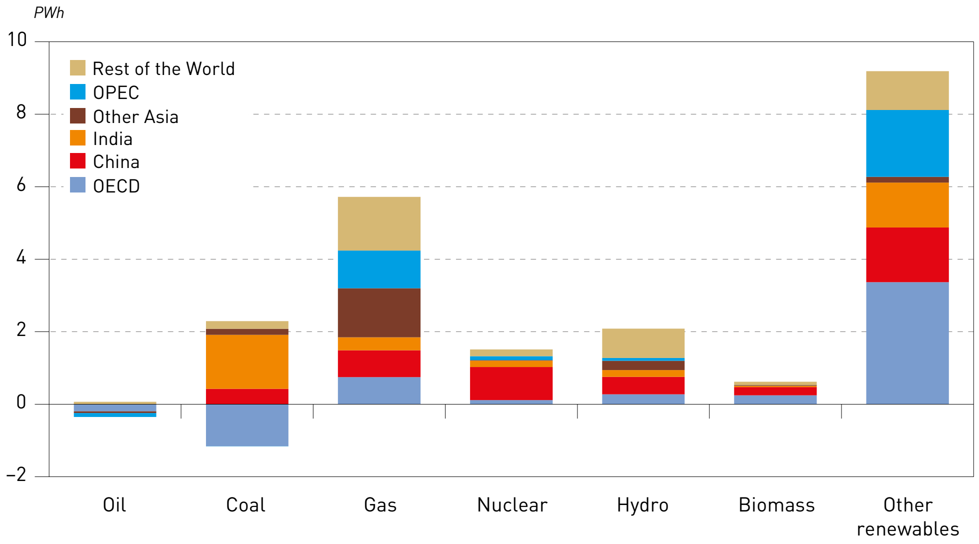
Technology developments are also important for the future of the power mix. For instance, 'other renewables' are increasingly becoming more competitive due to the continuous cost reductions through technological advancements and economies of scale. According to expectations, the levelized costs of wind and power generation (including capital costs for construction of new power plants) are now comparable to fossil fuels. OPEC Member Countries are set to increase the share of renewables (especially solar) in their respective generation mix in line with favourable economics. Some Middle Eastern OPEC Member Countries have reported record low tariffs for new solar projects going down to levels below $15/MWh.

Looking in more detail at the outlook for power generation (Figure 2.13) in the Reference Case, overall power generation is expected to increase by almost 20 PWh, reaching nearly 47 PWh in 2045. The growth in developing countries (largely China and India) accounts for more than 75% of the global growth in power generation. The share of the OECD countries in global power generation growth is estimated at levels of less than 20%. This takes into account substitution effects – e.g. substitution of oil by electricity due to the rising share of EVs, but also savings through energy-efficiency measures.

As shown in Figure 2.14, power generation from 'other renewables' (mainly wind and solar) is expected to increase by more than 9 PWh, which is almost half of the power generation growth. Falling costs for wind and solar plants, as well as continuous governmental support, are the major drivers of this growth. The improved efficiency of new additions (e.g. larger wind turbines and more productive solar installations) have contributed to improved competitiveness of wind and solar against the conventional power generation sources.

At the same time, power generation from hydro and biomass is set to increase by 2 PWh (mostly in developing countries) and 0.6 PWh (mostly in the OECD region and China), respectively. This

Figure 2.14
Electricity generation growth by fuel and region, 2019–2045



Source: OPEC.

means that renewable power generation is expected to increase by almost 12 PWh between 2019 and 2045, which is 60% of the total generation increase in this period.

The second largest increase will be accounted for by gas generation, reaching levels of nearly 6 PWh with significant increases in almost all regions. Although a fossil fuel, gas is still expected to be favoured in many regions as it helps to reduce CO_2 emissions when substituted for coal. This is why some countries seek to increase their share of gas-fired generation in the coming years and consequently provide policy support (the EU has already done so through CO_2 emission pricing). The increasing availability of gas (including LNG) is also one of the supporting factors for the expansion of gas-fired generation. In addition, the levelized costs of new gas power plants (e.g. CCGTs) are estimated to be considerably lower compared to new coal-fired power plants, which have significantly higher capital costs.

Unlike observed trends during the period 2000–2019, increases in coal-fired generation will be limited in the long-term outlook. With many countries decommissioning old coal power plants (e.g. in Europe) and trying to limit new facilities, the total increase in coal-fired generation is limited to just above 1 PWh, with increases in developing countries such as India and Other Asia (excluding China). OECD countries are expected to see a decline in coal-based generation of around 1.2 PWh, mostly due to decommissioning of old and inefficient coal power plants and substitution with gas and renewables.

Regarding nuclear generation, an increase of 1.5 PWh is expected over the long-term, with strong additions in developing countries, more than offsetting declines in developed countries (OECD Europe and OECD Asia Oceania) due to closures of older nuclear power plants.

Consequently, the share of fossil fuels in the generation mix is expected to decline from around 65% in 2019 to just above 50% in 2045. At the same time, the share of renewables (including hydro, biomass and 'other renewables') is projected to increase from 25% in 2019 to 40% in 2045. The share of nuclear power is broadly stable throughout the period.

However, several challenges are emerging. The rising share of renewables (mostly wind and power) in the power generation system could bring additional costs due to the increased need for balancing, reserve capacity and high-voltage transmission capacities.

As wind and solar are intermittent in nature, power systems will increasingly need more balancing on a daily but also seasonal basis, which can be reached in several ways. Conventional power plants have increasingly been used to balance out the mismatch between supply and demand in the system and it is expected that conventional power plants will remain the backbone of power systems for balancing purposes. Nevertheless, there are other possibilities that are likely to grow in importance, partly due to policy support. These include: improved interconnection between regions, battery storage, production of hydrogen with surplus electricity and demand-side management. The deployment of the above-mentioned balancing methods is expected to play an increasingly important role in line with the rising share of power generation from wind and solar.

2.5 Energy-related CO_2 emissions

Major energy trends outlined in the previous sections also determine future energy-related CO_2 emissions, which are summarized in Table 2.13. This table shows several high-level observations worth mentioning. Firstly, the natural effect of a sharp decline in demand for oil, gas and coal in 2020, driven by COVID-19 lockdowns, helps reduce emissions during the year. The assessed reduction could be in the range of 2.5 billion tonnes (bt), though this number is still subject to revision.

Secondly, following the expected recovery in energy demand during the medium-term period, energy-related CO_2 emissions will continue increasing to around 2035 before they stabilize at levels below 37 bt p.a. for the rest of the forecast period. This represents a downward revision of more than 1 bt compared to last year's forecast, resulting from the lasting effects of the COVID-19 pandemic, as well as a further acceleration in the growth of renewable energy.

Table 2.13
Energy-related annual CO_2 emissions by energy source, 2019–2045 *billion tonnes*

	2019	2020	2025	2030	2035	2040	2045
Coal	15.0	14.0	14.6	14.6	14.4	14.1	13.7
Oil	12.2	11.1	12.7	13.1	13.4	13.5	13.4
Gas	7.2	6.8	7.5	8.1	8.7	9.3	9.7
Energy-related emissions	**34.4**	**31.9**	**34.7**	**35.9**	**36.6**	**36.9**	**36.8**

Source: OPEC.

Thirdly, it appears that coal-related CO_2 emissions peaked in 2019 and, despite the projected partial recovery in coal demand over the next several years, related emissions will remain below 2019 levels. Moreover, these are projected to start declining systematically sometime after 2030 to reach 13.7 bt by 2045, a level which is more than 1 bt lower than in 2019. Nonetheless, coal will still be the largest source of CO_2 emissions, accounting for around 37% of the total in 2045.

Emissions related to the use of oil are projected to reach the level of 13.4 bt by 2045, around 1.2 bt more than in 2019. However, the bulk of incremental emissions will take place during the current decade when oil demand will still be on the rise. Oil-related emissions will stabilize around 13.5 bt p.a. during the second part of the forecast period and even marginally decline towards its end.

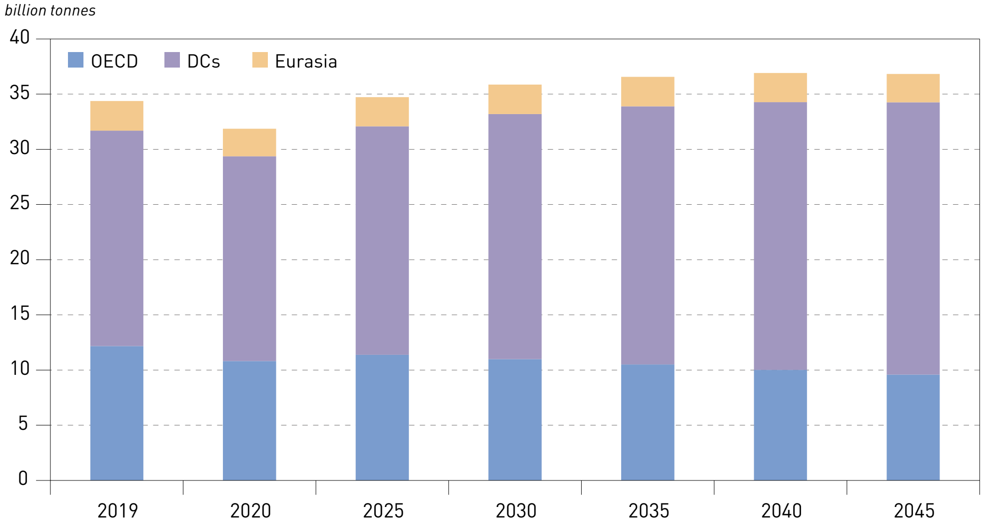
The largest increase in CO_2 emissions is expected for natural gas (+2.5 bt) as demand for this energy source is set to increase significantly over the forecast period. Combining coal, oil and gas, the overall increase in annual energy-related emissions of 2.5 bt between 2019 and 2045 represents a growth of 7%, which is only one-quarter of the overall increase in energy demand. This is a clear sign of the trend towards the use of lower-emitting energy sources in the future.

Annual CO_2 emissions for the major regions are provided in Figure 2.15. Emissions in developing countries will continue growing throughout the forecast period on the back of rising energy needs in these countries. Emissions in these countries will grow from 19.5 bt in 2019 to 24.7 bt in 2045. However, part of this growth will be offset by the strong decline in the use of coal and oil, a significant increase in the use of renewable energy and declining total energy demand in the OECD. In Eurasia, CO_2 emissions will remain in a very narrow range of 2.5 to 2.7 bt throughout the forecast period, hence having little effect on the overall pattern.

Besides considering emission trends on an absolute weight basis, as presented in Figure 2.15, it is equally important to look at these trends on a per capita basis as presented in Figure 2.16. From this perspective, the pattern for developing countries changes from emissions growth in Figure 2.15 to relative stability in Figure 2.16. Moreover, per capita emissions in OECD countries were almost three times higher than those for developing countries in 2019.

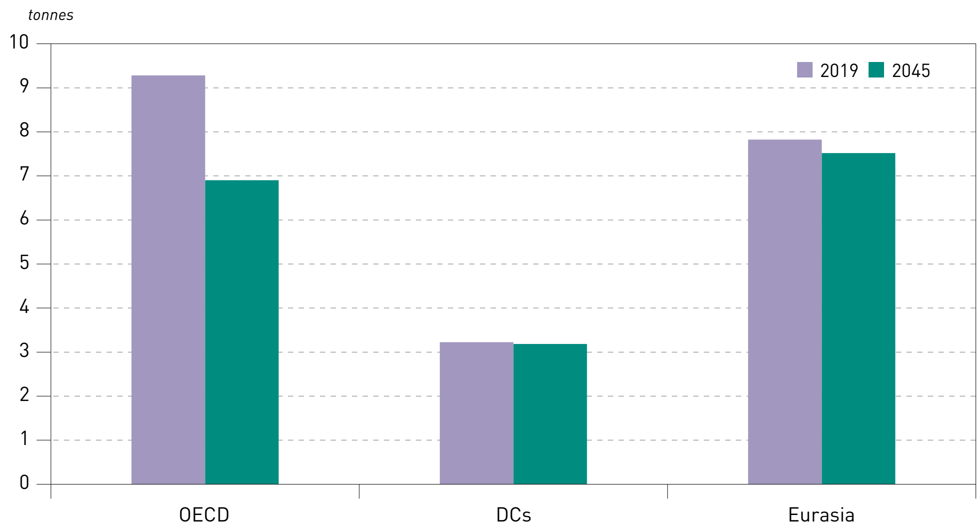
A similar disproportion also exists when comparing the Eurasia and Developing countries regions. Moreover, this gap will persist over the entire forecast period, although it becomes slightly narrower over time. More importantly, energy-related emissions on a per capita basis in developing

Figure 2.15
Energy-related annual CO_2 emissions by major region, 2019–2045



Source: OPEC.

Figure 2.16
Per capita CO_2 emissions by major region, 2019 and 2045

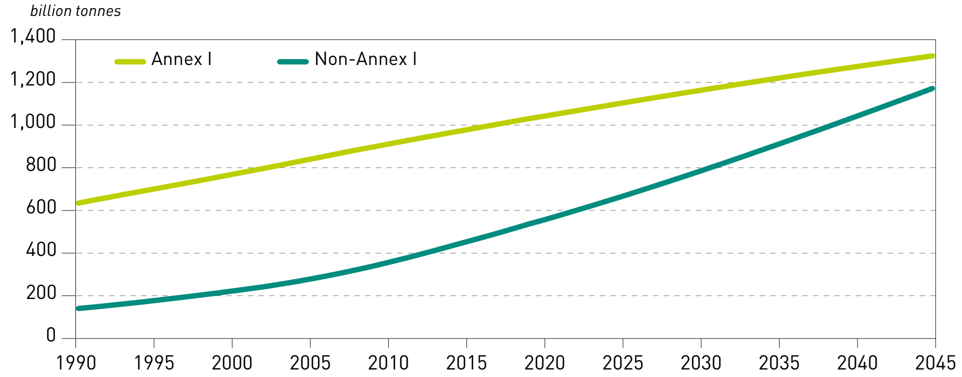


Source: OPEC.

countries are projected to remain at very low levels, signalling that energy poverty will continue to be an issue in many of these countries.

Finally, Figure 2.17 highlights another issue which is often part of the discussion on energy-related CO_2 emissions. It tracks cumulative CO_2 emissions since 1900 from the perspective of Annex I and non-Annex I countries. It first shows a substantial gap in cumulative emissions that developed throughout the past century. In 2000, cumulative emissions from Annex I countries were 3.5 times higher than those from non-Annex I.

Figure 2.17
Cumulative CO_2 emissions since 1900, 1990–2045



Source: OPEC.

Since then, the gap started to narrow as energy demand grew rapidly in many developing countries. Nevertheless, the gap is expected to remain throughout the forecast period. Even by 2045, historical cumulative emissions by non-Annex I countries will be more than 150 bt of CO_2 lower than those generated by Annex I countries since 1900.

2.6 Energy intensity and consumption per capita

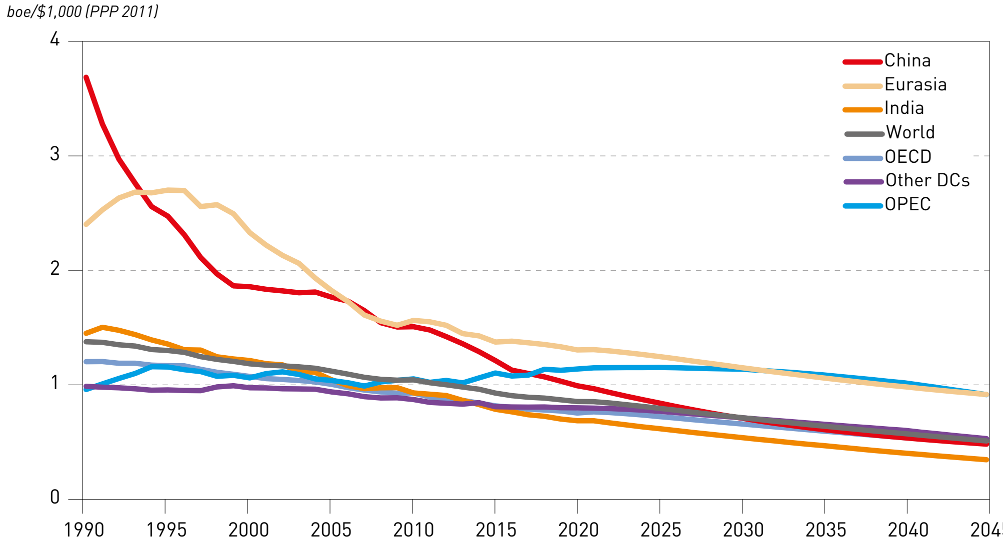
The COVID-19 pandemic has had a damaging effect on the global economy and has spared no economic sector, including energy. Yet despite the strong hit at the sectoral level, over the long run the impact on energy and efficiency efforts is likely to be mitigated. Benefits are still expected from improvements in standards, new infrastructure all along the energy supply chain, and advancements in efficiency through the deployment of smarter and more cost-effective technologies.

Figure 2.18 highlights the expected progress of energy intensity for specific developing countries and regions. Energy intensity patterns indicate that in most regions, and at the global level, the amount of energy required to produce one unit of GDP is falling. The obvious fact is that technological developments and policies have played a decisive role in lowering energy intensity over time. The world is moving forward with sustained improvements in energy consumption. In most regions, energy efficiency improvements are expected to continue at the same pace, if not accelerate, compared to those achieved over the past 50 years or so.

India and China will continue their improvement in 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 economic growth and energy use, and this is expected to continue in these regions. However, the recent economic shock at the sectoral level has raised serious concerns about an eventual industrial re-localization. Energy efficiency gains in the developed world, in part enabled by globalization, could be hampered by re-localization.

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 will move towards convergence, as previously wide gaps in energy intensities are gradually eliminated. The world may see the doubling of the rate of decline in energy intensity at the global level – as targeted by Sustainable Development Goal (SDG) 7.3 – reached by the late 2030s or early 2040s.

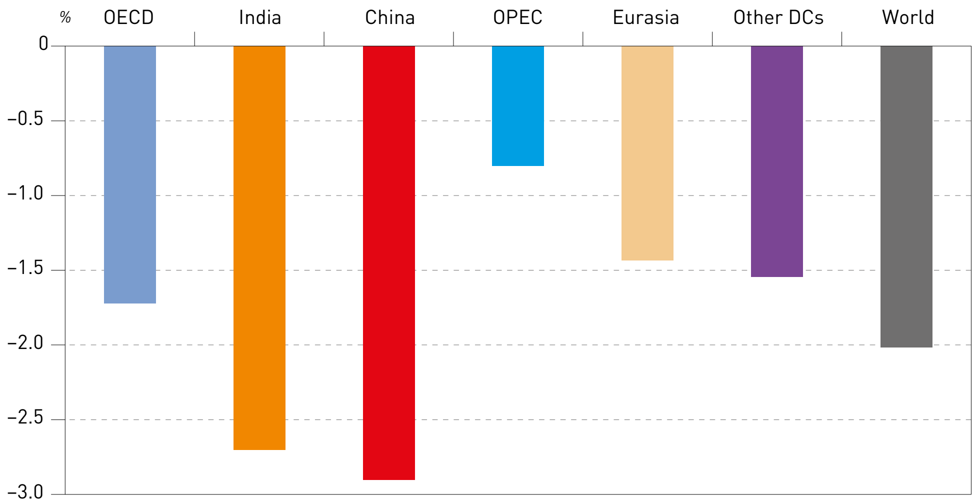
Figure 2.18
Evolution and projections of energy intensity in major world regions, 1990–2045



Source: OPEC.

Energy efficiency performance across the major regions is summarized in Figure 2.19. 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 2.9% p.a. and 2.8% p.a., respectively, between 2019 and 2045. The OECD is likely to achieve an estimated reduction of 1.6% p.a. Other regions will experience an estimated reduction in the range of 0.9% to 1.7% p.a., whereas the global average reduction is projected to be at a level of 2% p.a.

Figure 2.19
Average annual rate of improvement in global and regional energy intensity, 2019–2045

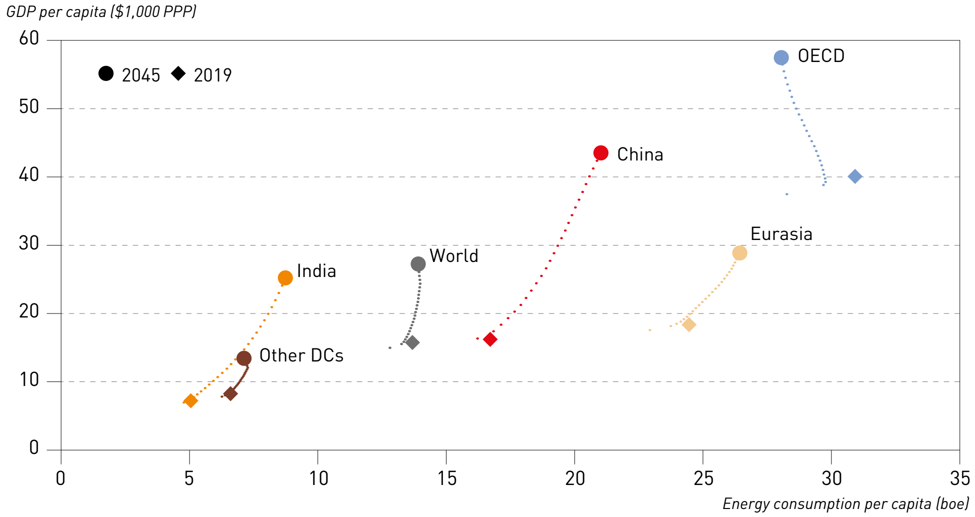


Source: OPEC.

Another important issue and trend to underscore is that global energy poverty is declining. In 1970, there was a wide gap between energy consumption per capita in the OECD and non-OECD regions. Average annual energy consumption was almost 27 boe per capita in the OECD, while in developing countries it was only 3 boe per capita. In countries such as China and India, the average annual consumption was even below 1.5 boe per capita. The gap had not narrowed significantly by 1990, but average consumption in the OECD region was still more than six times higher than in developing countries. Since then, however, rapid economic expansion in the developing world, particularly in developing Asia, has lifted millions of people out of poverty and enlarged the middle class, prompting an increase in access to energy. In 2015, average energy consumption in non-OECD countries had almost tripled compared to 1970 and the gap with the OECD had narrowed. Nevertheless, the gap is still wide and energy poverty remains an extremely important and urgent global issue.

From the perspective of energy demand, Figure 2.20 shows that differences in annual average per capita energy consumption (in a very broad sense, a proxy for energy poverty/wealth) can be linked to differences in the level of development and, therefore, in average income levels.

Figure 2.20
Energy consumption per capita *versus* GDP at PPP per capita, 2019–2045



Source: OPEC.

Major world regions have been strongly impacted by the considerable shock caused by the COVID-19 pandemic and this is clearly depicted with scattered outlier points in Figure 2.20, especially in 2020 and during the medium-term period. This Outlook anticipates that energy consumption in the non-OECD region will remain broadly coupled with rapid economic growth. This will bring increasing electrification, rising income levels, increasing urbanization and an expanding middle class. 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 increase significantly, from almost 16.7 boe in 2019 to more than 21 boe in 2045 after a slight anticipated fall in 2020 of 0.5 boe due to the pandemic. In India, average consumption is anticipated to move from a level of just over 5.1 boe to almost 8.7 boe by 2045 with a less significant drop in 2020 of 0.3 boe. For other developing countries, in general, both per capita income and consumption will remain at low levels, despite the significant increase in energy demand in absolute terms.

The OECD region, where economies are more service-oriented, is set to see energy consumption per capita continue to decline, a trend that began in 2004. The level of 30.9 boe observed in 2019 will drop to 28.0 boe by 2045. Notably, the impact of the COVID-19 pandemic on per capita energy consumption in the OECD region is estimated at 2.6 boe, representing a significant drop in 2020 from the 2019 level. 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 improvements in energy efficiency.

Oil demand

Key takeaways

- The COVID-19 pandemic unleashed a number of uncertainties related to future oil demand prospects.
- Following the demand collapse in 2020, oil demand growth is expected to recover over the medium-term and reach the level of 103.7 mb/d by 2025.
- The pandemic's effect on global oil demand in the OECD has further exacerbated the divergent trends between the OECD and non-OECD.
- OECD oil demand will decline by 1.1 mb/d between 2019 and 2025, partially offsetting potential demand growth in the non-OECD.
- Incremental oil demand in non-OECD countries is forecast at 5.1 mb/d between 2019 and 2025.
- Long-term oil demand is estimated to increase by 9.4 mb/d from 2019 to reach 109.1 mb/d in 2045. Oil demand in non-OECD countries is expected to increase by 22.2 mb/d between 2019 and 2045.
- By 2045, OECD demand is forecast to be around 13 mb/d lower than in 2019.
- Global oil demand will grow at a relatively healthy pace during the first part of the forecast period before demand enters a relatively long period of plateauing during the second half.
- India is anticipated to be the largest contributor to future incremental demand, adding some 6.3 mb/d between 2019 and 2045.
- The petrochemicals sector (+3.7 mb/d), followed by aviation (+2.8 mb/d) and road transportation (+2.6 mb/d), will be the primary drivers of oil demand between 2019 and 2045. Electricity generation is the only sector where oil demand is projected to decline.
- Road transportation will experience a strong decoupling between oil demand and transport services and the number of vehicles on the road. Nonetheless, it will remain the primary sector for oil demand and account for 43% of total demand by 2045.
- The total vehicle fleet is expected to reach 2.6 billion by 2045, increasing by around 1.2 billion from the 2019 level. The majority of the increase (1.1 billion vehicles) comes from non-OECD countries.
- From the total of 2.6 billion vehicles on the road by 2045, around 430 million will be EVs, second to internal combustion engine (ICE) based vehicles.
- With respect to refined products, major demand growth is expected for ethane/LPG (+2.5 mb/d), jet/kerosene (+2.4 mb/d) and naphtha (+2 mb/d).

The oil industry will remember 2020 as one of the most turbulent years in its history. At the beginning of the year comparisons were made to the 2003–2004 SARS epidemic, but COVID-19 soon became a major pandemic that affected all countries around the globe and sparked the most severe economic downturn since the Great Depression.

Indeed, measured on an annual basis, global economic activity is expected to declined by almost 4% during 2020 while implications for oil demand have been even more severe. Entire countries, across all regions, faced lockdowns or other restrictions for several months. The public health measures undertaken to contain COVID-19 triggered a sharp decline in auto use, grounded civil aviation, and reduced construction and manufacturing activity – resulting in an unprecedented decline in oil demand. At the global level, demand plunged by some 17 mb/d during the second quarter, compared to the same period in 2019. Since then, there has been a gradual recovery in most countries, though many uncertainties remain.

In this regard, there are many questions, but few answers. How quickly will the economy recover? After recovery, will we return to 'normal' growth rates, or will these remain subdued for some time? Will stimulus packages outlined by almost all governments be effective, leading to higher growth? Will consumer behaviour change in the post-COVID period? Will we use our cars the same way as before the crisis? Will the aviation industry return to normal? Or will tourists refrain from traveling? If so, for how long?

Most importantly, will policymakers adjust energy policies? Some already argue that investments in low-emission technologies should be deferred for some time in favour of using available resources to support the economic recovery. Others, by contrast, want to expedite investments in renewable energy as a way of supporting the economic recovery and accelerate the transition to cleaner fuels. The same question arises about the deployment of technology to boost energy efficiency: Will we see accelerated momentum to improve energy efficiency or will there be stagnation in the years to come?

This chapter does not offer answers to all these questions but tries to shed light on some of them by capturing and analyzing key factors while providing insights into the evolving outlook for oil demand in the medium- and long-term.

Bearing in mind the above-mentioned uncertainties, this chapter supports an expectation that oil demand will recover from the low levels experienced in 2020 and will continue to grow. Nevertheless, future demand will likely remain persistently below past projections due to the lingering effects of the COVID-19-related shutdowns and their impact on the global economy and consumer behaviour.

Similar to past trends, oil demand growth will be driven by non-OECD countries, while OECD countries will likely shift from positive growth to a negative trajectory within the next few years. Nevertheless, demand increases in non-OECD countries will more than offset declines in the OECD. This in particular will be the case for the first half of the forecast period and result in relatively healthy demand growth. In the second part, however, demand growth in several key non-OECD countries will decelerate and lead to an extended period of plateauing oil demand. In very broad terms at the global level, various forms of transport and petrochemicals will remain the key sources of future incremental demand.

3.1 Oil demand outlook by region

Following the demand collapse in 2020, especially in the second quarter when COVID-19-related lockdowns were introduced in most countries, oil demand is expected to partially recover in 2021. The recovery process will also extend into 2022 and 2023, especially in the aviation and road transportation sectors, before annual demand increments settle at more moderate rates for the rest of the medium-term period. The breakdown of this overall pattern in major regions is provided in

Table 3.1 and, in terms of annual incremental growth, in Figure 3.1. The latter illustrates that the extent of the demand decline in 2020, and the potential recovery in 2021, completely overshadow changes in the years thereafter.

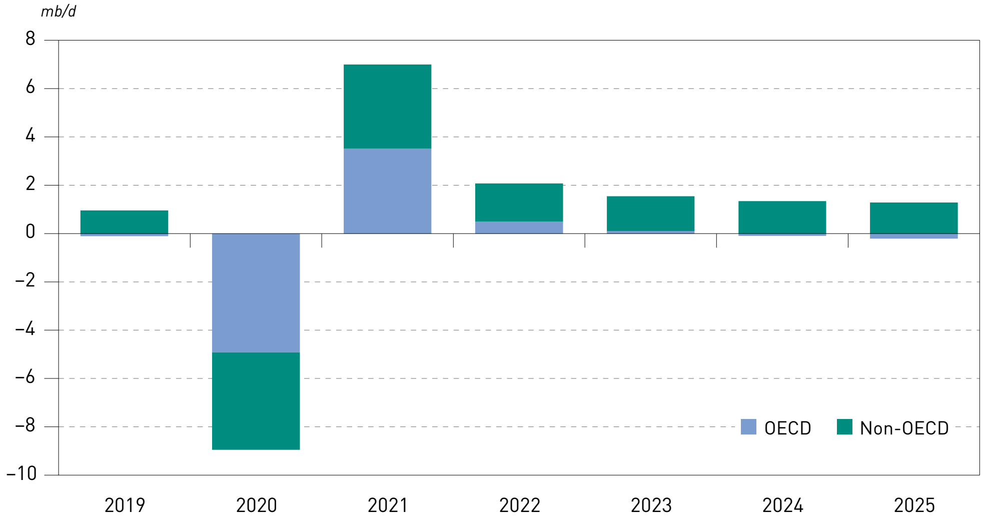
Table 3.1
Medium-term oil demand in the Reference Case

mb/d

	2019	2020	2021	2022	2023	2024	2025	Growth 2019–2025
OECD Americas	25.6	23.3	25.1	25.5	25.7	25.7	25.7	0.1
OECD Europe	14.3	12.6	13.8	13.9	13.9	13.8	13.7	–0.7
OECD Asia Oceania	7.9	7.1	7.5	7.5	7.5	7.5	7.4	–0.5
OECD	**47.9**	**43.0**	**46.5**	**47.0**	**47.1**	**47.0**	**46.8**	**–1.1**
Latin America	6.2	5.8	6.1	6.2	6.4	6.5	6.6	0.4
Middle East & Africa	4.3	3.9	4.1	4.3	4.5	4.6	4.8	0.4
India	4.8	4.3	5.0	5.2	5.4	5.6	5.8	1.0
China	13.1	12.1	13.2	13.6	13.9	14.2	14.4	1.4
Other Asia	9.0	8.5	8.9	9.2	9.4	9.7	9.9	0.9
OPEC	8.7	8.2	8.6	8.8	9.1	9.3	9.5	0.8
Russia	3.6	3.2	3.4	3.5	3.6	3.7	3.7	0.1
Other Eurasia	2.0	1.8	1.9	2.0	2.0	2.1	2.1	0.1
Non-OECD	**51.8**	**47.8**	**51.2**	**52.8**	**54.3**	**55.6**	**56.9**	**5.1**
World	**99.7**	**90.7**	**97.7**	**99.8**	**101.3**	**102.6**	**103.7**	**4.0**

Source: OPEC.

Figure 3.1
Annual oil demand increments by region, 2019–2025



Source: OPEC.

Based on the July 2020 edition of the OPEC Monthly Oil Market Report, global oil demand declined by 9 mb/d in 2020 on an annual basis. The OECD accounted for a disproportionately large part of the decline, at –4.9 mb/d, which represents around 55% of the global drop. In 2021, oil demand is projected to increase by 7 mb/d to 97.7 mb/d. This means that 2021 demand will still be around 2 mb/d lower than in 2019 and more around 4.3 mb/d lower than projected in the WOO 2019.

Another important observation relates to the breakdown of demand recovery in 2021. This will be shared almost equally by the OECD and non-OECD with each contributing 3.5 mb/d. The net effect is that OECD oil demand in 2021 will be almost 1.4 mb/d lower than the pre-crisis level of 2019 while the gap for the non-OECD will be only around 0.5 mb/d. Naturally, this will have lasting implications for future regional demand growth over both the medium and long-term.

After the turbulent years of 2020 and 2021, global oil demand in the medium-term is projected to continue rising at relatively high annual rates to reach 103.7 mb/d by 2025. Annual increments will be relatively high especially during 2022 and 2023, at 2.1 mb/d and 1.5 mb/d, respectively. There are two main reasons for this expectation.

The first relates to 'restored' economic growth during these years, especially in the major developing countries. By then, GDP in China and India will be growing at 5.5% to 6.5% p.a., respectively, supplemented by significant growth in several other Asian countries in the range of 4% p.a. and the Middle East & Africa growing by around 3% p.a. on average. Supported by a recovery in oil prices, faster economic growth could also be expected in major oil-producing countries, including OPEC.

The second reason is linked to demand 'catching up', especially in the sectors affected most by the administrative restrictions during the COVID-19 crisis. These sectors include aviation, road transport and industry. In the first two sectors, consumer confidence and the propensity to travel and fly longer distances will gradually return, hence supporting demand growth beyond the standard link to economic activity, including the counterbalancing effect of changed consumer behaviour related to COVID-19. A similar effect is also expected in the industry sector in 2020, when production declined significantly and many investment decisions were deferred. These are likely to bounce back in the coming years with support from government stimulus packages. In turn, oil demand in the sector will be positively affected.

The rest of the medium-term will be marked by further 'normalization' of the demand growth where longer-term trends and factors will support moderate levels of annual incremental demand of slightly more than 1 mb/d. Global GDP is projected to continue growing at 3.3% and 3.4% p.a. in 2024 and 2025, respectively, providing a solid basis for incremental oil demand.

However, this GDP growth will also be accompanied by further structural changes in the contributing elements to GDP in several countries, such as China, with a higher share coming from the service sector. Therefore, less economic activity in energy/oil intensive sectors will result in lower oil demand growth compared to a similar GDP growth in the past.

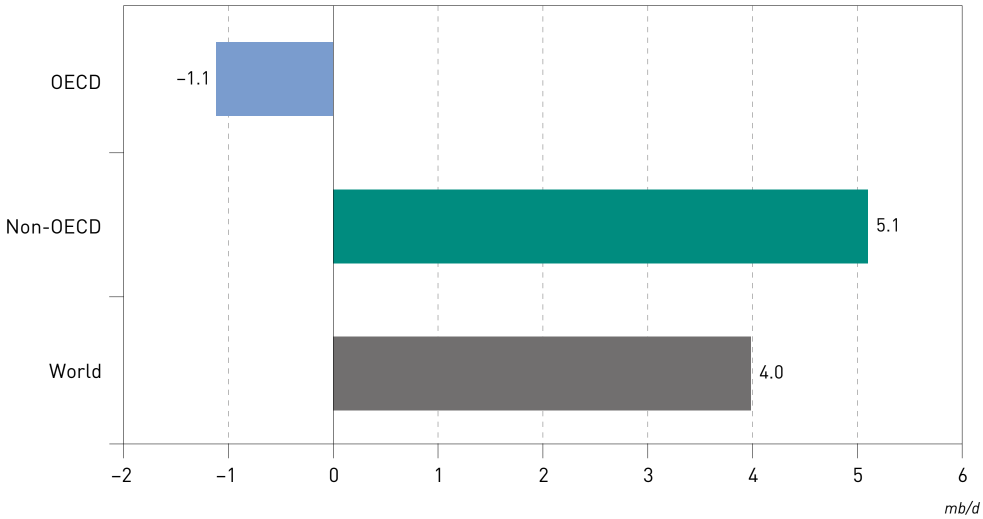
Moreover, potential demand growth will be partly offset by continued efficiency improvements and changing consumer behaviour – such as an increased share of home office work and the use of teleconferences instead of physical travel. In the first half of the medium-term outlook, the focus of most governments will be on restoring economies, eliminating social implications of the crisis and stimulating employment.

The EU is likely the only exception, with its strong emphasis on supporting environmental investment as part of the overall recovery process. In contrast, in most other countries energy-efficiency programmes will likely not be at the top of the agenda. Moreover, sales of new (and more efficient) cars will lag behind previous years. This, however, will likely change towards the end of the forecast period as economies stabilize and grow, consumer confidence is restored and attention to environmental issues moves higher on the agenda.

The likely effect of the combination of these factors will be twofold: improved efficiency in the areas where oil demand continues to grow; and oil substitution in areas where other energy sources, especially natural gas and renewables, are more economical or result in lower emissions. Examples of such options include the City Gas Distribution initiative in India that targets the replacement of LPG and kerosene by natural gas; replacement of oil in power generation by natural gas (as oil prices are expected to recover); the reduction of direct crude burning in the Middle East; the growing number of LNG-powered vessels in the shipping industry; the growing penetration of electric vehicles (EVs) in the overall car fleet; and a ban on oil-based heating systems in the residential sector in several European countries (e.g. in Norway as of 2020, Austria as of 2023 and the UK as of 2025).

Clearly, none of the above-mentioned factors has the potential on its own to significantly slow or even reverse the medium-term demand growth trend at the regional or global level. However, a combination of these factors may have a measurable effect on oil demand in a given region, leading to an overall decelerating trend at the global level. As a result, annual incremental demand decelerates to 1.1 mb/d in 2025. The overall demand increase over the medium-term period (2019–2025) will be 4 mb/d (Figure 3.2) with the average annual increment at 0.7 mb/d. It should be noted, however, that this global average is very much affected by demand loss in 2020.

Figure 3.2
Annual oil demand increments by region, 2019–2025



Source: OPEC.

Compared to past trends and projections in previous Outlooks, the effect of the COVID-19 pandemic on oil demand in the OECD has further exacerbated the divergent trends between the OECD and non-OECD. Over the medium-term period, incremental demand is forecast to come from non-OECD countries (+5.1 mb/d) primarily driven by continued GDP and population growth. However, part of this potential growth will be offset by other factors such as efficiency improvements and the implementation of various policy measures.

The expectation for OECD demand stands in stark contrast to that of non-OECD countries. Oil demand in the OECD will likely not recover to 2019 levels and, after severe ups and downs in 2020 and 2021, will gradually shift from slight growth to declining demand towards the end of the medium-term. In sum, OECD oil demand will decline by 1.1 mb/d between 2019 and 2025 thus further offsetting potential demand growth in non-OECD countries.

The demand trends prevailing at the end of the medium-term will also very much determine the transition to long-term demand patterns. This is summarized in Table 3.2, which shows a regional breakdown of future oil demand to 2045. At the global level, oil demand is expected to increase by almost 10 mb/d over the long-term, rising from 99.7 mb/d in 2019 to 109.3 mb/d in 2040 and to 109.1 mb/d in 2045.

Table 3.2
Long-term oil demand by region

mb/d

	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
OECD Americas	25.6	23.3	25.7	24.8	23.1	21.2	19.3	–6.3
OECD Europe	14.3	12.6	13.7	12.9	12.0	11.1	10.2	–4.1
OECD Asia Oceania	7.9	7.1	7.4	6.9	6.4	5.8	5.2	–2.7
OECD	**47.9**	**43.0**	**46.8**	**44.6**	**41.5**	**38.0**	**34.8**	**–13.1**
Latin America	6.2	5.8	6.6	7.1	7.4	7.6	7.9	1.6
Middle East & Africa	4.3	3.9	4.8	5.5	6.2	6.9	7.6	3.3
India	4.8	4.3	5.8	7.2	8.6	9.9	11.1	6.3
China	13.1	12.1	14.4	15.5	16.2	16.7	17.1	4.0
Other Asia	9.0	8.5	9.9	10.9	11.7	12.4	13.0	3.9
OPEC	8.7	8.2	9.5	10.5	11.3	11.7	11.7	3.0
Russia	3.6	3.2	3.7	3.8	3.8	3.8	3.7	0.1
Other Eurasia	2.0	1.8	2.1	2.2	2.3	2.3	2.3	0.2
Non-OECD	**51.8**	**47.8**	**56.9**	**62.6**	**67.4**	**71.2**	**74.3**	**22.5**
World	**99.7**	**90.7**	**103.7**	**107.2**	**108.9**	**109.3**	**109.1**	**9.4**

Source: OPEC.

Besides the trends already outlined in the medium-term, there are some additional factors which will play an increasing role in the long-term. In the first place, as discussed in detail in Chapter 1, economic growth will decelerate, especially during the last ten years of the forecast period. Bearing in mind the continued structural changes in major economies and the use of energy-efficient technologies, oil intensity is expected to decline.

More detailed discussion of these issues is presented in the analysis of demand trends in various sectors. In addition, energy policies will play an increasing role in diversifying the future energy mix, leading to oil substitution in areas where policy and technology developments make other energy sources competitive.

Several high-level observations in respect to long-term oil demand are worth noting. First, current oil demand projections for 2040 represent a downward revision of more than 1 mb/d to the levels projected in the WOO 2019. The primary reason for this change is the lingering implication of the COVID-19 crisis.

The effect of the GDP drop in 2020 and recovery over the medium-term mean that the level of economic activity during the second half of the forecast period will be around 6% lower than assumed in the WOO 2019. Moreover, the difference in 2020 oil demand between the WOO 2019 and the current Outlook is more than 10 mb/d. This difference is reduced to less than 2 mb/d in 2025, but is not expected to be fully eliminated during the forecast period.

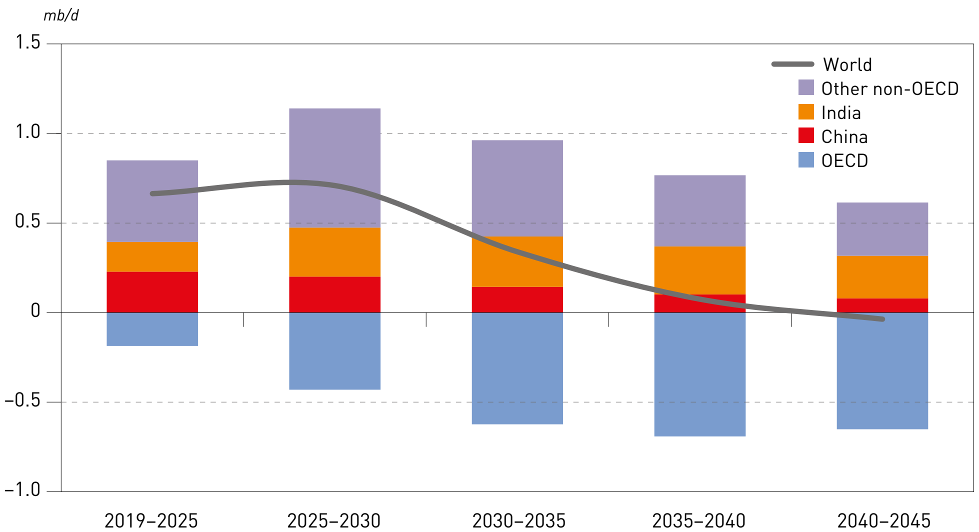
Secondly, as is already the case during the medium-term, long-term demand projections show a contrasting picture between the two major regions: declining long-term OECD demand and growing demand in the non-OECD. Indeed, OECD demand is expected to plateau at around 47 mb/d during 2022–2025.

Thereafter, it starts a longer-term decline towards the level of 35 mb/d by 2045 as population growth in the region will be very low and long-term economic growth will remain consistently below 2% p.a. At the same time, efficiency improvements will take place across all sectors of consumption, including a significant penetration of alternative fuel vehicles (AFVs) in the transportation sector, as well as a shift from oil (and coal) to gas and renewable energy in other sectors.

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 22.5 mb/d between 2019 and 2045, reaching the level of 74.3 mb/d in 2045. The largest contributor to this incremental demand is anticipated to be India, adding some 6.3 mb/d between 2019 and 2045.

The third observation relates to the deceleration of incremental oil demand in the long-term as demonstrated in Figure 3.3. Considering high fluctuations during the medium-term period, average incremental demand to 2025 is projected at around 0.7 mb/d p.a. A comparable rate of growth is also expected in the period to 2030. This, however, will change quite significantly during the next five-year period as the decline in the OECD accelerates and demand growth in the non-OECD region starts to decelerate. To sum up, global oil demand will grow at relatively healthy rates during the first part of the forecast period before demand plateaus during the second half.

Figure 3.3
Average annual oil demand increments by region, 2019–2045



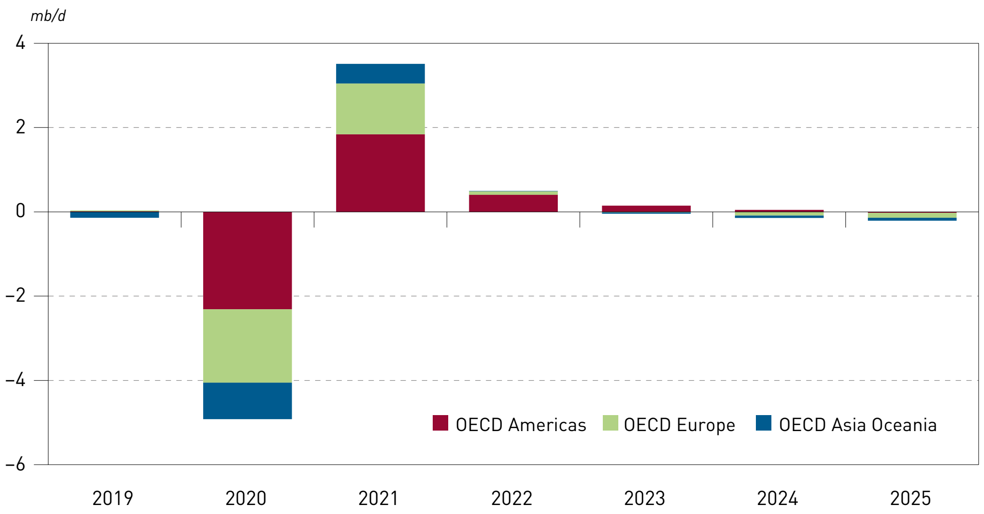
Source: OPEC.

3.1.1 OECD

Tables 3.1 and 3.2 outline the key trends in OECD oil demand over the medium- and long-term periods. Figure 3.4 further details annual incremental oil demand in the major OECD sub-regions post-COVID-19. It is worth noting three primary observations illustrated in Figure 3.4:

- Oil demand in 2021 will still fall short of overall levels achieved in 2019;
- Despite the large demand base in the OECD, the range of annual change will be fairly limited;
- Oil demand in the OECD region will likely shift after 2023 from growth to a declining trend.

Figure 3.4
Annual oil demand growth in the OECD, 2019–2025



Source: OPEC.

The first observation was already discussed in the previous section. For the second one, OECD demand constituted around 48% of global demand in 2019. Yet its annual change was –0.1 mb/d during the same year. A return to a similar order of magnitude is expected after the wild fluctuations of 2020 and 2021 settle somewhat because of maturing demand in this region. Vehicle markets are nearly saturated and provide little room for growth; economic growth is forecasted to remain below the 2% mark p.a.; population growth will be limited; and policy- and technology-driven efficiency improvements and fuel substitution will offset potential growth.

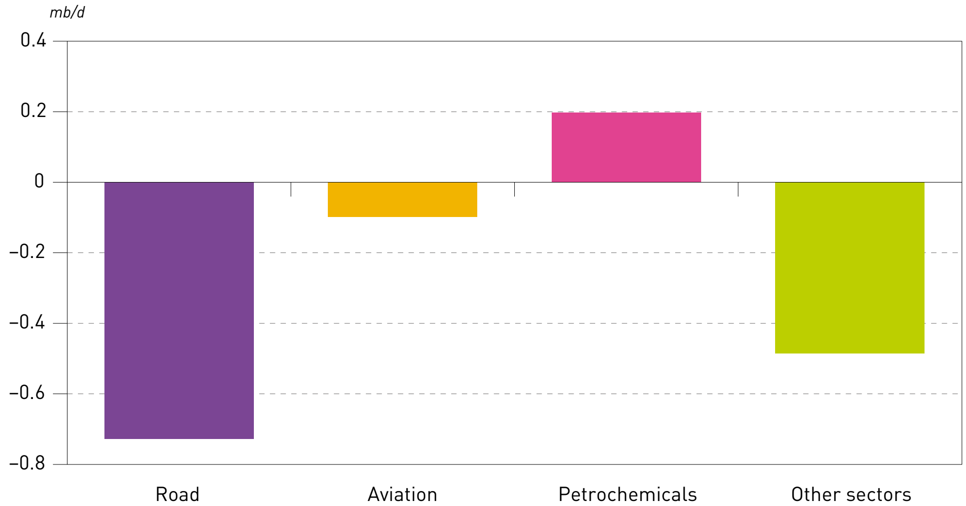
Sales of new vehicles during the first half of 2020 are a further reflection of this pattern in the OECD. In the EU, passenger car registrations declined by around 40%. In Japan, the car market was less affected but still recorded a contraction of around 20%. Somewhere in between is the US, where new cars sales fell by around 32% compared to the same period of 2019.

While some improvement in new car sales is to be expected in the second half of 2020, it is clear that overall sales for the year will be significantly lower than those of last year. Moreover, the share of EVs in new sales has increased, especially in Europe where EVs accounted for almost 7% of new sales in the first quarter of 2020 compared to less than 3% in the first quarter of 2019. Part of the sharp rise of this share relates to the overall contraction of new vehicle sales since ICE sales fell more sharply than EVs. Nonetheless, an implication for future demand is further decelerating growth in OECD regions.

As a result of the combination of these factors, oil demand growth will not only be constrained but will gradually revert from overall growth to decline. Decelerating growth in OECD Americas is the key element behind this, since oil demand in the other two regions, OECD Asia Oceania and OECD Europe, had been on a downward trajectory since 2018. This trend will be interrupted in 2021 and 2022 as part of the recovery process after a sharp drop in 2020, but is expected to prevail in the years thereafter.

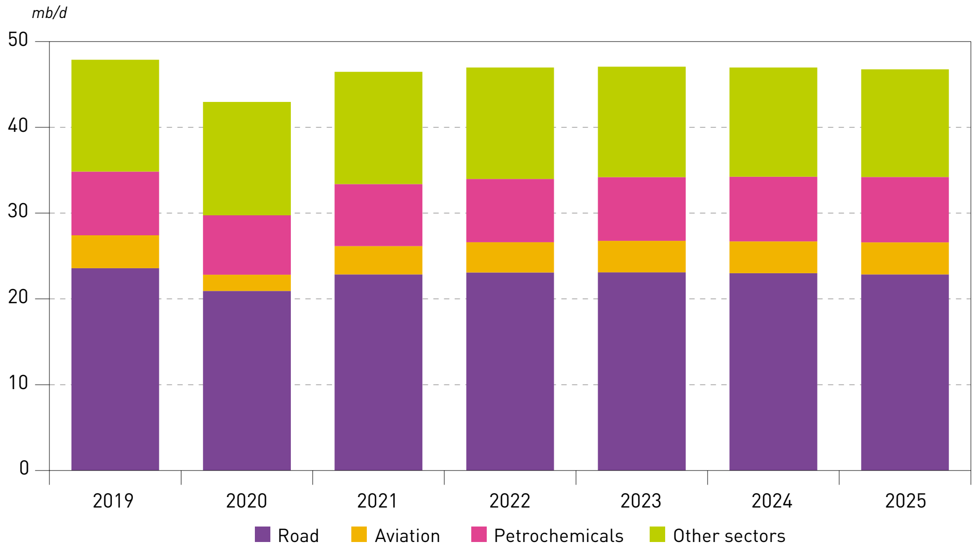
Figures 3.5 and 3.6 further explain these trends from the sectoral perspective. Clearly, the largest demand decline will take place in the road transportation sector which, in the case of the OECD, will not recover to pre-COVID-19 levels. It should be noted, however, that road transportation demand in OECD Asia Oceania and OECD Europe was on the decline before the pandemic crisis, which accelerated this trend.

Figure 3.5
Annual oil demand growth in the OECD by sector, 2019–2025



Source: OPEC.

Figure 3.6
OECD oil demand by sector, 2019–2025



Source: OPEC.

From the total OECD demand decline of 0.7 mb/d in this sector, OECD Europe will account for around 0.4 mb/d and OECD Asia Oceania for another 0.3 mb/d. In contrast, road transportation in OECD Americas will fully recover to the 2019 levels sometime around 2023 before it begins a marginal decline for the rest of the period.

A similar pattern is projected for the aviation sector, although the OECD demand decline in this sector will be much less pronounced and it will continue to grow beyond the medium-term horizon. The aviation sector was the most severely affected by the COVID-19 pandemic and related travel restrictions across the globe. OECD Europe was among the regions with the sharpest demand drop as the vast majority of aircraft were grounded for several months. Although air travel is expected to recover slowly during the second half of 2020, the change in consumer behaviour will restrain growth. As a result, 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, the petrochemical industry in the OECD is expected to recover from the COVID-19 crisis faster than other sectors. While there will be some lasting implications for OECD Europe and Asia Oceania, large capacity additions in OECD Americas, especially in the US, combined with the continued availability of domestic feedstock at competitive prices, will spur demand growth. The net increase in OECD Americas will be around 0.3 mb/d between 2019 and 2025, part of which will be offset by the demand decline in OECD Asia Oceania and marginally in OECD Europe. Oil demand in other sectors is mainly linked to the level of economic activity and substitution options. Since the post-COVID-19 GDP growth in the OECD will remain sluggish and natural gas will be available at competitive prices, oil demand in these sectors will remain below 2019 levels.

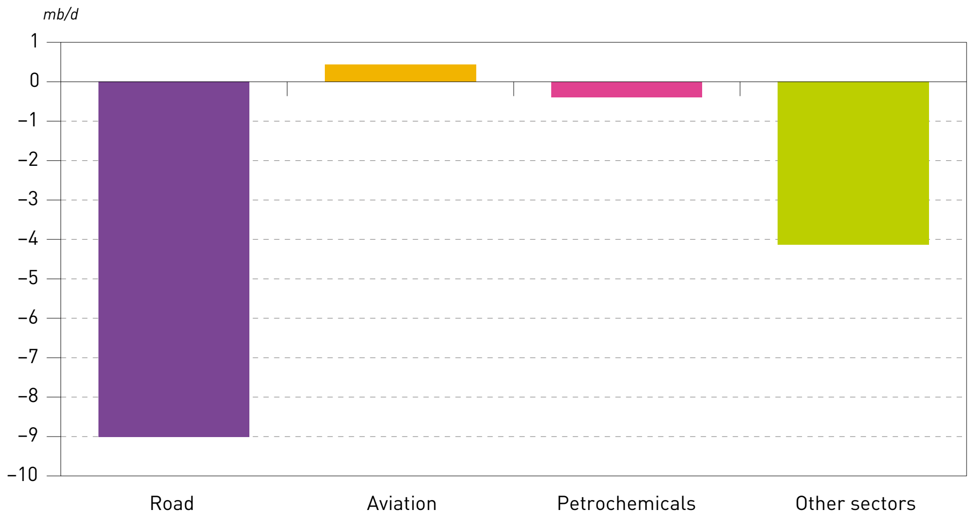
Turning to the long-term perspective, the outlook for the OECD region is for a steady oil demand decline as illustrated in Figures 3.7 and 3.8. The overall demand drop between 2019 and 2045 will be around 13 mb/d. Of this, 9 mb/d will materialize in road transportation led by OECD Americas (–4.5 mb/d), followed by OECD Europe (–2.9 mb/d) and OECD Asia Oceania (–1.7 mb/d). The level of decline reflects the demand base in 2019, as well as structural changes in the vehicle fleets and driving habits in specific regions. These are discussed in detail in 3.2.1 (the road transportation section).

In short, the high demand base in these regions also provides room for significant efficiency improvements as new vehicles gradually replace the older ones. An important component relates to the growing penetration of alternative vehicles such as BEVs and plug-in hybrid electric vehicles (PHEVs), especially when considering the extended time horizon to 2045. By then, the share of alternative vehicles will be in the range of 30% to 40%, hence capturing a significant portion of potential oil demand.

Another reason for the significant OECD demand decline relates to expected developments in the industrial, residential, commercial and electricity generation sectors (shown in Figures 3.7 and 3.8 as 'other sectors'). Part of the oil demand in these sectors will continue to be replaced by natural gas and electricity, driven by both regulatory policies and technological advances. Regulations will drive this change mainly in Europe and in OECD Asia Oceania. Tighter building codes, partial exclusion of oil-based heating systems from the residential and commercial sectors, emission-trading systems in the industrial sector and oil substitution in electricity generation are just a few examples of mechanisms steering the demand decline. On top of this, more energy-efficient technologies are a permanent issue contributing to the demand decline in the OECD region.

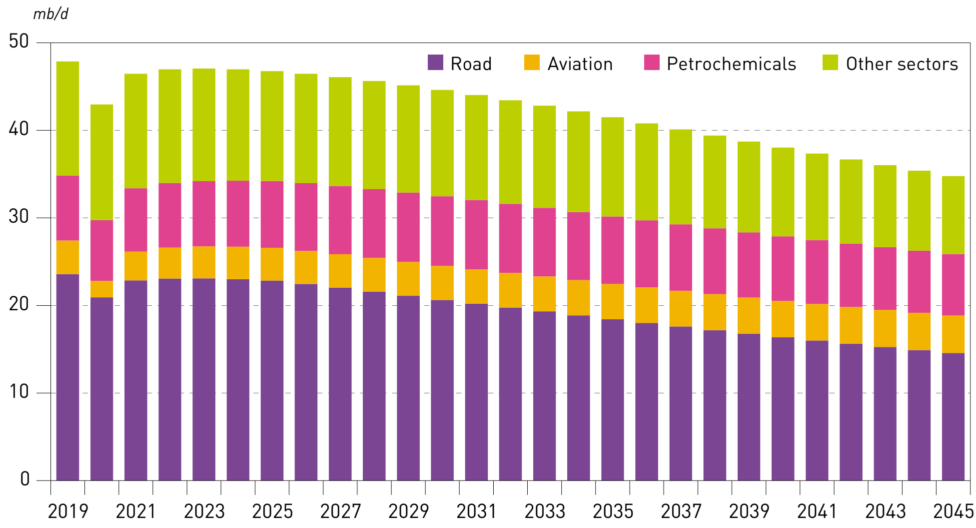
Demand developments in the aviation and petrochemical sectors reflect a different dynamic. In the latter, OECD oil demand will rebound relatively quickly after the COVID-19 crisis and will continue growing until around 2030 – driven by capacity expansion and market conditions in the US. In the second half of the forecast period, however, demand will start falling on the back of declining tight oil production in the US, as well as increased competition from Asian and Middle Eastern

Figure 3.7
Oil demand growth in the OECD by sector, 2019–2045



Source: OPEC.

Figure 3.8
OECD oil demand by sector, 2019–2045



Source: OPEC.

countries. The net effect will be that 2045 oil demand in OECD Americas will be around the same level as in 2019. However, demand will drop quite significantly in OECD Europe (–0.4 mb/d between 2019 and 2045) and, to a lesser extent, in OECD Asia Oceania (–0.1 mb/d).

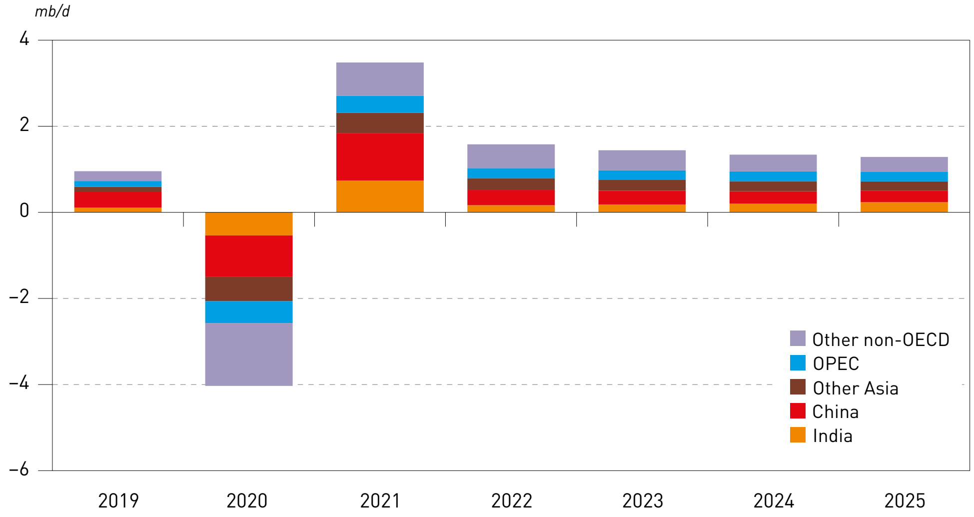
A reverse pattern is expected in the OECD for oil demand in the aviation sector, which was badly hit by COVID-19 lockdowns and the recovery process is expected to take years. Nevertheless, a turnaround is expected over the long-term. In fact, aviation is the only OECD sector where oil demand in 2045 will be higher than in 2019. Overall incremental demand will be fairly limited, at 0.4 mb/d, and shared between the major sub-regions.

3.1.2 Non-OECD

All short-term projections (i.e. for 2020 and 2021) included in this Outlook are consistent with the July 2020 edition of the OPEC Monthly Oil Market Report. At the time of writing, the COVID-19 pandemic seemed to be relatively contained in Europe and Asian OECD countries. High infection rates were still reported for the US but daily peak rates appeared to have been reached. In contrast to the OECD, growing or high numbers of infections were reported in several countries in Latin America, Asia and Africa. The continued uncertainty has potential implications for economic performance and oil demand in the non-OECD.

Bearing this in mind, recent projections indicate a non-OECD oil demand contraction of around 4 mb/d in 2020. However, this sharp demand drop will be largely recovered in 2021 (Figure 3.9) and will provide additional support to demand growth in 2022. 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. For most developing counties, this will be in the range of 4.5% to 4.6% p.a. on average during 2022-2025, somewhat lower than 5.4% in 2021. Demand growth will also be supported by Eurasian countries, though at a much slower pace.

Figure 3.9
Annual oil demand growth in non-OECD countries, 2019–2025

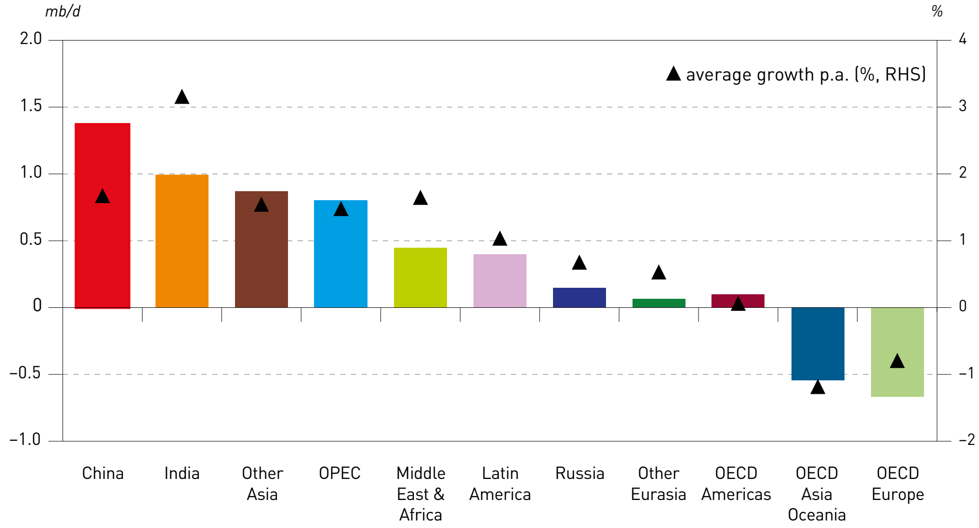


Source: OPEC.

Reflecting this, incremental non-OECD demand between 2023 and 2025 will stay in a relatively narrow band of 1.3 to 1.4 mb/d p.a. with a minor deceleration towards the end of the medium-term. The combined effect of bust and boom in 2020 and 2021 with the steady demand growth throughout 2022–2025 results in an overall demand increase of 5.1 mb/d between 2019 and 2025, reaching the level of 56.9 mb/d in 2025 compared to 51.8 mb/d in 2019. Figure 3.10 shows how this growth is distributed between regions (including OECD regions, for ease of comparison), together with the corresponding average annual demand growth rate.

Figure 3.10 demonstrates that the centre of demand growth is in non-OECD Asian countries, led by China and India. Combined, these countries are estimated to require an additional 3.3 mb/d of

Figure 3.10
Regional oil demand growth between 2019 and 2025



Source: OPEC.

oil. The largest demand increase is expected to come from China, at 1.4 mb/d between 2019 and 2025, followed by India (+1 mb/d) and Other Asia (+0.9 mb/d). However, the pace of demand growth in India will be by far the fastest among all regions, at 3.2% p.a. on average.

India

The higher demand growth rate in India implies that the country will gradually catch up to China in terms of annual incremental growth in volumetric terms. In this respect, both countries will be at parity by 2025, each contributing by around 0.25 mb/d to the global demand growth. The different demand paths in these two countries become even more visible when assessed in the long-term. Demand growth in China decelerates quite significantly during the second half of the forecast period while India is projected to continue growing at higher rates.

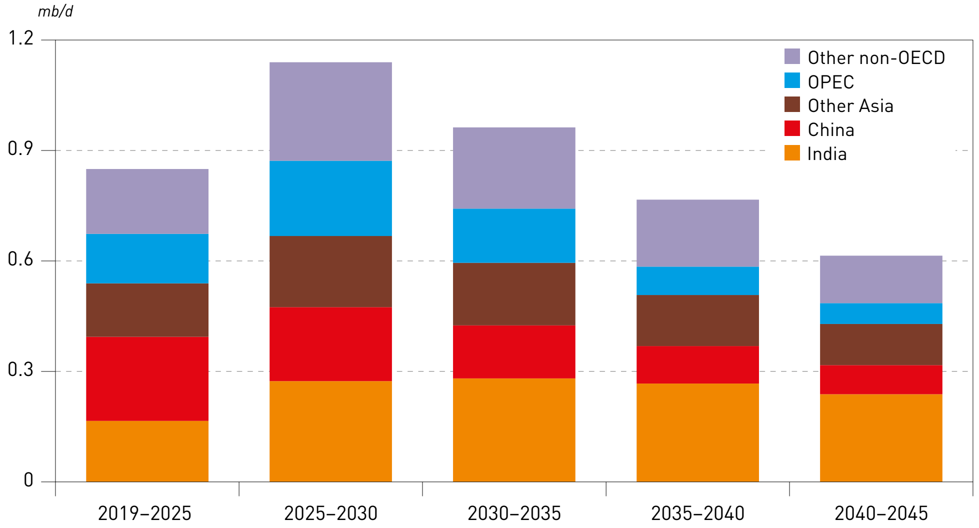
Therefore, overall incremental oil demand in India will be more than 6 mb/d (2019–2045) while in China it is projected at 4 mb/d. Nevertheless, total 2045 demand in India will still be far below the level of China (11.1 mb/d in India compared to 17.1 mb/d in China).

The two key features of the medium-term demand developments in the non-OECD – robust but decelerating growth and the importance of Asia for future demand – also characterize the long-term trends. Both are clearly visible in Figure 3.11, which shows the average annual demand increments in five-year intervals.

A steady deceleration in demand growth in the non-OECD is more than clear, although the picture is somewhat distorted by a very unusual pattern during the first period of 2019 to 2025. As noted earlier, by considering the period of 2022 to 2025 (instead of 2019 to 2025), demand growth would instead decelerate from a level of 1.3 mb/d to around 0.6 mb/d in the last five years of the forecast period.

There are several factors at play, partly with offsetting effects, which contribute to this pattern. These include slowing rates of population and GDP growth; structural change in the GDP composition towards more services and a shift away from heavy industry; continued improvements in

Figure 3.11
Average annual oil demand growth in non-OECD, 2019–2045



Source: OPEC.

efficiency; and fuel substitution. Fuel substitution, in particular, will increasingly occur in the road transportation, electricity generation, marine bunker fuels and residential sectors.

On the other hand, a number of factors will counterbalance these trends and will provide support to oil demand, such as the growing number of passenger cars and commercial vehicles, especially in developing countries; the expansion of the middle class with its propensity to travel and shift energy consumption to modern sources; growing urbanization; the use of petrochemical products, among others. All in all, the net result will be continued, but decelerating oil demand growth in the non-OECD.

Regarding the role of developing Asia in future demand growth, this region will be by far the largest source of incremental demand over the entire forecast period. Indeed, developing Asia will provide around 65% of incremental demand during the medium-term and this will broadly be maintained over the long-term. What will change, however, is that India will overtake China as the main source of incremental demand. India's population will be around 200 million larger (and still growing) than China's towards the end of the forecast period. Moreover, India's GDP is expected to grow by around double that of China after 2040 and exceed the GDP of OECD Americas by then.

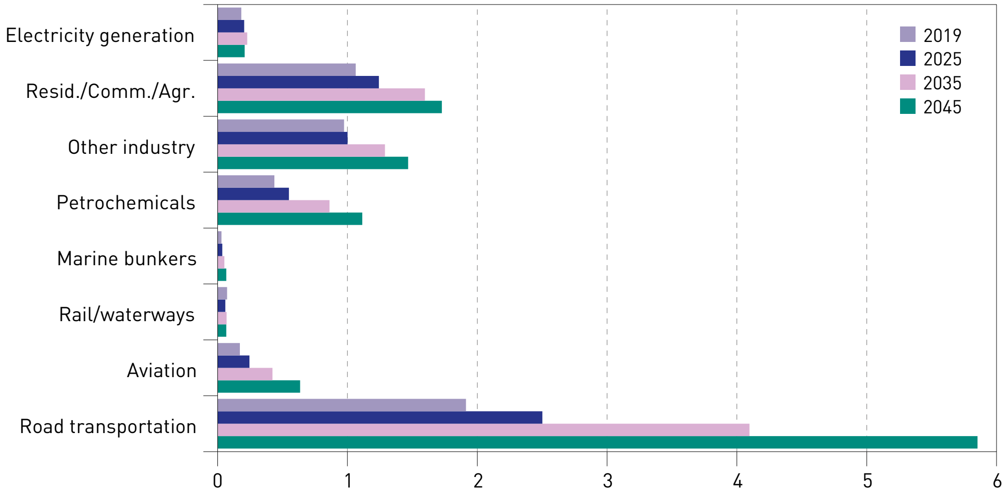
Africa's role also will grow in importance during the second half of the forecast period. Especially towards the end, Africa will be the second largest source of incremental demand, surpassing both China and Other Asia.

Despite a temporary decline in 2020, India's economy is expected to remain strong with GDP growth staying in the range of 6% to 7% during the current decade. The growth will slow to the range of 5% to 6% in the second part of the forecast period, nevertheless still remaining solid. This should provide the impetus for further industrialization, infrastructure development and urbanization.

In turn, this is expected to result in robust energy demand with an increased appetite for all forms of energy. Driven by strong economic growth, oil demand is set to grow from 4.8 mb/d in 2019 to 5.8 mb/d in 2025 and further to 11.1 mb/d in 2045.

As presented in Figure 3.12, by far the largest part of this incremental demand will be related to the rapidly expanding road transportation sector (+3.9 mb/d between 2019 and 2045). Significant growth will also take place in the petrochemical, residential, aviation and other industry sectors, each of them adding between 0.5 and 0.7 mb/d. However, in terms of relative growth, the aviation sector is expected to have the highest average growth rate of 5.2% p.a. followed by road transportation at 4.4% p.a.

Figure 3.12
Oil demand in India by sector, 2019–2045



Source: OPEC.

Strong demand growth in road transportation will by driven by the rapid rise in the number of vehicles, as well as infrastructure expansion in the country (these issues are discussed in detail in Section 3.2.1 and in Box 3.1). The total number of vehicles (other than two-wheelers) in India will increase from less than 50 million in 2019 to more than 250 million in 2045. 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. Driven by economic growth, commercial vehicles will also grow significantly and support a massive increase in diesel demand in India of almost 2.5 mb/d between 2019 and 2045. However, diesel demand will also get significant support from the growth in the industrial and residential/agricultural sectors.

Box 3.1

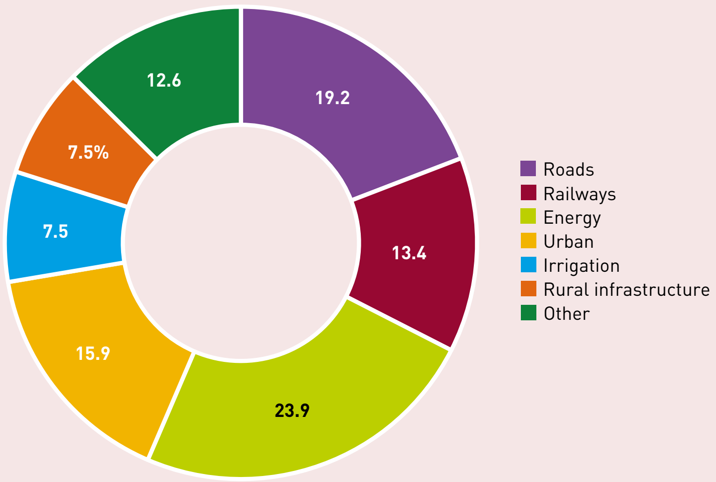
Indian infrastructure: poised for expansion

India's GDP is set to quadruple by 2045, representing the fastest growth within the regional breakdown of the current Outlook. A result of this is the substantial growth in oil demand, which is expected to more than double between 2019 and 2024. Naturally, this economic growth is dependent on the development of necessary infrastructure. The Indian government estimates that it needs to invest $4.5 trillion in infrastructure by 2040.

In order to achieve the mid-term target in a coordinated and efficient way, the Indian government unveiled a National Infrastructure Plan (NIP) in 2019. It assumes that 102.5 trillion rupees ($1.4 trillion) will be allocated to infrastructure projects during the period 2020–2025 to achieve its mid-term economic goal of increasing GDP by $5 trillion by the 2024–2025 fiscal year. In the previous decade, national investment in infrastructure amounted to $1.1 trillion with more than 60% of capital expenditure allocated between projects in power, roads and bridges, railways, airports and ports.

On average, the central government and states are expected to finance the NIP in equal proportions, 39% each, while the private sector will fund the remaining 22%. As presented in Figure 1, investments in the road and railway sector will account for approximately one-third of the total amount.

Figure 1
Distribution of investments under India's National Infrastructure Plan by sector



Source: Department of Economic Affairs, India.

Road infrastructure development

Under the NIP and its $1.4 trillion budget, India's national highway network will be extended from the current 133,000 km to 193,000 km by 2025. This means that on average every year India must build around 12,000 km of new roads. Over the past five years, the road construction rate in India has improved dramatically, from 4,400 km in 2014–2015 to 10,900 km in 2018–2019. According to Indian officials, the country is the fastest highway developer globally with a construction rate of 28 km per day.

The planned road expansion also includes the construction of express highways. Their total distance is expected to grow from the current 1,600 km to 17,100 km, of which some 2,000 km are coastal and port roads; 2,000 km are border and strategic highways; 2,500 km are expressways and highways; and 9,000 km are economic corridors.

Railway infrastructure development

According to the Indian Railways (IR) Year Book (2018–2019), the national railway network exceeds 67,000 km in length and has about 7,300 stations. IR has a unique place in the country's economy as the largest national employer with about 1.4 million workers. It carries more than 23 million passengers and 3.4 million tonnes of freight daily.

IR is also among India's biggest energy consumers. According to the Indian Ministry of Railways, in the 2018–2019 fiscal year the national railway network consumed about 20.4 TWh of electricity (1.7% of Indian electricity consumption) and around 50 tb/d of diesel (2.8% of Indian diesel consumption).

Under the NIP's projection, $190 billion will be invested in IR over the next five years. Major projects include freight corridors (FCs) and high-speed rail. Two dedicated FCs have been fast-tracked – a western route (Jawaharlal Nehru Port to Dadri) and an eastern route (Ludhiana to Dankuni). These two routes together will account for 3,360 km of railway. Another landmark project, the Mumbai-Ahmedabad high-speed rail, costing $15 billion, is expected to be completed and fully operational by 2023.

In the framework of the NIP, steps towards liberalization of the rail sector are also anticipated and the targets are as follows: up to 30% of net cargo volumes and 500 passenger trains are to be privatized, as well as 30% privatization of 750 railway stations. Furthermore, significant investments are anticipated in railway station modernization across the country.

IR announced its ambitious plan to become the first railway operator in the world to be 100% operated on renewables in the next ten years. The current plan is to achieve 5 GW of renewables capacity by 2025, which is an extension of IR's project to install 1 GW of solar and 130 MW of wind power capacity between 2017 and 2022.

Natural gas pipeline development

The Indian government plans to increase the share of natural gas in the energy consumption mix from the current 6.2% to 15% by 2030. This plan envisages investment of $60 billion in a broad spectrum of related projects, including cross-country pipelines, LNG infrastructure development and City Gas Distribution (CGD).

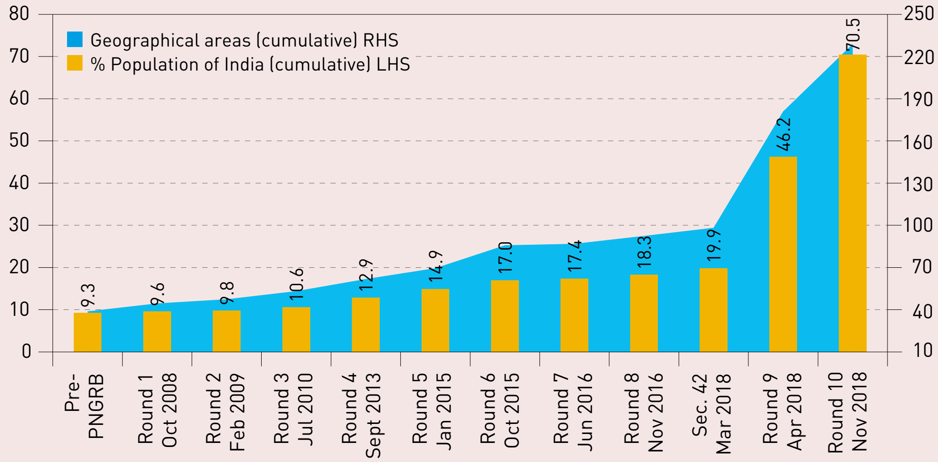
According to the Ministry of Petroleum and Natural Gas, India's current gas pipeline network is about 16,300 km long. The government wants to expand the length to 27,000 km without providing details about the timing of the plan.

State-owned GAIL Limited is the primary Indian gas pipeline capacity provider, with around 11,000 km of pipeline infrastructure in 16 states and two Union Territories. GAIL continues to expand its pipeline network across the country. The company's major pipeline projects, which are at various stages of development, include the Jagdishpur-Haldia and Bokaro-Dhamra pipeline, Vijaipur-Auraiya-Phulpur pipeline and Kochi-Koottanad-Bengaluru-Mangaluru pipeline. The length of these projects exceeds 4,200 km.

CGD

Another important area of infrastructure development in India relates to transmission and distribution of natural gas to residential, commercial, transport and industrial sectors under the umbrella of CGD. To facilitate growth in natural gas demand, since 2008 the Petroleum and Natural Gas Regulatory Board (PNGRB) grants permission to different entities for developing CGD infrastructure, making compressed natural gas (CNG) and piped natural gas (PNG) available to the public at large. So far, this was done in ten rounds as summarized in Figure 2. Importantly, regulations for authorization and bidding for CGD were revised in 2018. The resulting new regulatory framework supports more extensive involvement from the public and private sectors. The 9th and 10th CGD bidding rounds, which took place after the regulations were revised, together have authorized work in 136 areas, hence significantly increasing the geographical coverage.

Figure 2
CGD coverage of population and geographical areas of India



Source: Petroleum and Natural Gas Regulatory Board, India.

According to commitments made during the two CGD rounds, it is expected that more than 4 million domestic PNG connections and 8,200 CNG stations for the transport sector will be installed by the end of March 2029, the date when all projects should be finalized. As a result, by then, CGD would expand its coverage to over 27 states and Union Territories, covering about 70% of India's population and 53% of the country's geographic area.

Demand growth in India's residential sector will be driven primarily by expanding the use of LPG, especially for cooking. Strong growth will continue for several more years, but will likely slow in the longer term once market saturation is achieved. Furthermore, LPG demand will be affected by the City Gas Distribution project which will improve the availability of natural gas and thus partly substitute for LPG. Nonetheless, LPG demand in the residential/agricultural sector is likely to grow to 1 mb/d in 2030 and further to 1.2 mb/d in 2045, up from less than 0.7 mb/d in 2019. A similar range of incremental demand growth in India is also expected in the petrochemical industry (0.7 mb/d between 2019 and 2045) as the need for petrochemicals is tightly linked to economic growth. Demand in this sector is expected to recover relatively swiftly during 2021 and will get a further boost from the addition of two petrochemical units to an existing refinery in Bhatinda, Punjab, to be completed in 2021.

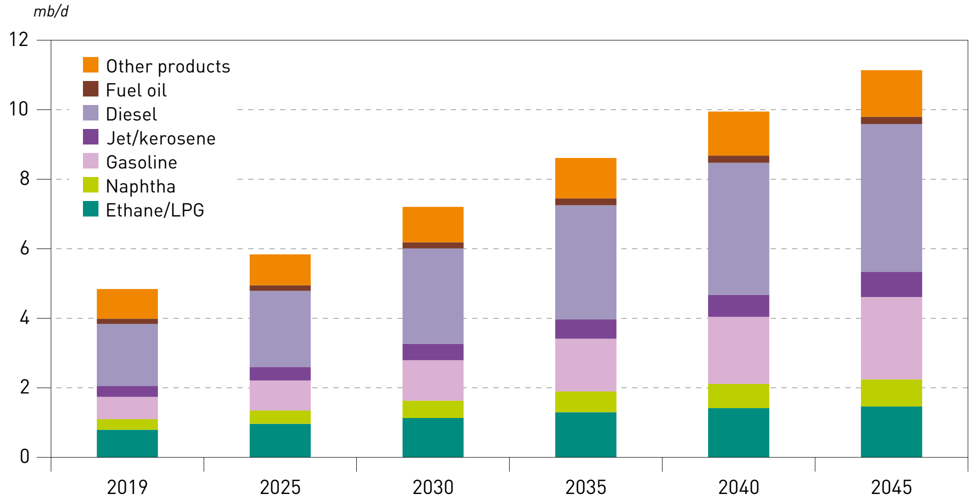
Another large project that may help to meet future demand is the planned Ratnagiri refinery, a joint venture between Saudi Aramco, ADNOC and Indian state-owned oil marketing companies. With a planned capacity of 1.2 mb/d of crude distillation capacity, combined with 18.5 mt/y of petrochemical capacity, it would significantly boost naphtha/ethane supply in India.

Aviation and 'other industry' both expect incremental demand of around 0.5 mb/d each over the forecast period. The aviation sector in India, as in the rest of the world, was severely affected by the COVID-19 pandemic. Nevertheless, oil demand in this sector is expected to recover gradually during 2021 and 2022 and the growth will continue as the Indian economy expands and the general standard of living improves. According to the latest projections by the International Air Transport Association (IATA), India will overtake the UK to become the third largest market with 278 million passengers in 2025, up from its seventh place ranking in 2017 ('Approach to Realize India's

Aviation Potential', IATA). Significant growth is also expected in the industry sector. Many industries, including steel and cement, use fuel oil and diesel to power their furnaces. This provides a solid base for steady demand growth in the sector, which is projected to reach around 1.5 mb/d in 2045, compared to less than 1 mb/d in 2019.

Sectoral trends on future product demand in India are summarized in Figure 3.13. The largest demand increase during the entire forecast period is projected for diesel, at 2.5 mb/d, on the back of robust growth in commercial vehicles, industry and the agricultural sector. This product is followed by gasoline (+1.7 mb/d) and LPG (+0.7 mb/d). Growth in the aviation and petrochemical sectors will result in increased demand for jet kerosene (+0.4 mb/d) and naphtha (+0.5 mb/d), respectively.

Figure 3.13
Oil demand in India by product



Source: OPEC.

Significant growth is also projected for the group of 'other products' (+0.5 mb/d) such as bitumen, pet coke, lubes/greases and waxes. This growth is driven by the expansion of road infrastructure and production of energy-intensive goods such as cement, aluminium and steel. The combined demand for all these products in India is likely to reach more than 1.3 mb/d in 2045 from less than 0.9 mb/d in 2019.

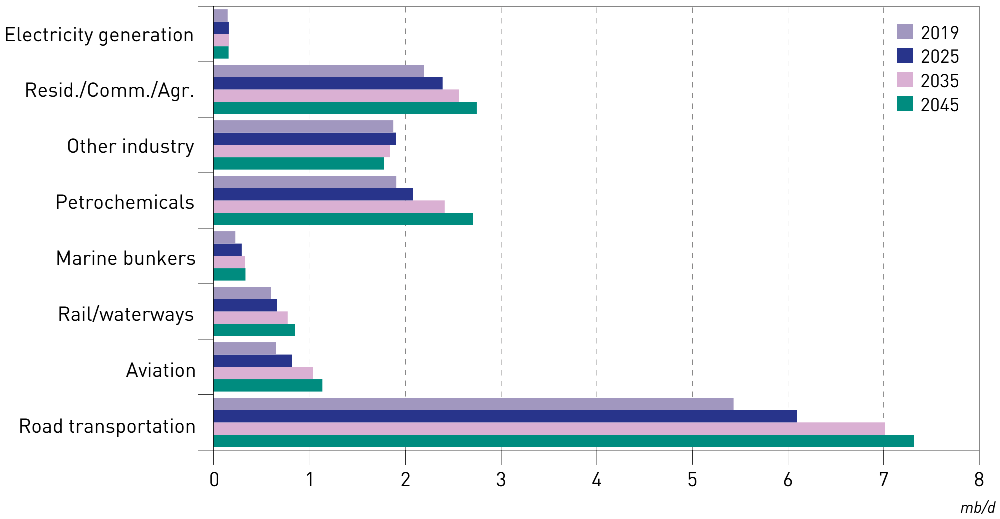
The smallest demand change is projected for residual fuel oil. This will remain at the level of around 0.2 mb/d during the entire forecast period since there are major international bunkering hubs in India and the electricity sector is dominated by the use of coal, renewables and natural gas.

China

China's oil demand is projected to decline by around 1 mb/d in 2020 as a result of COVID-19 lockdowns in various regions of the country. However, in contrast to many other countries and regions, oil demand in China is expected to recover to 2019 levels quite swiftly, already in 2021, and will continue to grow at the rate of 0.2 mb/d to 0.3 mb/d for the remaining years of the medium-term. Moving forward, incremental demand will gradually decelerate to below 0.2 mb/d around 2030 and to less than 0.1 mb/d during the last five years of the forecast period.

As shown in Figure 3.14, demand growth will be driven mainly by the road transportation, petrochemical and residential/commercial/agricultural sectors. Growth in these sectors will be supplemented by other transportation means as well, especially aviation. The base demand in these sectors is, however, much lower and hence the resulting incremental demand is also lower.

Figure 3.14
Oil demand in China by sector, 2019–2045



Source: OPEC.

Road transportation in China will account for almost half of the overall demand growth – 1.9 mb/d out of the total 4 mb/d of incremental demand – between 2019 and 2045. The strong demand will result from a large expansion of the vehicle fleet. The size of the passenger vehicle fleet will almost triple, rising from around 173 million cars in 2019 to around 475 million in 2045. Part of the potential growth, however, will be offset by improved average efficiency, as well as fuel substitution through electrification, hydrogen and natural gas. This will increasingly be a factor towards the end of the forecast period, leading to much slower growth in oil demand.

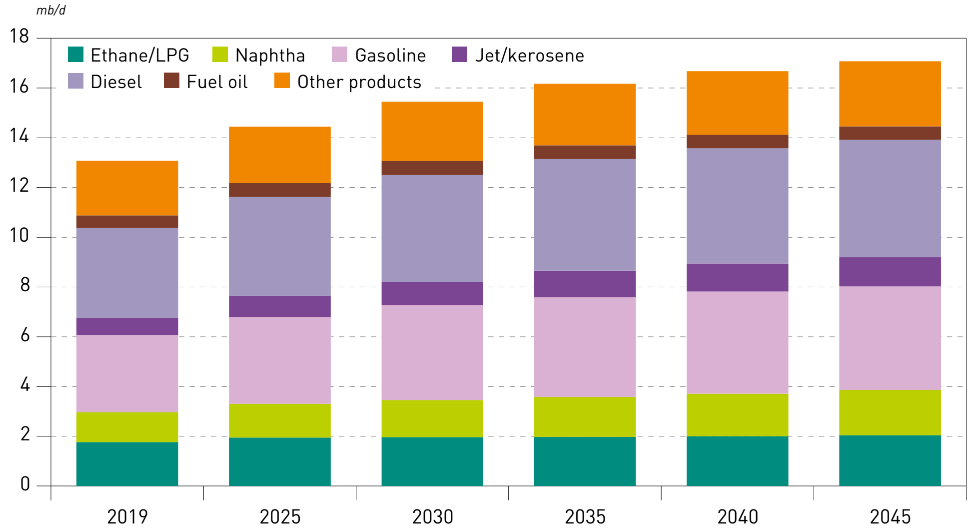
Similar trends are also projected for commercial vehicles in China, growing from 28 million in 2019 to more than 70 million in 2045. However, substitution options in this segment are limited and geared more towards natural gas rather than EVs. Nevertheless, electrification of commercial transport will also continue, to some extent, especially in city transport and smaller vehicles on certain routes.

In addition to road transportation, in 2045 the petrochemical industry in China is expected to consume around 0.8 mb/d more of oil products than in 2019. A large part of this expansion will be naphtha-based (+0.6 mb/d) supplemented by ethane and LPG. Somewhat lower incremental demand is projected for the residential/commercial and aviation sectors. These are estimated to add around 0.6 mb/d and 0.5 mb/d, respectively.

At the other end of the spectrum are electricity generation and the industry 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 industry sector (other than petrochemicals), China's gradual departure from energy-intensive industries will also result in a slow decline in oil demand in this sector in the long-term.

Figure 3.15 translates sectoral trends in China into demand for specific liquid products. Reflecting the strong growth in the number of vehicles, gasoline and diesel will lead demand growth in China in both the medium and long-term. Over the medium-term, demand for these products increases by 0.4 mb/d each. This parity in incremental demand is also maintained when moving to the long-term, at around 1.1 mb/d each between 2019 and 2045.

Figure 3.15
Oil demand in China by product



Source: OPEC.

The other two growing products, naphtha and jet/kerosene, are almost exclusively linked to developments in the petrochemical and aviation sectors, respectively. Demand for naphtha will grow from 1.2 mb/d in 2019 to slightly above 1.8 mb/d in 2045. In the case of jet/kerosene, corresponding numbers are 0.7 mb/d in 2019 and 1.2 mb/d in 2045. Some growth is also projected for 'other products' (+0.4 mb/d), partly for non-energy use (road construction and as lubricants) while the remaining part will be consumed in the expanding refining and industry sectors. Ethane and LPG will find additional outlets mainly in the petrochemical and residential sectors while demand for residual fuel oil will remain rather limited.

Other non-OECD regions

Almost at parity with China, **Other Asia**'s long-term demand outlook shows strong growth of an additional 3.9 mb/d, with total demand reaching 13 mb/d in 2045. Oil demand in this region was less affected by the COVID-19 pandemic in 2020 and is expected to rebound relatively quickly. Moreover, the region is expected to experience consistent economic growth above 4% p.a. between 2021 and 2030 and still healthy growth of 3% to 4% for the rest of the forecast period. This will provide strong support for oil demand as well, especially in the road transportation, petrochemical and aviation sectors.

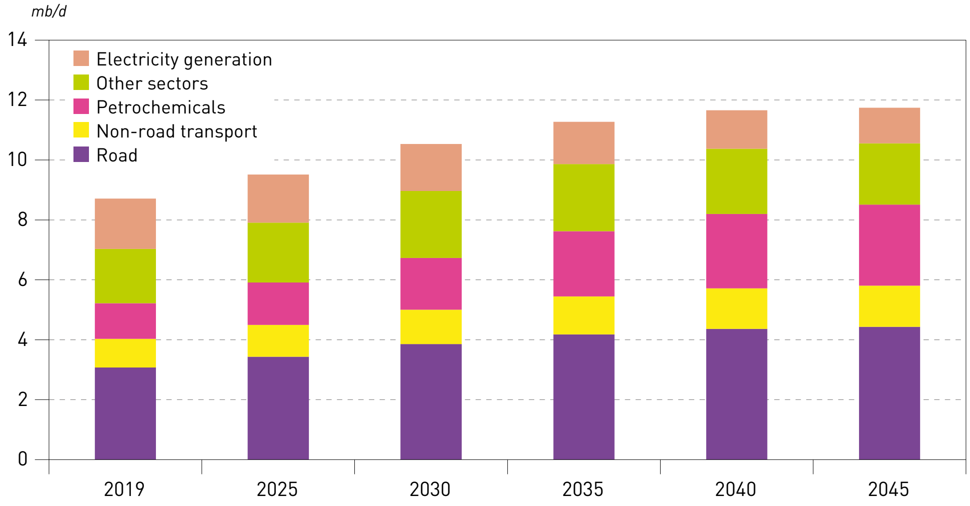
Robust demand growth is also projected in the Middle East & Africa. In absolute terms, incremental demand between 2019 and 2045 will be in the range of 3.3 mb/d, reaching 7.6 mb/d in 2045. Considering the relatively low demand base in 2019, this makes the Middle East & Africa (excluding OPEC Member Countries) the second fastest growing region in relative terms (2.2% p.a. on average), falling just behind India. This is primarily due to the outlook for strong economic growth and demographic developments.

From the sectoral perspective, a large portion of incremental demand will come from road transportation (+1.7 mb/d over the entire forecast period) followed by the residential/commercial sector (+0.5 mb/d), electricity generation (+0.4 mb/d) and aviation (+0.3 mb/d). Interestingly, less than 0.1 mb/d of incremental growth in this region is projected for petrochemicals.

For **OPEC**, demand decline in 2020 is projected at around 0.5 mb/d compared to 2019. To a large extent this was caused by COVID-19-related lockdowns but also by lower oil prices and their effect on domestic economic activity. Nevertheless, with the expectation of gradual price recovery and rebounding GDP growth, oil demand in these countries returns to pre-crisis levels in 2021 and will grow to around 9.5 mb/d in 2025, 10.5 mb/d in 2035 and almost 12 mb/d in 2045. This outlook compares to the 8.7 mb/d recorded in 2019.

As presented in Figure 3.16, the largest part of this future demand growth will come from the petrochemical and road transport sectors. Extending the time horizon to 2045, the petrochemical industry is expected to be the largest contributor to OPEC future oil demand as growth in the road transport sector decelerates towards the end of the forecast period.

Figure 3.16
Oil demand in OPEC by product



Source: OPEC.

Compared to these two sectors, the anticipated demand increase in other sectors is rather limited, in the range of 0.3 mb/d in the aviation and industry sectors and even lower elsewhere. In contrast, a strong decline is projected for oil demand in electricity generation (–0.5 mb/d between 2019 and 2045), primarily due to oil being substituted by natural gas and renewable electricity.

Demand growth in the remaining regions – Latin America, Russia and Other Eurasia – is projected at significantly lower levels. Unfavourable economic conditions are expected to continue in **Latin America** throughout the next several years. GDP growth is expected to improve towards the 2% level at the end of the medium-term and remain in this range thereafter. This will likely put a cap on oil demand growth, which is assessed to be in the range of 50–60 tb/d annually, resulting in total incremental demand of 1.6 mb/d. Not surprisingly, around 0.5 mb/d of this rise is attributable to road transportation followed by residential/commercial/agriculture (+0.4 mb/d) and the aviation sector (+0.3 mb/d).

Oil demand growth in both **Other Eurasia** and **Russia** is expected to remain fairly limited. The cumulative demand change over the medium-term in each is around 0.1 mb/d. Some growth is also projected for the period to around 2035 before demand starts plateauing in Other Eurasia and marginally declining in Russia. The net effect is that, in 2045, oil demand in Other Eurasia will be just 0.2 mb/d higher than in 2019. The difference is even smaller for Russia, at 0.1 mb/d, though the change would stand at 0.2 mb/d if 2019 is compared to 2035.

The overall situation is primarily driven by declining GDP growth rates, with Other Eurasia's GDP projected to fall from the range of 2.5% to 3% p.a. for several years after 2021 to 2% p.a. towards the end of the forecast period. Moreover, base demand in this region is rather low, just around 2 mb/d, hence the cumulative change is also low compared to other regions.

The same factors also apply to Russia, with the GDP growth rates even lower, by 1 pp. Moreover, Russia's population is projected to peak around 2030 and the ageing populace will contribute to oil demand reversal from growth to decline.

3.2 Oil demand outlook by sector

The analysis of regional oil demand contained in Section 3.1 demonstrates that the COVID-19 pandemic has huge implications on demand in 2020 and will affect the oil industry for many years to come. COVID-19 shifted global demand expectations to lower levels compared to pre-crisis projections. It also shifted the relative weight of various sectors within the global consumption pattern as aviation and road transportation were disproportionally affected compared to other sectors. Moreover, likely changes in consumer behaviour will have lasting implications for medium- and long-term developments in several sectors.

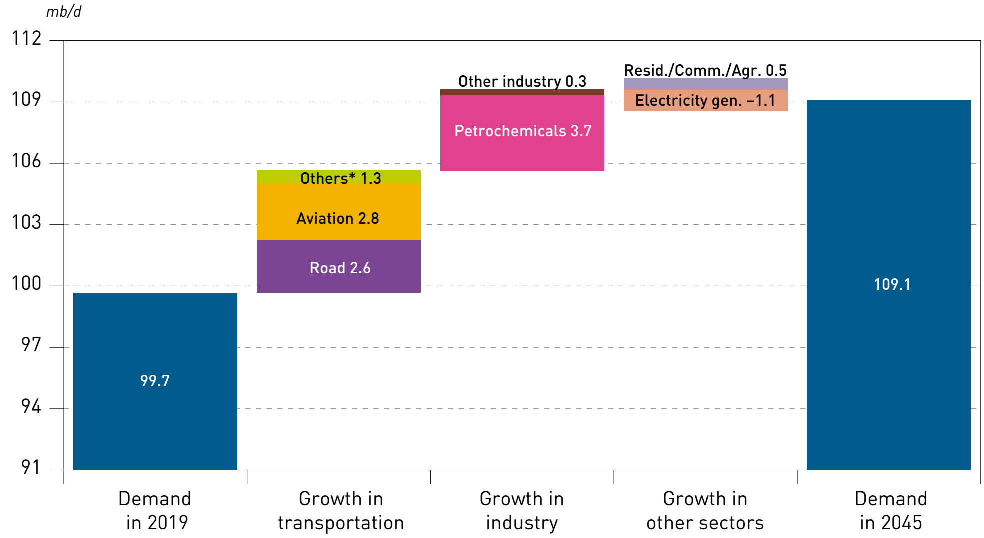
The major trends in sectoral oil demand are presented in Table 3.3 and Figure 3.17. With the exception of 2020 to 2023, the share of the transportation sector in global oil demand will remain in a fairly narrow range of 57 to 58%, although some shifts in the share between various transport modes will be inevitable.

Table 3.3
Oil demand by sector, 2019–2045 *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
Road	44.4	40.1	46.3	46.9	47.1	47.1	47.0	2.6
Aviation	6.7	3.5	7.1	7.7	8.4	8.9	9.4	2.8
Rail/waterways	1.9	1.8	1.9	2.0	2.1	2.1	2.0	0.2
Marine bunkers	4.2	4.0	4.4	4.6	4.7	4.7	4.6	0.5
Transportation	**57.2**	**49.4**	**59.7**	**61.2**	**62.2**	**62.8**	**63.2**	**6.0**
Petrochemicals	13.7	12.9	14.7	15.9	16.7	17.0	17.3	3.7
Other industry	12.8	12.7	13.0	13.5	13.5	13.3	13.1	0.3
Industry	**26.5**	**25.6**	**27.8**	**29.4**	**30.2**	**30.3**	**30.4**	**4.0**
Resid./Comm./Agric.	11.1	10.8	11.4	12.0	12.2	12.1	11.6	0.5
Electricity generation	4.9	4.9	4.8	4.6	4.3	4.1	3.9	–1.1
Other uses	**16.0**	**15.7**	**16.1**	**16.6**	**16.5**	**16.1**	**15.5**	**–0.5**
World	**99.7**	**90.7**	**103.7**	**107.2**	**108.9**	**109.3**	**109.1**	**9.4**

Source: OPEC.

Figure 3.17
Oil demand growth by sector, 2019–2045



* *Marine bunkers, rail and domestic waterways.*
Source: OPEC.

Moreover, the transportation sector will be the major contributor to future incremental demand. Combining all transport modes together, demand will grow by 5.6 mb/d between 2019 and 2045. The largest demand for oil comes from road transportation, which in 2019 represented 45% of global demand at 44.4 mb/d. Demand in this sector was hit hard by COVID-19 lockdowns in 2020, falling by more than 4 mb/d compared to 2019.

Over the medium- and long-term, however, oil demand in road transportation is expected to grow to 47 mb/d in 2045. In the years to come, this sector is forecast to experience a strong decoupling between oil demand and transport services and the number of vehicles on the road. This will primarily result from efficiency improvements driven by technological developments, the tightening of energy policies and an increasing penetration of EVs, natural gas and to some extent hydrogen as fuel sources.

Turning to aviation, this sector was most affected by COVID-19 restrictions in relative terms. Oil demand declined by almost 50% during 2020 on an annual basis. Demand is projected to recover partially in 2021 and will grow thereafter, though it will likely reach 2019 levels only. in 2023–2024.

In fact, aviation is projected to be the fastest growing sector in relative terms, with oil demand growing at 1.3% p.a. on average between 2019 and 2045. On a volume basis, this corresponds to incremental demand of 2.8 mb/d, rising from 6.7 mb/d in 2019 to 9.4 mb/d in 2045. Some growth is also projected in the marine sector, as well as in rail and domestic waterways. The average rate of growth, however, is much slower than in aviation, at 0.4% p.a. (marine) and 0.3% p.a. (rail and domestic waterways).

Compared to the transportation sector, the industrial use of oil is much lower. Moreover, the larger and growing part of industrial demand is for non-energy purposes as a feedstock for the petrochemical industry to produce plastics and chemicals. Demand for these products is strongly linked to economic growth, hence the signposts for oil demand in this segment hint at strong growth. Indeed, the petrochemical sector is actually the largest single contributor to incremental oil demand over the forecast period, growing by 3.7 mb/d.

In contrast, the other part of industrial demand – covering mainly iron, steel and cement production, mining and construction – is projected to grow at much lower rates. The main reason for this is fuel substitution options, primarily natural gas and renewable electricity. This is especially the case in OECD regions where oil demand in 'other industry' is set to follow a downward trajectory.

Oil substitution will also play a role in non-OECD regions, leading to decelerating demand growth, though not to the extent of reversing the trend. Another factor contributing to slower growth in the non-OECD region relates to structural changes in the economies of these countries as the share of the service sector rises at the expense of industrial production, especially for energy-intensive industries.

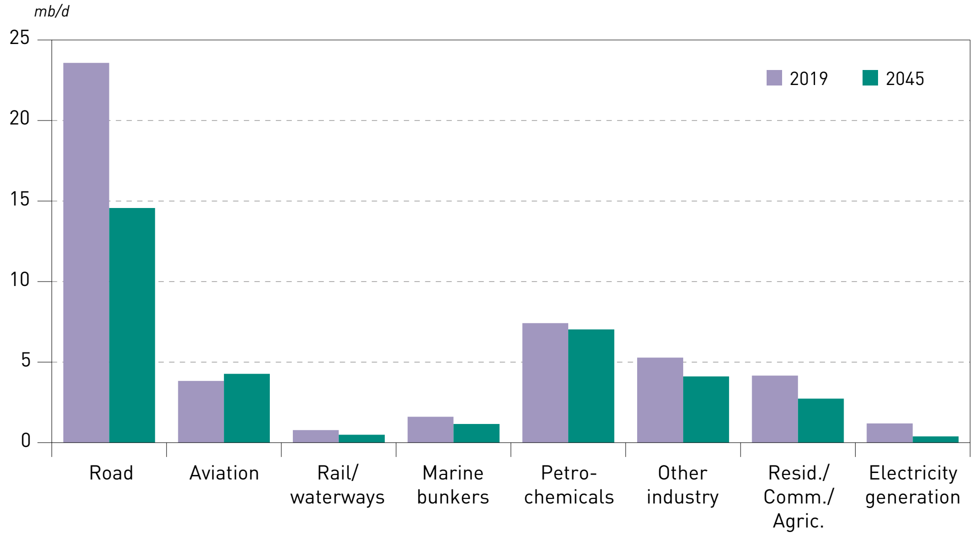
The net effect of these counter-balancing trends is that the global demand increase in the 'other industry' sector will be just 0.3 mb/d between 2019 and 2045. However, demand in this sector will peak sometime between 2030 and 2035 at levels around 0.7 mb/d higher than in 2019 before a steady decline takes place at the global level.

The demand pattern for the residential/commercial/agricultural sector is quite similar to that of 'other industry'. Because of strict policy measures, especially for building codes and heating systems, combined with electrification and fuel substitution, OECD demand in this sector is already declining. This trend will continue during the forecast period and lead to significantly lower demand in 2045 (–1.4 mb/d) compared to 2019.

Nevertheless, strong growth in the non-OECD region, especially in India, China and Africa, will offset the demand loss in the OECD and result in net growth of 0.5 mb/d at the global level. Electricity generation is the only sector where demand is forecast to decline, a result of increasing competition from natural gas and renewables.

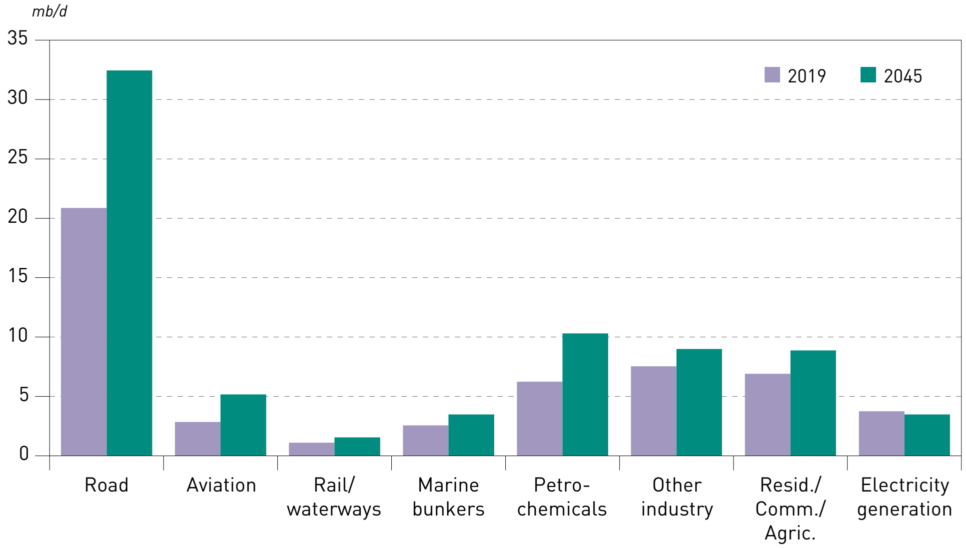
Figures 3.18 and 3.19 provide a summary of sectoral demand changes in the major regions. The long-term implications of the COVID-19 pandemic and a shift in the forecast horizon to 2045 somewhat alter these figures compared to past editions of this Outlook. In the case of the OECD, for the period 2019 to 2045, oil demand is projected to decline in all major sectors expect for aviation. The largest demand drop is projected for road transportation, at –9 mb/d, followed by residential (–1.4 mb/d) and 'other industry' (–1.2 mb/d).

Figure 3.18
Sectoral oil demand in the OECD region, 2019 and 2045



Source: OPEC.

Figure 3.19
Sectoral oil demand in non-OECD countries, 2019 and 2045



Source: OPEC.

For the non-OECD region, demand in all sectors is projected to grow except for electricity generation. The largest demand increase is in road transportation (+11.6 mb/d) and petrochemicals (+4.1 mb/d). Significant growth is also expected in the aviation (+2.3 mb/d), residential (+2.0 mb/d) and 'other industry' (+1.5 mb/d) sectors.

3.2.1 Road transportation

The COVID-19 pandemic during the first half of 2020 had unprecedented implications for the road transportation sector. The otherwise busy streets of large cities became empty and quiet. Car sales plunged by more than half in many countries over the course of several months. Oil demand in the sector collapsed.

Although the situation improved in the second half of the year and further recovery is expected in 2021, many uncertainties remain. On the one hand, a shift towards the wider use of home offices could reduce the use of cars, while on the other hand, fear of infection could result in a partial shift from public transportation to private cars. It remains uncertain how long and cross-border long-distance travel could be disrupted, how fast new car sales will recover, and how consumer preferences might change in respect to the cars they drive.

The COVID-19 crisis appeared at a time when road transportation already faced broader diversification and a shift to varying powertrains. The increasing penetration of AFVs supported by public policies; improving fuel efficiency of ICEs; and growing use of carpooling, ride hailing and car sharing have increasingly affected oil demand.

Bearing in mind these uncertainties and assuming a gradual demand recovery during the next few years, oil demand in this sector is projected to reach around 47 mb/d by 2030 and to hover around this level for the rest of the forecast period. This pattern will result in a combination of factors with offsetting effects, such as the growing number of vehicles in developing countries, increasing penetration of AFVs, improved engine efficiency and changes in distances travelled. An interplay of these factors is analyzed in detail in this chapter.

Vehicle stock

Future oil demand in the road transportation sector will heavily depend on developments in global vehicle stocks in terms of their size and composition. With the differences in GDP growth, demographics and other factors, global growth of vehicle stocks and hence oil demand varies from region to region. In the OECD region, the growth in the number of vehicles is relatively low due to the high motorization rate, infrastructure limitations and availability of public transport in most regions. However, as presented in Table 3.4, vehicle fleets continue to expand in developing countries due to economic and population growth, and urbanization. Globally, the number of passenger cars is expected to rise by more than 950 million over the forecast period to reach 2.1 billion in 2045.

Table 3.4
Number of passenger cars

millions

	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
OECD Americas	281.5	282.5	286.3	300.3	314.1	323.9	331.2	49.7
OECD Europe	258.4	259.4	260.7	262.3	264.8	266.5	267.0	8.5
OECD Asia Oceania	94.0	94.1	94.8	95.1	95.0	94.6	93.9	–0.1
OECD	**633.9**	**635.9**	**641.8**	**657.7**	**673.9**	**684.9**	**692.0**	**58.2**
Latin America	82.5	83.9	89.1	96.4	103.5	110.4	118.1	35.5
Middle East & Africa	36.8	38.6	47.3	60.6	77.4	98.4	120.9	84.1
India	29.2	31.8	49.1	74.1	106.6	144.9	182.7	153.6
China	172.7	184.5	256.0	326.2	388.2	435.1	475.3	302.7
Other Asia	74.2	78.8	104.2	141.2	183.5	228.6	272.8	198.6
OPEC	52.5	55.0	69.2	85.9	103.3	121.1	139.3	86.8
Russia	36.8	37.4	41.5	43.7	45.3	46.5	47.7	11.0
Other Eurasia	48.0	48.9	52.7	57.7	62.0	65.8	69.8	21.8
Non-OECD	**532.6**	**558.9**	**709.1**	**885.8**	**1,069.9**	**1,250.8**	**1,426.7**	**894.1**
World	**1,166.5**	**1,194.8**	**1,350.9**	**1,543.5**	**1,743.8**	**1,935.7**	**2,118.7**	**952.3**

Source: OPEC.

China's automobile market is experiencing a transformation, with sales of new vehicles declining by around 8% in 2019 compared to 2018. This decrease is primarily connected to the introduction of stricter emission measures, taxes and changes in the subsidy scheme for new energy vehicles (NEVs). China's NEV sales contracted for the first time in over five years in 2019 after a significant streamlining and reduction of subsidies took effect.

Despite these factors, an additional 21.5 million new passenger cars were registered in China in 2019. New car registrations will be much lower in 2020 but are expected to rebound in 2021. The number of passenger cars in China is projected to reach almost 330 million in 2030 and more than 470 million in 2045. This represents an increase of around 300 million cars compared to 2019.

The situation is different in the EU, where new passenger car stocks increased by around 1.2% at the end of 2019 from the previous year. EU new car registrations declined at the beginning 2019 following the introduction of a new emission test method in the last quarter of 2018. However, growth appreciated in the second half of the year as a result of significant additions in France and Sweden, which introduced a new CO_2 taxation regime for 2020.

The Netherlands also recorded growth in new registrations of ICE cars in the last quarter of 2019 subsequent to a new benefit-in-kind taxation regime for electric cars. Overall, the EU replenished the 2019 automobile stocks with about 18 million new vehicle registrations for both the passenger and commercial vehicle segments. Moreover, customer preference for gasoline ICE engines persists as the share of gasoline vehicles in the new registrations superseded diesel in the passenger car segment. However, the share of EVs in European new sales continues to rise, even throughout the first half of 2020 when overall car sales collapsed.

The US light-vehicle segment experienced a downturn in 2019, with new registrations declining by roughly 1.3% compared to the previous year. Registrations of light trucks and sport utility vehicles (SUVs), however, increased by 2.6%. Rising sales in this segment negatively impact efficiency gains of passenger cars.

Even though new car registrations in OECD countries are relatively high, the on-the-road vehicle population has changed only marginally due to the high scrappage ratio. Therefore, over the forecast period, the OECD region is set to add less than 60 million new passenger cars. Most of this addition will come from OECD Americas, which has less developed public transport networks. Growth is expected to stagnate in OECD Asia Oceania and OECD Europe.

Other regions with appreciable growth include Other Asia, India, OPEC and Middle East & Africa due to the expanding middle class, GDP growth and high population growth. India and Other Asia are set to add 200 million and 150 million, respectively, to the global passenger car segment. In relative terms, the fastest growth is projected for India (at almost 8% p.a. on average) followed by Other Asia (+5.5% p.a.) and Middle East & Africa (+4.8% p.a.), albeit all of them from a much lower base than the OECD and China.

Commercial vehicles are projected to increase by more than 260 million over the forecast period, rising from 245 million in 2019 to 510 million in 2045 (Table 3.5). This represents average annual growth of 2.7%, which is higher than in the passenger car segment (2.3% p.a.). Moreover, growth is spread among a wider range of regions, including OECD Americas and Europe, as the increase in the commercial vehicle fleet is related more to trade and economic growth.

Table 3.5
Number of commercial vehicles

millions

	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
OECD Americas	39.9	40.4	43.2	47.7	52.7	57.3	61.5	21.7
OECD Europe	41.9	42.6	46.6	51.5	57.0	62.9	68.9	27.0
OECD Asia Oceania	25.5	25.5	25.9	26.2	26.5	26.7	26.9	1.4
OECD	**107.3**	**108.5**	**115.6**	**125.4**	**136.2**	**146.9**	**157.3**	**50.1**
Latin America	21.2	21.8	25.0	29.3	34.0	39.2	44.8	23.6
Middle East & Africa	16.5	17.2	20.5	25.5	32.0	40.8	50.2	33.7
India	16.9	17.9	24.4	32.9	43.5	56.8	70.0	53.2
China	28.0	29.1	36.7	45.0	54.0	63.5	72.0	44.0
Other Asia	28.0	29.0	34.5	42.3	50.3	58.3	66.1	38.0
OPEC	16.3	16.6	18.8	21.9	25.5	29.9	34.3	18.0
Russia	6.1	6.0	6.4	6.4	6.3	6.3	6.3	0.3
Other Eurasia	4.9	5.1	5.7	6.5	7.3	8.3	9.3	4.4
Non-OECD	**137.9**	**142.7**	**172.0**	**209.7**	**253.0**	**303.1**	**353.1**	**215.1**
World	**245.2**	**251.2**	**287.6**	**335.1**	**389.2**	**450.0**	**510.4**	**265.2**

Source: OPEC.

The number of commercial vehicles has grown steadily in OECD Europe for the past seven years due to increasing commercial activity. Germany, France and the UK remain the major growth centres. The pace of growth was interrupted in 2020 by the COVID-19 pandemic but is expected to bounce back in the post-COVID-19 period. Current estimates foresee OECD Europe adding around 27 million commercial vehicles to the global stocks in the long-term. OECD Americas is also projected to post healthy growth in commercial vehicle stocks as the region adds close to 22 million vehicles at the end of 2045.

Increasing stock levels of commercial vehicles is primarily linked to the need for transfer of goods and services within and outside the regions. The effect of shared mobility is almost absent in this category of vehicles. This means that some restrictions that apply to the deployment of passenger cars are not necessarily applicable to commercial vehicles. There is also a low level of electrification in commercial vehicles, especially heavy vehicles, mainly due to battery size, range requirements and demanding operating conditions.

Therefore, the number of commercial vehicles – primarily ICEs – in the non-OECD region is expected to continue growing at a healthy rate over the forecast period, ranging from 0.2% p.a. in Russia to 5.6% p.a. in India. In addition to having the fastest rate of growth, India will add the largest number of commercial vehicles among all regions. Its market will grow by more than 50 million by 2045, more than quadrupling the 2019 level.

Besides India, the majority of the increase comes from China (+44 million) and Other Asia (+38 million). As a result, China is expected to become the largest market for commercial vehicles, surpassing OECD Europe sometime around 2040. A significant increase in commercial vehicles is also projected in OECD Americas (+22 million) and OECD Europe (+27 million).

Vehicle fleet composition

Even though stock deployment is important for oil demand in road transportation, fleet composition plays an equally significant role in determining future consumption trends. Currently, the composition of the vehicle fleets keeps evolving with the introduction of powertrain alternatives to ICEs.

The newest in the portfolio of passenger vehicle power propulsion systems are electric, with varying degrees of electrification, and hydrogen. Each has advantages and disadvantages. Although EVs enjoy wider acceptability and fast adoption rates, particularly in the passenger segment, hydrogen vehicles are becoming the subject of wider discussion and have attracted the attention of policymakers in several regions, such as Japan, the EU, China and California. Other alternative vehicle fuelling options include natural gas and biofuels.

Electric mobility, as an optional powertrain, is gradually changing the landscape of fleet composition, primarily in the three major regions: China, OECD Americas and Europe. The steep growth of electric mobility is, at least for now, confined only to those regions. The EV market in those regions still rely deeply on subsidies and evolving policies even though battery cost reduction adds additional incentive for expansion. Since the upfront cost of EVs is still not equal to that of ICE vehicles, removing any of the supporting mechanisms hinders EVs penetration growth.

China has been scaling back its five-year subsidy programme with the intention of gradually removing it entirely after 2020. The reliance of some local manufacturers on the subsidy regime required the government to further adjust cuts this year, thereby stabilizing the regime at the current status.

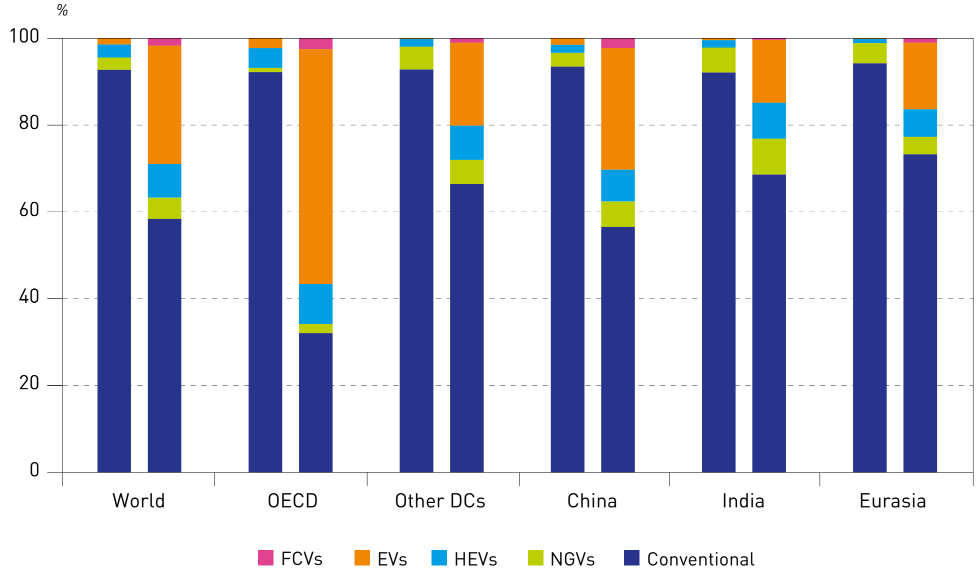
The NEV subsidy re-adjustment that took effect in July 2019 excluded EVs with a battery driving range lower than 250 km while halving subsidies for vehicles with a battery range of 400 km.

These actions exerted downward pressure on sales of electric vehicles in China for the first time in several years. New registrations of NEVs in China declined by 4% y-o-y with sales of about 1.1 million vehicles in 2019.

The trend is mixed in Europe where some countries reviewed subsidies and incentives while others, like the UK, announced plans to ban ICE vehicles by 2035. The European market is the only region that witnessed appreciable new EV sales growth in 2019 as sales grew by 40% y-o-y on average ahead of a new regulation setting an emissions target of 95mg CO_2/km. The EV market expansion trend was interrupted in 2020 due to COVID-19, but is expected to be restored in 2021 and thereafter. In short, all these developments in the major EV markets did not significantly change the global picture from the previous Outlooks nor the expectations for future growth.

The summary of projected changes in the regional sales of passenger vehicles over the forecast period is presented in Figure 3.20. The largest shift in most regions, and in the OECD and China in particular, is that between conventional ICE vehicles and EVs. At the global level, the share of EV sales is projected to rise to more than 27% in 2045. Moreover, an increase in new sales is also projected for natural gas vehicles (NGVs) and fuel cell vehicles (FCVs) even though the penetration of FCVs is subject to further technology development. Despite this expansion, ICEs (including HEVs) are still estimated to account for almost 60% of all passenger vehicles sold in 2045.

Figure 3.20
Shares of new passenger car sales by powertrain, 2019 and 2045



Source: OPEC.

Similar to previous Outlooks, the OECD will maintain its leading position as the region with the highest penetration of EVs sales, with their share forecast to reach 55% in 2045. This is driven by EU moves to adopt stringent emissions regulations and in anticipation of a narrowing of the gap between the performance of ICE vehicles and EVs as battery costs decline further. Electric mobility progression in other regions (other than the OECD and China) will remain sluggish as shares in those regions are not expected to exceed 15 to 20% by the end of the forecast period.

In the commercial vehicle segment, the fleet composition has not changed significantly because of the COVID-19 pandemic. Preliminary figures for the second half of 2020 indicate some revival in sales of commercial vehicles but a full recovery is not expected during the year. As fleet development in commercial vehicles is typically closely linked to industrial output, the recovery in sales is expected to be delayed. Moreover, electrification is exerting minimum pressure on diesel demand for long-haul trucks and freight movement since diesel provides the needed energy density. Unfavourable operating conditions and terrains also do not support the deployment of battery-powered trucks at the moment even though some prototypes exist.

Box 3.2

Battery cost, emissions and EVs: the race is on

Lithium-ion battery (LIB) technology is relatively new compared to lead-acid technology. Nonetheless, LIB is currently the dominant battery technology and is foreseen to remain in the lead – at least during the current decade. For the longer perspective, however, solid-state and even all-solid-state batteries and 'air-breathing' battery technologies are the most prominent and probably disruptive future innovations for EV applications. Sodium- and sulphur-based battery families and alternative material batteries are all finding proponents for further technological developments, but not necessarily in EVs.

Short- to medium-term trends in the development of batteries for EVs are essentially based on high-voltage nickel-manganese-cobalt (NMC) oxide cathodes. High-energy NMC cathode technology today represents the best compromise between the performance parameters required for electric mobility.

There is a constant improvement in battery economics. The average cost for all cell formats has moved from $1,000/kWh in 2010 to well below $200/kWh in 2018. Based on the Bloomberg NEF 2019 battery price survey, battery pack prices have gone down by 87% since 2010 and reached $156/kWh in 2019. The experience curve and learning effect suggest that the $100/kWh cell production cost is attainable with 1 TWh cumulative battery production (see e.g. Thielmann at al., Graz Battery Days 2018).

This 1 TWh production level could be achieved as early as 2025 if 10 gigawatt hour (GWh) pack assembly lines are introduced and EV mass deployment follows. However, it remains to be seen how far the industry will progress towards achieving this, especially given the impact of COVID-19 and the related decline in EV sales in 2020.

Despite impressive cost reductions, LIB is still challenged by high costs and the need to increase energy density while maintaining the life cycle. One recent cost reduction analysis (Thielmann, Neef & Hettesheimer, 2018) has shown that battery cell cost potential depends mainly on optimizing material consumption with up to 60% reduction potential. Depreciation could also potentially reduce the cost by around 12% while lowering assembly costs though automation could save a further 5%.

The industry is progressing towards lowering the battery cost below $100/kWh, though it is doing so largely by relying on China's low-cost manufacturing and technology learning curve. Relocation of industries, a key concern post-COVID-19, would not help reach the cost objective globally. In addition, post-COVID-19, the industry may see an increased struggle to build sound partnerships between leaders in both battery and vehicle manufacturing, hence hindering efforts to cut costs.

In addition to the battery cost, stakeholders need to incorporate the lifecycle or 'cradle to grave' environmental considerations into their approach to tackle the sustainability of EVs. The largest source of CO_2 emissions in conventional vehicles comes essentially from tail-pipes, whereas for EVs, CO_2 emissions primarily occur in electricity generation and in the energy-intensive cell manufacturing process.

EVs with low specific CO_2 emissions are found in countries with a very high share of renew-ables or nuclear power, or both. Medium levels of specific emissions are achieved by using natural gas in conjunction with CCGTs for power generation or by combining fossil fuels with high CO_2 emissions (basically coal) with an increased share of renewables, as has been observed in Germany in recent years. In countries with a low share of renewables, EVs typically emit a substantial amount of CO_2, often higher than emissions related to ICE-based vehicles that are subject to stringent emissions and fuel economy standards. The new generation of vehicles compliant with advanced standards (e.g. in the EU and China) may lead to lower net emissions compared to EVs given the current power mix in many regions.

For battery production, different structures of power generation may cause significantly different specific CO_2 emissions depending on the region where batteries and their components are produced, or where elements such as lithium, cobalt or manganese are mined and refined (such as China). Battery production can easily add another 10g to 30g of CO_2 per driven kilometre over the lifetime of the vehicle and battery. The larger the battery, the greater the GHG emissions in the manufacturing process.

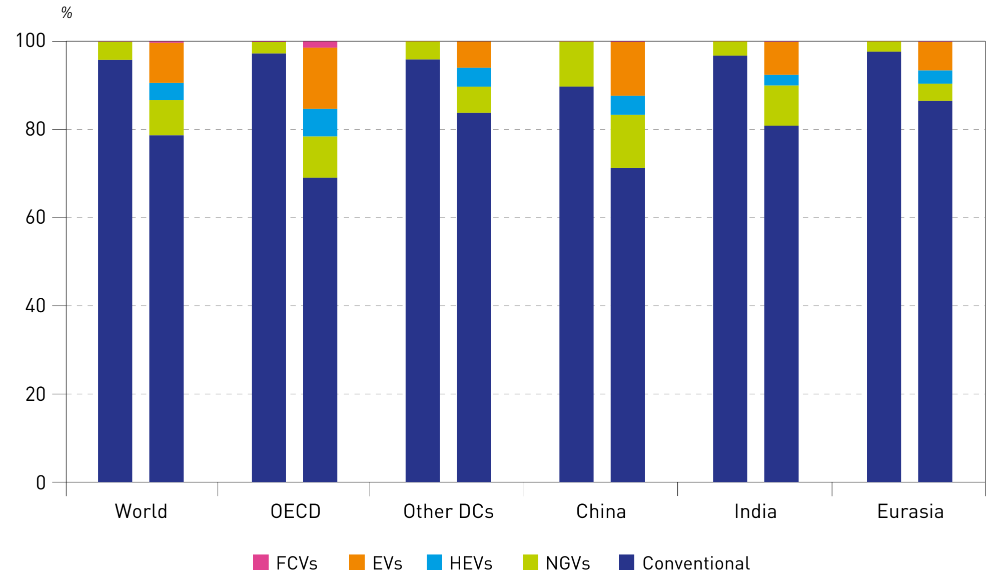
Finally, recycling is expected to play an important future role, not only in view of the availability of materials, but also in terms of limiting emissions during the manufacturing process. As the demand for valuable minerals increases, especially aluminium, neodymium, lithium and cobalt, recycling will become more important than has been the case with conventional vehicles, which still largely rely on steel. The recycling process is also an important part of the circular economy. Therefore, the design of new batteries should allow for easy dismantling and recovery of critical materials. Another option to be considered could be a second life for older batteries as stationary storage, which may shift recycling further into the future.

It is worth noting, however, that natural gas and LNG are gradually substituting for diesel in China and India. Moreover, several 'green' cities in China are mandating the use of e-buses, which are rapidly displacing conventional fuel commuter buses, with the goal of electrifying all intra-city buses. There is some movement in this direction in Europe and India as well.

At the global level, the vast majority of medium and heavy commercial vehicles will continue to use conventional fuel as electrification of these vehicles will progress at a relatively slow pace. This is reflected in Figure 3.21, which shows that the share of ICE-based vehicles in commercial vehicle sales will decline very gradually, from almost 96% in 2019 to 79% by 2045. This drop is mainly the result of a rising number of EVs and HEVs in the commercial segment, to around 9% and 4% in 2045, respectively. Another reason is the rise of NGVs, which are anticipated to increase from around 4% in 2019 to more than 8% in 2045.

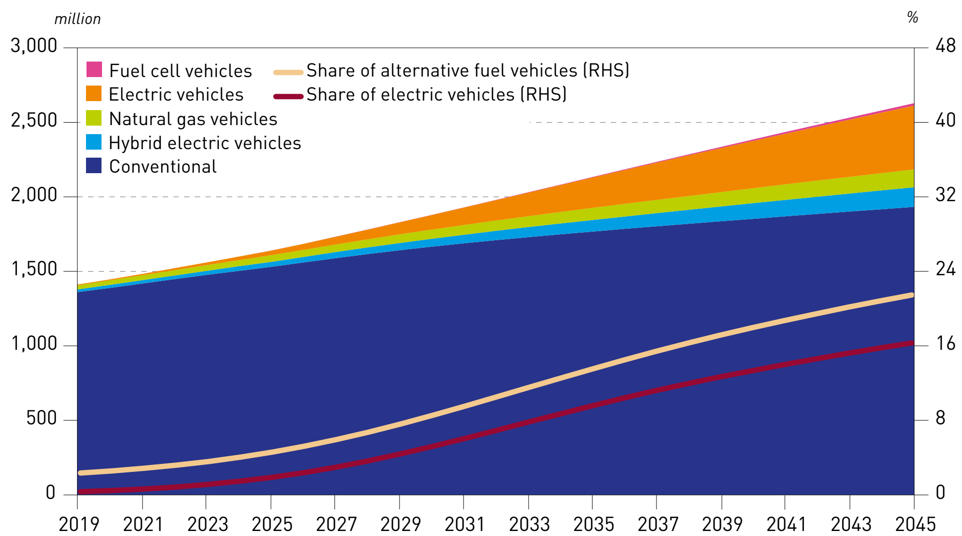
Figure 3.22 illustrates the implications of the outlined trends in new vehicle sales, for both passenger cars and commercial vehicles, on the changing composition of the global vehicle fleet. It

Figure 3.21
Shares of new commercial vehicle sales by powertrain, 2019 and 2045



Source: OPEC.

Figure 3.22
Composition of the global vehicle fleet, 2019–2045



Source: OPEC.

is worth emphasizing that the structural changes in the global vehicle fleet will be rather smooth and much slower than the change in the composition of new sales.

This is due to the large existing base of almost 1.4 billion vehicles currently on the road and the relatively long-life span of the average vehicle. The turnover of new vehicles is clearly faster in developed regions, especially in the OECD, and slower in developing countries. Therefore, oil-based vehicles will constitute the large majority of all vehicles over the entire forecast period. Their share will gradually decline, nevertheless, to around 78% by 2045.

Of the total 2.6 billion vehicles on the road by 2045, around 430 million will be EVs, constituting the second largest group after ICE-based vehicles. The share of EVs is projected to reach around 5% in 2030, 13% in 2040 and more than 16% in 2045. NGVs will account for around 120 million vehicles by then while EVs are expected to become the second largest group sometime towards 2030. The incremental number of EVs is estimated to accelerate in the second part of the forecast period. Hence, their share will also grow significantly.

Combining the growth of all AFVs – EVs, NGVs and FCVs – results in a higher shift in the penetration curve, but it is not expected to dramatically change the general pattern. This is because the increase in the share of NGVs is rather limited, and this category will account for less than 5% of the total fleet in 2045, compared to 2% in 2019. This curve shifts slightly upward towards the end of the forecast period when FCVs are also expected to contribute to the overall car fleet. However, the share of FCVs will likely remain below 1% even at the end of the forecast period. This expectation could potentially change in the years to come as the use of hydrogen, including in road transportation, is currently high on the agenda of policy-makers in several countries.

Outlook for oil demand in road transportation

Taking into account projected regional developments in the size of the vehicle fleet, its composition, fuel economy and vehicle miles travelled (VMT), Table 3.6 summarizes projected oil demand in the road transport sector. An immediate observation is the huge demand decline in 2020. Needless to say, the reasons for this decline were primarily COVID-19 lockdowns and the related sharp decline in economic activity. Passenger cars were especially affected by COVID-19-related restrictions while commercial vehicles were affected to a lesser degree since haulage of goods and materials continued to a large extent.

Table 3.6
Oil demand in the road transportation sector by region *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
OECD Americas	14.0	12.7	14.0	12.7	11.4	10.3	9.6	–4.5
OECD Europe	6.8	5.9	6.3	5.7	5.1	4.5	3.8	–2.9
OECD Asia Oceania	2.8	2.3	2.5	2.2	1.9	1.5	1.2	–1.6
OECD	**23.6**	**20.9**	**22.9**	**20.6**	**18.4**	**16.4**	**14.6**	**–9.0**
Latin America	3.0	2.8	3.2	3.3	3.4	3.4	3.5	0.5
Middle East & Africa	2.0	1.7	2.2	2.5	2.9	3.3	3.7	1.7
India	1.9	1.7	2.5	3.3	4.1	5.0	5.9	3.9
China	5.4	5.0	6.1	6.7	7.0	7.2	7.3	1.9
Other Asia	3.4	3.2	3.9	4.4	4.8	5.1	5.4	2.1
OPEC	3.1	2.9	3.4	3.9	4.2	4.4	4.4	1.4
Russia	1.1	1.0	1.2	1.2	1.1	1.1	1.0	–0.1
Other Eurasia	0.9	0.8	1.0	1.1	1.1	1.2	1.1	0.2
Non-OECD	**20.9**	**19.2**	**23.5**	**26.3**	**28.6**	**30.7**	**32.4**	**11.6**
World	**44.4**	**40.1**	**46.3**	**46.9**	**47.1**	**47.1**	**47.0**	**2.6**

Source: OPEC.

Despite the anomaly related to COVID-19, oil demand in this sector is expected to continue to improve when economic activity starts to pick up in 2021. This expectation is depicted in the projected demand increase of almost 2 mb/d in 2025 compared to 2019. This growth, however, will significantly decelerate in the period to 2030. In absolute terms, demand between 2025 and 2030 will increase by just 0.6 mb/d to reach the level of 46.9 mb/d. For the rest of forecast period, oil demand in this sector will remain broadly stable around this level.

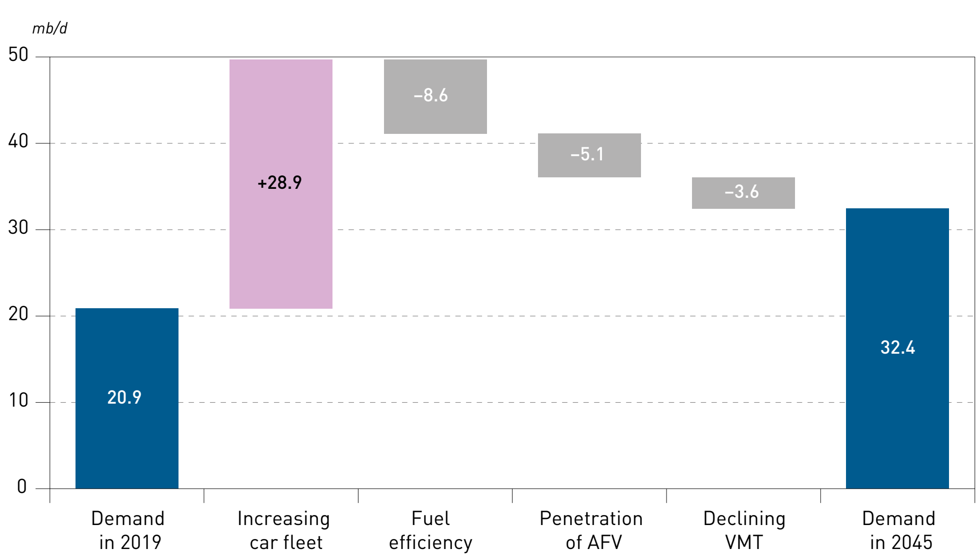
There are two main reasons for this expectation: at the regional level, offsetting trends in the OECD and non-OECD regions and, at the structural level, offsetting trends in the passenger car and commercial vehicle segment.

From the regional perspective, oil demand in the non-OECD region is projected to expand significantly, by 11.6 mb/d between 2019 and 2045. A large part of this strong growth, however, will be offset by demand decline in the OECD of 9 mb/d during the same period.

Within the non-OECD region, India is pivotal to oil demand growth over the forecast period, adding about 3.9 mb/d mainly in the commercial vehicle segment. China's oil demand growth rate is lower than India's since China is the global leader in EV deployment and also as a result of partial fuel substitution in freight with the use of LNG for heavy-duty trucking. The other growth region is Other Asia where demand is set to increase by some 2.1 mb/d over the forecast period.

Figure 3.23 explains the main reasons for this significant demand growth in the non-OECD region. Lower car ownership along with the growth in population and per capita income in the non-OECD region mean there is substantial potential for fleet development. This drives vehicle ownership to the upside and translates to additional oil use of around 29 mb/d over the forecast period, *ceteris paribus*. This potential growth, however, is reduced by the penetration of alternative powertrains (mainly in China), improved efficiency and declining VMT. As a result, oil demand in the non-OECD region is forecast to reach 32.4 mb/d by 2045.

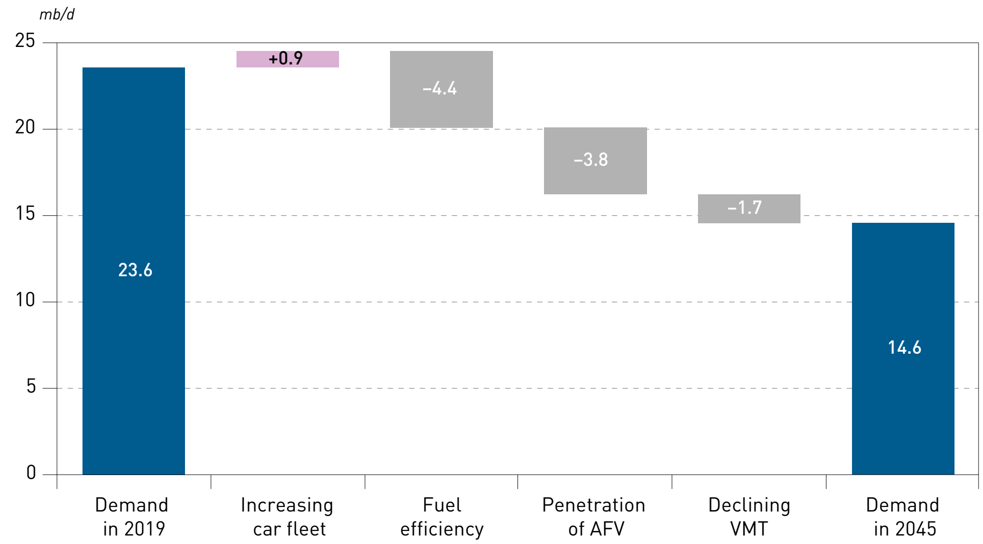
Figure 3.23
Demand in road transportation in non-OECD countries, 2019 and 2045



Source: OPEC.

In the OECD, car ownership is nearing the saturation point as presented in Figure 3.24. Fewer than 110 million vehicles are expected to be added within the forecast period, driving oil demand up by roughly 1 mb/d by 2045. However, OECD regulatory policies and efficiency requirements push demand downward by approximately 4.4 mb/d over the same period. In addition, a relatively large number of AFVs reduces the region's oil demand further by 3.8 mb/d and declining VMT by 1.7 mb/d. In total, OECD is set to witness an oil demand decline in the road transport sector on the magnitude of 9 mb/d, thus reducing regional oil demand to just 14.6 mb/d by 2045.

Figure 3.24
Demand in road transportation in OECD countries, 2019 and 2045



Source: OPEC.

The second reason for oil demand in this sector remaining broadly stable is the offsetting trend in the passenger car and commercial vehicle segments. This is to a large extent embedded in the calculations underlying results presented in Figures 3.23 and 3.24. Nonetheless, it worth emphasizing it separately.

Even as oil demand related to passenger cars grows at the beginning of the forecast period, it starts plateauing within the next ten years and declines during the second part of the forecast period. This is mainly attributable to powertrain substitution and improvements in the efficiency of passenger cars fleets, factors that are present to a much lesser extent in the commercial vehicle segment. In the latter segment, continued GDP growth, especially in developing countries, will provide support to ongoing expansion of the commercial vehicle fleet. This, in turn, will keep overall demand in the road transport sector at a relatively stable level of around 47 mb/d.

3.2.2 Aviation

According to World Bank data, the number of passengers carried by airlines and the volume of air freight during the last 30 years has more than quadrupled, representing average annual growth above 5%. This impressive growth was driven by economic expansion; rising incomes and the related propensity to travel; and expanding international trade, among other factors. Last year's Outlook expected this trend to continue in the years to come though at somewhat more moderate rates.

At the beginning of 2020, however, the outbreak of COVID-19 and subsequent regional lockdowns became a major challenge for the global economy, in general, and the aviation industry in particular. Global GDP is expected to contract by around 4% in 2020 while the aviation industry was hit by both the weak macroeconomic environment and restrictions on travel. As a result, demand for passenger flights in 2020 is estimated to decline by more than half compared to 2019.

Despite the gradual removal of travel restrictions in the second half of 2020 and partial oil demand recovery in 2021, the COVID-19 pandemic will substantially affect the oil demand associated with global aviation in the medium-term. Projections included in this Outlook assume only gradual demand recovery to pre-COVID-19 levels over several years. Faster recovery is assumed in most developing countries while the recovery process will take longer in OECD regions. This, however, is subject to a number of uncertainties especially with regard to developments in the pandemic situation and related changes in consumer behaviour. Additional waves of the virus would obviously delay the recovery. On the other hand, the accelerated introduction of a COVID-19 vaccine or treatment could help to expedite the recovery. For the long-term prospects, however, it is assumed that the recent developments will have a less significant effect on oil demand in this sector.

The International Air Transport Association's (IATA) 20-year passenger forecast suggests that the annual passenger growth rate will be 3.7% over the next two decades, resulting in a doubling of passengers carried to more than 8 billion in 2039. It is also expected that the frequency of air travel for the average citizen will grow, especially in emerging markets. Depending on the country/region, trips per person are projected to increase by 2% to 5% p.a. on average.

In order to sustain the expected growth, the industry will continue to invest in new airports and related infrastructure. More than 90% of new airports brought into operation during the last decade were in the Asia-Pacific region and this trend will continue in the current decade. The development of existing airports and related infrastructure is more common for the mature OECD aviation markets.

Other drivers, such as the liberalization of the regional markets and the rapid development of low-cost carriers (LCCs), will also support future aviation market development. Liberalization itself has brought significant growth to the industry, resulting in increased competition between airlines, more affordable pricing and improved productivity as a result of more efficient route operations. According to ICAO figures, in 2018 the share of LCCs in global passenger turnover was 31% with 1.3 billion travellers, which represented about 9% growth compared to the previous year. LCCs' share in the market is expected to continue to grow, especially in Asia. However, a sudden drop in the number of flights due to COVID-19 will likely lead to some consolidation and restructuring of the market in the next several years.

Another challenge facing the industry relates to the quest for improved efficiency and the reduction of emissions. The sector is increasingly being impacted by energy policies that target the decarbonization of the industry. The two leading targets for the aviation sector – set by ICAO and IATA – are a cap on net aviation CO_2 emissions (carbon-neutral growth) from 2020 and a reduction in net aviation CO_2 emissions of 50% by 2050 (compared to 2005 levels). Broadly, this should be achieved by a combination of measures such as more efficient technology, optimization of scheduling, improved air traffic control, route optimization and emission-offsetting programmes in other sectors.

On the technology side, available options 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. Moreover, electrification is also under way in air transportation, although at a substantially slower pace than in road transportation. These advances should be supplemented by higher load factors, better navigational equipment and, more importantly, improving fuel economy in future aircraft. However, the next generation of aircraft is not expected to enter the market before 2035, hence the overall improvement in efficiency during the forecast period will be rather limited.

Table 3.7 summarizes expected oil demand in the aviation sector and reflects all of the mentioned factors. At the global level, oil demand in this sector is expected to grow by 2.8 mb/d during the forecast period, from 6.7 mb/d in 2019 to 9.4 mb/d in 2045. Similar to other sectors, the large majority of this incremental demand is projected in non-OECD countries (+2.3 mb/d) while total OECD demand will grow by only 0.4 mb/d as the OECD represents a mature market where growth is somewhat constrained by infrastructure capacity.

Table 3.7
Oil demand in the aviation sector by region *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
OECD Americas	1.9	0.9	1.9	2.0	2.0	2.0	2.1	0.1
OECD Europe	1.4	0.8	1.3	1.3	1.4	1.5	1.5	0.1
OECD Asia Oceania	0.6	0.2	0.5	0.6	0.6	0.7	0.7	0.1
OECD	**3.8**	**1.9**	**3.7**	**3.9**	**4.0**	**4.1**	**4.3**	**0.4**
Latin America	0.3	0.2	0.3	0.4	0.5	0.5	0.5	0.3
Middle East & Africa	0.3	0.2	0.3	0.3	0.4	0.5	0.5	0.3
India	0.2	0.1	0.2	0.3	0.4	0.5	0.6	0.5
China	0.7	0.3	0.8	0.9	1.0	1.1	1.1	0.5
Other Asia	0.8	0.6	0.9	1.0	1.1	1.2	1.3	0.5
OPEC	0.4	0.2	0.5	0.5	0.6	0.7	0.7	0.3
Russia	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.0
Other Eurasia	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Non-OECD	**2.8**	**1.6**	**3.4**	**3.8**	**4.4**	**4.8**	**5.2**	**2.3**
World	**6.7**	**3.5**	**7.1**	**7.7**	**8.4**	**8.9**	**9.4**	**2.8**

Source: OPEC.

Within the non-OECD region, more than 60% of incremental demand is linked to the growing air traffic in Other Asia, India and China. This will be driven primarily by strong economic growth in these regions, the rapidly increasing middle class and hence the higher propensity to travel, as well as the rising demand for freight transport. Some growth is also projected for OPEC, Latin America and the Middle East & Africa, each contributing by around 0.3 mb/d to future demand.

3.2.3 Marine bunkers

The year 2020 was supposed to be a critical one for the marine bunkering sector. On 1 January 2020, the IMO's regulation on the sulphur content of marine fuels (0.5% on a weight basis) took effect. The industry was concerned that the regulation could be disruptive for the shipping sector, as well as the global refining system. Concerns raised in a number of reports, including past editions of the WOO, questioned the ability of the global refining system to provide the required fuels in a timely manner and the ability and willingness of the shipping industry to invest in scrubbing technology to retrofit large vessels. Potential consequences could have been regional shortages of fuels, widening price differentials for specific products and crudes, and low compliance rates.

All these concerns were completely overshadowed and mostly eliminated by the outbreak of COVID-19. Collapsing oil demand, in the range of 9 mb/d compared to around 4 mb/d of total demand in the marine sector, provided ample room for refiners to adjust. Moreover, demand in the marine sector itself declined by around 0.2 mb/d in 2020, compared to 2019. Contrary to the expectation that the IMO regulation could lead to higher oil prices, these declined significantly following lower demand and negative economic growth.

Nonetheless, in line with the expectation that the global economy will bounce back in 2021 and GDP growth will continue in the coming years, shipping activity, and hence oil demand in this sector, should also recover. However, how much of the GDP growth will translate into additional oil demand depends on the progress of vessel engine technology improvements; hull and propeller design; optimized operating modes; and the potential substitution by other sources of energy.

In this regard, of particular importance are IMO targets for efficiency gains in this industry. The next target set by the IMO is to achieve 30% efficiency improvements by 2025 for all new ships compared to 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 to 2008 levels. This is a challenging target which, if achieved, would have significant implications for future oil demand in this sector.

Certainly, technology will contribute to efficiency improvements in ICEs used in the 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 is slow steaming. However, a slower ship also needs more time to get to its destination and the fuel and cost savings are lower when referring to the specific fuel consumption per tonne-mile.

Nonetheless, 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.

One obvious alternative is LNG. The lack of reliable bunkering facilities remains an obstacle to a widespread adoption of LNG, although an increasing number of ports are now providing bunkering services. Additional support for the use of LNG as a bunker fuel could emerge if a ban on open-loop scrubbers is considered.

Other alternatives include the use of hydrogen, ammonia and electricity as energy sources for maritime transport. Prototype vessels for each of these alternative powertrains exist already, demonstrating their advantages, but clearly also disadvantages. Given the relatively slow vessel turnover in the shipping industry and lack of necessary infrastructure required for the widespread use of any of these alternative powertrains, it is very unlikely that they will have a material impact on marine bunker demand during the forecast period.

Having considered recent developments in the marine bunker sector, future economic prospects and technological options for future vessels, Table 3.8 translates all these factors into oil demand over the forecast period. Globally, oil demand in this sector is not expected to experience significant changes over the forecast period. Demand is projected to increase by only 0.5 mb/d, from 4.2 mb/d in 2019 to 4.6 mb/d in 2045. For the third consecutive year, this represents a drop from last year's projection, resulting from a combination of the downward revision in the projected level of GDP and larger oil substitution, especially towards the end of the forecast period.

From a regional perspective, the largest incremental demand is projected for Other Asia. This is mainly due to the large demand base in the region, which is home to the largest bunkering port in the world. In relative terms, the average annual growth in the region is comparable to China, OPEC and Latin America where large bunkering centres also exist. 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 2019. Therefore, the growth potential in these regions is rather low in volume terms, although India, followed by the Middle East & Africa, are projected to see the fastest growth in relative terms.

Table 3.8
Oil demand in the marine bunkers sector by region *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
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	0.8	0.7	0.7	0.6	–0.2
OECD Asia Oceania	0.3	0.3	0.2	0.2	0.2	0.2	0.2	–0.1
OECD	**1.6**	**1.6**	**1.5**	**1.5**	**1.4**	**1.3**	**1.2**	**–0.4**
Latin America	0.3	0.2	0.3	0.4	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	0.2	0.3	0.3	0.3	0.3	0.3	0.1
Other Asia	1.2	1.1	1.3	1.4	1.5	1.5	1.6	0.4
OPEC	0.5	0.4	0.5	0.6	0.6	0.6	0.6	0.1
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**	**3.3**	**3.4**	**3.5**	**0.9**
World	**4.2**	**4.0**	**4.4**	**4.6**	**4.7**	**4.7**	**4.6**	**0.5**

Source: OPEC.

A relatively large demand base also exists in OECD countries. The Port of Rotterdam in the Netherlands, Busan in South Korea and Los Angeles in the US are among the ten largest bunkering hubs in the world. Therefore, demand for marine bunker fuels in OECD will remain relative stable over the next ten years. In the long-term, as the centre of economic gravity (and trade) further moves towards Asia, demand for marine bunker fuels in the OECD will start to decline slowly.

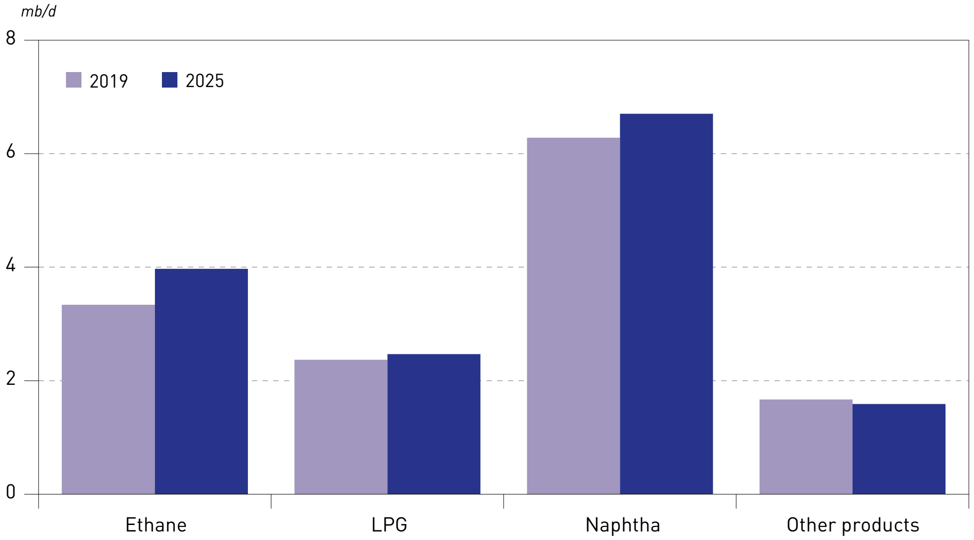
3.2.4 Petrochemicals

The demand shock initiated by the COVID-19 pandemic has resulted in a number of uncertainties for the global petrochemical industry. This sector was hit hard by COVID-19 due to its close link to economic growth and uncertainties that surround the economic recovery also affect the prospects for this industry.

The COVID-19 crisis brought to the fore the need for supply diversification and (at least some) capacity re-relocation closer to consuming regions instead of fully relying on global trade. Another 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 investments. Environmental considerations and regulations, such as bans on single use plastics (Box 3.3), will play an increasingly important role in shaping long-term prospects by adding another disruptive element to future demand growth.

These issues and concerns are fully reflected in the recent downward revisions for oil demand in the petrochemical sector included in this Outlook. As presented in Figure 3.25 and Table 3.9, global oil demand in this sector will grow by 1 mb/d over the medium-term. The single largest source of incremental demand will be OECD Americas, primarily the US, where additional demand is projected at 0.3 mb/d. However, demand in Asia – if combined – will grow by around 0.5 mb/d during the same period. If the total oil-based feedstock is broken down to specific products,

Figure 3.25
Oil demand in the petrochemical sector by product, 2019–2025



Source: OPEC.

Table 3.9
Oil demand in the petrochemical sector by region, 2019–2045 *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
OECD Americas	3.5	3.2	3.8	4.1	3.9	3.7	3.5	0.1
OECD Europe	1.9	1.7	1.8	1.8	1.7	1.6	1.5	–0.4
OECD Asia Oceania	2.1	1.9	2.0	2.0	2.0	2.0	2.0	–0.1
OECD	**7.4**	**6.9**	**7.6**	**8.0**	**7.7**	**7.4**	**7.0**	**–0.4**
Latin America	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.1
Middle East & Africa	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
India	0.4	0.4	0.5	0.7	0.9	1.0	1.1	0.7
China	1.9	1.8	2.1	2.2	2.4	2.6	2.7	0.8
Other Asia	1.3	1.3	1.5	1.7	1.9	2.0	2.1	0.8
OPEC	1.2	1.2	1.4	1.7	2.2	2.5	2.7	1.5
Russia	0.9	0.9	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	**6.2**	**6.0**	**7.1**	**8.0**	**9.0**	**9.7**	**10.3**	**4.1**
World	**13.7**	**12.9**	**14.7**	**15.9**	**16.7**	**17.0**	**17.3**	**3.7**

Source: OPEC.

ethane is set for largest increase (+0.6 mb/d), followed by naphtha (+0.4 mb/d), as ethane-based capacity additions still dominate the sector's expansion. Some growth is also projected for LPG while, notably, there is a slight reduction is demand for other products.

In the **US**, the greatest post-COVID-19 uncertainty is the crude oil price environment, which may put naphtha cracking back on a competitive trajectory and dissuade investment in general since the US petrochemical industry has been expanding with successive waves of ethane cracking. COVID-19 and the low crude oil price may suspend the ethane build-up dynamics. This could potentially revive an investment balance between ethane-based and naphtha-based ethylene production and feedstock flexibility. Mixed cracker operators that can utilize the full range of feedstock will be at an advantage compared to ethane-based crackers.

Therefore, the second wave of US petrochemical projects and projects scheduled for completion for the second half of the medium-term are less certain and are more likely to see delays. Despite commitments by the current US administration to expand energy production and to increase manufacturing, ambitions for the US Shale Crescent region (Pennsylvania, West Virginia and Ohio) to become the second US petrochemical hub after the US Gulf Coast may be compromised. Another potential implication could be a consolidation in the US petrochemical market among its key chemical leaders.

In **China** alone, more than 5 mt of new capacity planned over the medium-term will be naphtha-based. Petrochemical refinery integration with a crude-oil-to-chemicals (COTC) type has been completed by Zhejiang Petrochemical and Hengli Petrochemical. Both companies integrate chemical production in their newly built 400 tb/d refinery. This will lead to a demand increase for naphtha supported by capacity additions in other Asian countries and the Middle East.

In the **Middle East**, petrochemical projects are increasing in size and complexity since the success of the Sadara megaproject in Jubail, Saudi Arabia, in 2017. In this region, the growth of ethylene capacity is based on the advanced integration of ethane associated with oil production. Saudi Arabia, the UAE and Kuwait together represent approximately 10% off the global ethylene supply. In Saudi Arabia, Saudi Aramco and SABIC announced the selection of Yanbu as the site of the first COTC project in the region. This $20-billion complex is likely to be commissioned in 2025 and is expected to produce 9 mt per year of chemicals and base oils, bringing a new business model to the industry. Additional projects in the region exist in IR Iran, Kuwait and Oman.

In **Russia**, Sibur's ambition is to become a leader in the petrochemicals sector in Europe. The company recently completed a sizeable world-class ethylene and derivatives plant in Tobolsk. Russia has a long list of proposed projects in its petrochemical sector but it is unlikely that all of these will be completed within the medium-term horizon given the current demand hit.

The demand dynamics and growth in petrochemicals have been attenuated by the recent demand shock in the sector but are expected to rebound and carry on beyond the medium-term, though at a slower pace than previously anticipated. The long-term demand trends for this sector are presented in Table 3.9. It shows timid demand growth of 0.9 % p.a. on average over the forecast period (2019–2045). This is significantly lower compared to the 1.3% average growth projected over the medium-term. Nonetheless, this is the second fastest growth rate at the sectoral level, behind aviation.

In terms of incremental demand, this represents an increase of 3.7 mb/d at the global level, from 13.7 mb/d in 2019 to a forecasted level of 17.3 mb/d in 2045. It is worth emphasizing that, in volume terms, this sector is experiencing the largest incremental demand among all the sectors. Novel technologies are making syngas derivatives, namely methanol and ammonia, more climate-friendly and this will enable methanol to better adapt to future requirements.

The bulk of this incremental demand is forecast to come from Asia, OPEC and OECD Americas. In fact, these three regions are expected to account for the largest incremental demand and more than 70% of oil demand in the petrochemical sector by 2045. Asia alone will likely absorb 6 mb/d of oil products in this sector by the end of the forecast period. The concentration of the petrochemicals industry in these regions is driven by two major factors – feedstock availability and demand for petrochemical products, mostly as an intermediate material for production of finished products.

A similar trend is also expected in OPEC countries where the relative weight of ethane is expected to increase. Out of a total sectoral growth of 1.5 mb/d between 2019 and 2045, ethane is forecast to increase slightly above 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.

The composition of petrochemical feedstock in Other Asia is skewed towards naphtha in contrast to the wider use of ethane in OPEC and OECD Americas. In 2019, naphtha accounted for 70% of the total petrochemicals demand in Other Asia. The share of naphtha is expected to increase by a marginal 1 pp in the period to 2045, to reach 1.6 mb/d. This illustrates that Asia's petrochemical industry will remain dominated by naphtha, despite some growth in ethane demand.

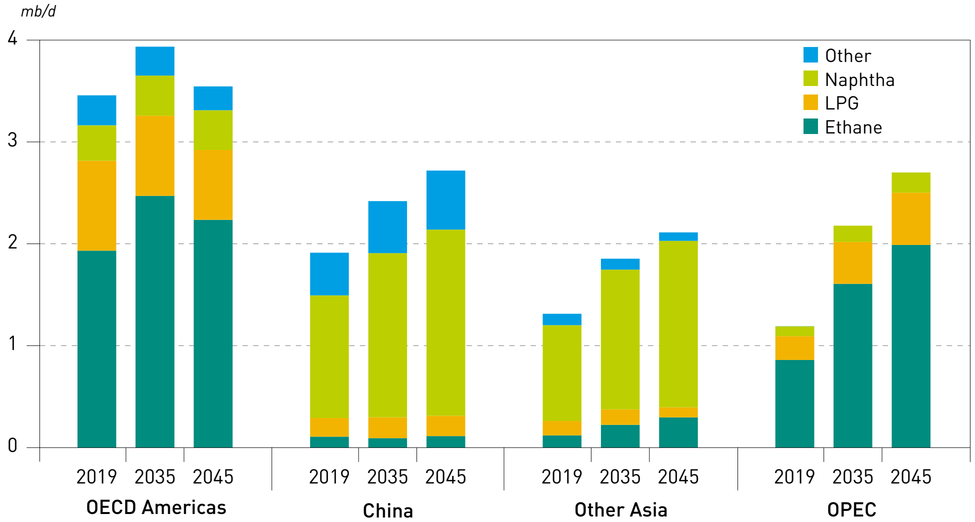
In OECD Americas, some growth will persist during the current decade before a marginal decline will start in the second part of the forecast period. Bearing in mind current uncertainties, it is likely that almost all of the additional sectoral demand will be sourced from cheap ethane.

In the other two OECD regions, the outlook for the petrochemical sector is not as bright, especially in OECD Europe, where oil demand for petrochemicals is anticipated to decline despite the expected NGLs trade from the US. Other regions, essentially 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 in its petrochemical sector. In total, however, demand for oil products in the petrochemical sector of both regions is expected to decline substantially over the forecast period. Minor demand growth increments, in the range of 0.1 mb/d, is expected in some of the developing regions like Russia, Latin America and the Middle East & Africa with no significant impact on the sector's overall demand.

To complete the picture, Figure 3.26 summarizes regional trends in the petrochemical industry from the perspective of major oil products, mainly from a feedstock perspective, but also for energy use. Most feedstocks are on the rise predominantly in OECD Americas and OPEC countries. These feedstocks include ethane and to a lesser extent LPG, either from natural gas or associated gases. Naphtha and other liquid feedstocks are still leading in China and Other Asia. Ethane and propane imports have also gradually been introduced in the feedstock landscape in Other Asia and China.

Figure 3.26
Regional demand in the petrochemical sector by product, 2019–2045



Source: OPEC.

Finally, it is important to reiterate the uncertainties about the prospects for petrochemicals. On the one hand, the petrochemical requirements outlook continues to highlight potential growth for oil demand in this sector, despite the recent demand shock. On the other hand, growing environmental and consumer concerns about the use of plastics and polymers are prompting policymakers to enact measures – such as bans on single-use plastics and stronger recycling and waste management requirements – that weigh on future demand (Box 3.3).

Box 3.3

Plastics and policies: which way to go?

Single-use plastics, as the name suggests, are used only once before they are thrown away or recycled. Each year, more than 8 million tonnes of plastic ends up in the world's oceans. World production of plastic materials in 2016 was 280 million tonnes, of which about one-third was single-use. It is estimated that up to 5 trillion plastic bags are consumed globally each year. An estimated 10% to 13% of plastic items are recycled globally.

Not all plastics can be easily recycled or degrade naturally, which complicates disposal in a sustainable way. Plastics that cannot be recycled, put in landfill or are not biodegradable need to be incinerated. This combustion process is evolving towards a waste-to-energy model including CCS, an environmentally-friendly process that is a promising long-term option.

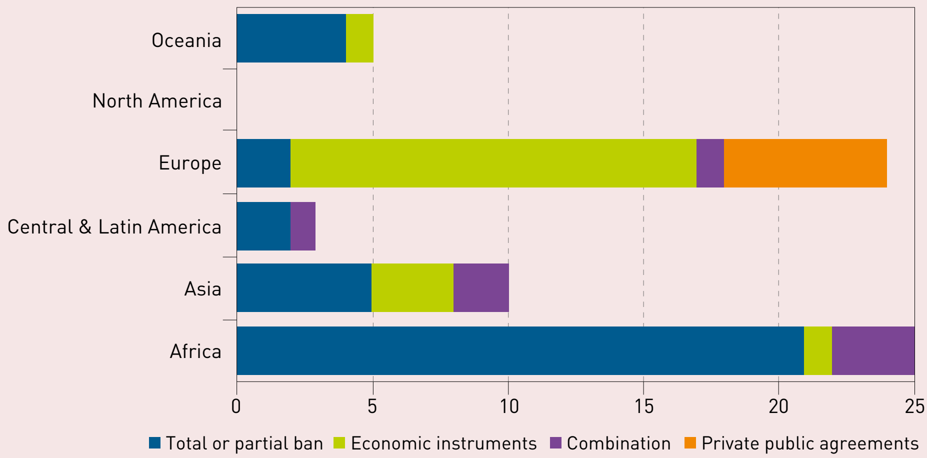
Growing awareness of the proliferation of plastics in the environment has prompted policymakers to address the issue through a variety of measures, including total or partial bans; restrictions on the manufacture, use, distribution, sale or trade of single-use plastics; and market-based instruments such as taxes or deposits to encourage recycling. Plastic bags are currently the main target of legislators. The primary regulatory focus is typically on non-recyclable low-density polyethylene (LDPE) bags, such as those used to wrap fresh produce. It can take centuries for plastic bags to decompose, and very few are recyclable. Composting is also a way to dispose of plastics but less common.

Africa has taken a lead in regulating plastic bags and has the largest number of countries which have adopted bans, whereas Europe leads in the use of economic instruments to reduce plastics pollution (Figure 1). China is banning plastic bags from major cities by the end of 2020 and in all cities and towns in 2022. Plastic wrap for fresh produce will be exempt until 2025. The production and sale of plastic bags less than 2.5 microns (0.025 mm) thick will be banned, as will plastic film less than 10 microns (0.01 mm) thick for agricultural use.

The EU has defined lightweight bags as those with a thickness of up to 50 microns (0.05 mm). Policy measures include the recent EU decision to ban specific single-use plastics by 2021. This also includes an ambitious target of collecting and re-using or recycling 90% of plastic bottles by 2029, as well as several other measures aimed at reducing plastic waste.

Canada's policy is part of a larger circular economy initiative and green growth act focused on reducing waste. In the US, plastics are not regulated at the federal level with the exception of a ruling intended to reduce solid waste generation. Some states prohibit the use of plastic bags. Indian regulations are also at the sub-national level.

Figure 1
Types of national policies on plastic bags, by continent



Source: The plastics landscape: regulations, policies and influencers, UNEP finance initiative and UN global compact.

For single-use plastics, there is a big variation in the scope and range of regulations intended to reduce single-use plastics. The UN, in a recent survey ('Legal Limits on Single-Use Plastics and Microplastics: A Global Review of National Laws and Regulations', United Nations Environment Programme), found that 27 countries have enacted restrictions of some type on the manufacture, distribution, use, sale and/or import of single-use-plastics. The report states also that 29 countries have enacted some type of tax on single-use plastics, either as a special environmental levy, waste disposal fee or charge, or in the form of higher excise taxes.

In the EU the 'European Strategy for Plastics in a Circular Economy' (2018–2030) is intended to reduce the unnecessary generation of single-use plastic waste and eliminate over-packaging. The US, by contrast, has convoluted legislation regulating plastics usage that range from pre-emptive rules that protect the plastics industry by instituting a 'ban on banning', to fees or prohibitions on the use of plastics adopted by several states. In Japan, there are no bans in place on single-use plastics, but there is a high degree of social consciousness and a very effective waste management system. Notably, Costa Rica aims to become the first country in the world to eliminate single-use plastics by 2021 ('Single-use plastics, A Roadmap for Sustainability', United Nations Environment Programme, 2018).

Recycling is also gaining attention. Recycling targets and mandates of various forms are being instituted worldwide, including those seeking to replace plastic bags with biodegradable, reusable and eco-friendly materials. Another example is the **New Plastics Economy Global Commitment** that was announced in October 2018. It unites over 350 businesses, governments and organizations around the world in efforts to eliminate unnecessary plastic items and "to innovate to ensure 100% of plastic packaging can be easily and safely reused, recycled or composed by 2025".

Landfilling of plastics is also on the verge of being gradually banned on a global scale, leaving room only for recycling and/or waste incineration, for example through waste-to-energy technology. The latter seems to be a promising option from a climate change perspective.

There has also been a rising emphasis on improving plastic waste management. Recently, a landmark **UN Plastic Waste Pact** was reached by 186 countries (excluding the US) which sets out to legally bind the countries to monitor and track the movement of plastic waste outside their borders. No country would be able to send unmanageable amounts of plastic waste to private waste-handling companies without the consent of the receiving countries' government.

There is a growing movement towards environmentally sustainable products and services and the deployment of technology to recycle plastic more efficiently. More than 100 countries have introduced measures to limit the growth in the use of plastics. Even though these policies have so far been mostly limited to certain products, such as plastic bags, it does signal the evolution of more comprehensive policies aimed at reducing plastic waste and replacing single-use plastics with alternatives. Policy measures, combined with efforts to shift consumer behaviour to use plastics more responsibly and in an environmentally sustainable manner, will affect the use of oil as a petrochemical feedstock, although it remains to be seen in what manner and to what extent.

3.2.5 Other sectors

Global oil consumption in the **residential, commercial and agricultural sector** combined is anticipated to grow by around 0.5 mb/d by 2045 compared to 2019. However, this expectation masks several trends which make up for the overall demand increase. Two stand out: divergent demand trends between OECD and non-OECD regions, and peaking oil demand in this sector sometime around 2035, as presented in Table 3.10.

Non-OECD oil demand in this sector is set to grow by approximately 1% p.a. on average to increase by 2.0 mb/d by the end of the forecast period compared to 2019. In volume terms, demand will reach the

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

	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
OECD Americas	1.7	1.7	1.7	1.8	1.9	1.6	1.1	–0.6
OECD Europe	1.6	1.5	1.6	1.5	1.3	1.2	1.2	–0.4
OECD Asia Oceania	0.8	0.9	0.8	0.8	0.6	0.6	0.5	–0.4
OECD	**4.2**	**4.2**	**4.1**	**4.1**	**3.9**	**3.4**	**2.7**	**–1.4**
Latin America	0.8	0.7	0.8	1.0	1.0	1.1	1.2	0.4
Middle East & Africa	0.7	0.6	0.7	0.9	1.0	1.0	1.1	0.5
India	1.1	1.0	1.2	1.4	1.6	1.7	1.7	0.7
China	2.2	2.1	2.4	2.5	2.6	2.7	2.8	0.6
Other Asia	0.9	0.9	0.8	0.8	0.8	0.8	0.8	–0.1
OPEC	0.6	0.6	0.6	0.7	0.6	0.6	0.5	0.0
Russia	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.0
Other Eurasia	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.0
Non-OECD	**6.9**	**6.6**	**7.3**	**7.9**	**8.4**	**8.7**	**8.9**	**2.0**
World	**11.1**	**10.8**	**11.4**	**12.0**	**12.2**	**12.1**	**11.6**	**0.5**

Source: OPEC.

level of 8.9 mb/d in 2045 mainly due to population expansion, urbanization and the gradual decline in the use of traditional biomass for cooking, lighting and heating. This will also be supported by a growing agricultural sector. From the regional perspective, the largest incremental demand is projected for India and China followed by Middle East & Africa (largely Sub-Saharan Africa) and Latin America.

As for refined products, it is not surprising that the use of ethane/LPG is expected to account for most of the increase in sectoral demand in the non-OECD, reaching 5 mb/d by 2045. This fuel category competes directly with traditional fuels for cooking, but also with kerosene, which is set to decline over the forecast period. The use of gasoil/diesel is expected to increase in developing countries. This, however, will be almost entirely offset by declines in the OECD and Russia.

Conversely, OECD regions witness oil demand decline in the residential, commercial and agricultural sector due to the growing use of renewable electricity, gas and improved efficiencies through the adoption of 'smart-home' appliances, better insulation and stronger efficiency standards for new buildings. Part of the reduction is also due to deployment of more efficient technologies like district heating, photovoltaic (PV) panels and heat pumps.

These measures are already well established in most OECD countries and are either mandatory via building codes for new construction or supported by incentives for existing buildings. Examples of such policy measures are the EU's Energy Performance of Buildings Directive with a target of having all new buildings 'nearly zero-energy' from 31 December 2020. Considering these factors, OECD oil demand in this sector is estimated to decline by 1.4 mb/d by 2045.

Oil use in **rail and domestic waterways** is the lowest among all sectors considered in this Outlook. Global demand in this sector is only in the range of 2 mb/d and is projected to move in a very narrow band around this level. Moreover, more than half of demand is currently concentrated in only two regions, OECD Americas and China (Table 3.11). In the case of the OECD Americas, the majority of 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 *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
OECD Americas	0.5	0.6	0.5	0.5	0.5	0.4	0.3	–0.2
OECD Europe	0.2	0.1	0.2	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	0.7	0.8	0.8	0.9	0.3
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**	**1.0**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**0.5**
World	**1.9**	**1.8**	**1.9**	**2.0**	**2.1**	**2.1**	**2.0**	**0.2**

Source: OPEC.

Therefore, future prospects for oil demand in this sector are tightly linked to the level of rail network expansion and electrification. For example, as discussed in Box 3.2, the rail network in India is expanding at impressive rates yet oil demand in this sector of the Indian economy is projected to remain relatively stable as electrification is also progressing. The intention of the current government is to achieve full electrification.

The rate of rail electrification in China is also relatively high, around 70%, and in Europe, around 60%. It is expected that these rates will increase in future leading to declining oil demand in this sub-sector.

In contrast to these regions, rail electrification in the US is not expected to increase significantly over the forecast period. Therefore, relatively stable oil demand in the sub-sector results from the offsetting effects of increasing freight traffic and improved efficiency. However, efficiency improvements will start outweighing the rather saturated traffic conditions towards the end of the forecast period and lead to declining oil demand.

As noted earlier, specific to China is its huge waterway infrastructure system that has been developed over centuries. As there are plans for further expansion of this system, the expectation is for continued growth in domestic waterway traffic in China, both for passengers and freight. This will support oil demand growth by around 0.3 mb/d between 2019 and 2045. In addition to China, some demand growth is also projected in other developing countries, in particular in Latin America and Other Asia.

Electricity generation is undergoing a radical transformation. Fuel substitution in the power sector is mainly favouring deployment of low-carbon resources and renewables. In addition, the policy in several OPEC Member Countries is to reduce direct use of crude oil for power generation in order to benefit from the higher added value of available oil resources. Given these two factors, oil use in electricity generation will decrease by almost 1% p.a. on average to 3.9 mb/d by 2045 from 4.9 mb/d in 2019 (Table 3.12). It is worth noting that this is the only sector where oil demand at the global level will decline over the forecast period.

Table 3.12
Oil demand in the electricity generation sector by region *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
OECD Americas	0.4	0.5	0.3	0.2	0.2	0.1	0.1	–0.4
OECD Europe	0.3	0.3	0.3	0.2	0.2	0.2	0.1	–0.2
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**	**0.6**	**0.5**	**0.4**	**–0.8**
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	0.0
China	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.0
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	1.6	1.4	1.3	1.2	–0.5
Russia	0.2	0.1	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	**3.7**	**3.6**	**3.8**	**3.8**	**3.7**	**3.5**	**3.5**	**–0.3**
World	**4.9**	**4.9**	**4.8**	**4.6**	**4.3**	**4.1**	**3.9**	**–1.1**

Source: OPEC.

In the OECD region, oil use in power generation will continue to decline due to increasing use of renewable electricity and natural gas. Growing deployment of wind (both offshore and onshore), solar and geothermal energy (mainly in OECD Europe) is exerting downward pressure on oil-based generation in the OECD region. As a result, this is projected to decline by 0.8 mb/d between 2019 and 2045. In fact, at the end of the forecast period oil will be almost entirely displaced from this sector in the OECD regions.

As noted above, significant oil demand reduction in the power sector is also projected in OPEC countries. The net decline of 0.5 mb/d over the forecast period will result from reduced use of direct crude burning, part of which will be offset by the increased use of refined products in several countries.

Demand decline in the above regions will be partly compensated for 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 SDG 7 – which seeks to expand energy access and clean cooking fuel by 2030 – is assisting Sub-Saharan Africa (and other regions) with further alleviation of energy poverty. This is providing some momentum for growth of oil-based generation via rural electrification in remote locations without gas supply infrastructure. Consequently, demand for electricity generation in the non-OECD region is set to grow during the current decade and marginally decline at the end of the forecast period.

Finally, major demand trends in the 'other industry' sector (i.e. the industry sector excluding petrochemicals) are broadly similar to those discussed earlier for the residential, commercial and agricultural sector, although the weighting of contributing regions differs.

Oil demand in this sector is tightly linked to the level of economic activity, but also the structure of economies. Typically, industrialization is the tipping point when economies start to grow at a much higher rate compared to countries with a higher share of agriculture. At this stage, energy demand, in general, and oil demand, in particular, also grow. Moreover, this development stage also includes rapid expansion of necessary road infrastructure which, in turn, will support demand for asphalt, bitumen and other related products. This is the case of regions where the largest incremental oil demand over the forecast period is projected: India (+0.5 mb/d), the Middle East & Africa (+0.3 mb/d) and OPEC (+0.3 mb/d) (Table 3.13).

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

	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
OECD Americas	3.0	3.0	3.1	3.0	2.8	2.5	2.3	–0.7
OECD Europe	1.5	1.5	1.4	1.4	1.4	1.3	1.3	–0.2
OECD Asia Oceania	0.9	0.9	0.8	0.7	0.7	0.6	0.5	–0.3
OECD	**5.3**	**5.4**	**5.2**	**5.1**	**4.8**	**4.4**	**4.1**	**–1.2**
Latin America	0.9	0.9	1.0	1.0	1.1	1.1	1.2	0.2
Middle East & Africa	0.6	0.6	0.6	0.7	0.8	0.9	1.0	0.3
India	1.0	0.9	1.0	1.1	1.3	1.4	1.5	0.5
China	1.9	1.9	1.9	1.9	1.8	1.8	1.8	–0.1
Other Asia	0.9	0.9	1.0	1.0	1.1	1.1	1.1	0.2
OPEC	1.2	1.3	1.4	1.6	1.6	1.6	1.5	0.3
Russia	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Other Eurasia	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.0
Non-OECD	**7.5**	**7.3**	**7.8**	**8.4**	**8.7**	**8.9**	**9.0**	**1.5**
World	**12.8**	**12.7**	**13.0**	**13.5**	**13.5**	**13.3**	**13.1**	**0.3**

Source: OPEC.

However, as a country moves further down the development path and income levels increase, the share of the industrial sector tends to decline in favour of the services sector. This is clearly the case for China where oil demand in 'other industry' is likely to experience no growth over the next ten years, before it starts to decline in the longer-term.

On the other end of the scale are developed countries where the weight of the industry sector is shrinking and fuel consumption switches towards natural gas in tandem with technology and policy-driven efficiency improvements. The road network in these countries is already well developed and only limited expansion will be required. Therefore, OECD oil demand in the 'other industry' sector will steadily decline over the forecast period. The range of the decline will be more than 1 mb/d between 2019 and 2045.

3.3 Oil demand outlook by product

Sections 3.1 and 3.2 provided a number of references on demand for specific refined products in major regions. This section summarizes the implications of sectoral demand trends on major categories of refined products as shown in Table 3.14. Light products are grouped into three categories: ethane/LPG, naphtha and gasoline (including ethanol). Middle distillates are grouped into two categories: jet/kerosene (including jet kerosene and domestic kerosene) and diesel/gasoil (including biodiesel). Finally, residual fuel oil (including refinery fuel oil) and 'other products' (including bitumen, lubricants, waxes, still gas, coke, sulphur and direct use of crude oil) account for the heavy part of the refined barrel.

Table 3.14
Long-term oil demand by product *mb/d*

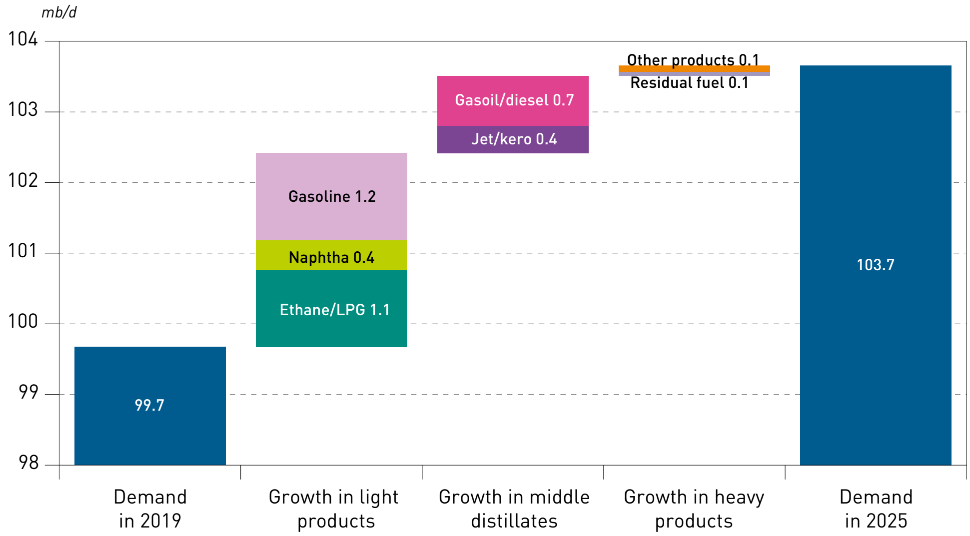
	2019	2020	2025	2030	2035	2040	2045	Growth 2019–2045
Ethane/LPG	12.6	12.2	13.7	14.8	15.3	15.3	15.1	2.5
Naphtha	6.3	5.9	6.7	7.2	7.6	8.0	8.3	2.0
Gasoline	26.4	24.0	27.6	27.9	27.8	27.6	27.4	1.0
Light products	**45.3**	**42.1**	**48.1**	**49.9**	**50.7**	**50.9**	**50.8**	**5.5**
Jet/kero	7.6	4.4	8.0	8.5	9.1	9.6	10.0	2.4
Gasoil/diesel	28.4	26.3	29.1	29.8	30.1	30.1	30.0	1.6
Middle distillates	**36.0**	**30.7**	**37.0**	**38.3**	**39.3**	**39.7**	**40.0**	**4.1**
Residual fuel	7.2	6.9	7.2	7.5	7.4	7.3	7.1	–0.1
Other products	11.2	11.0	11.3	11.6	11.5	11.3	11.1	–0.1
Heavy products	**18.4**	**17.9**	**18.5**	**19.0**	**19.0**	**18.6**	**18.2**	**–0.2**
World	**99.7**	**90.7**	**103.7**	**107.2**	**108.9**	**109.3**	**109.1**	**9.4**

Source: OPEC.

Demand projections for the products included in this year's Outlook show some further shifts in the demand pattern compared to previous Outlooks. Over the medium-term horizon, changes are primarily driven by the COVID-19 pandemic in 2020 which affected all transport fuels disproportionately. As noted in previous parts of this chapter, this also has some implications on the long-term demand trends which are further amplified by extending the forecast period to 2045. Therefore, it is important to analyse these trends from the medium- and long-term perspectives separately.

The major changes in the product demand over the medium-term are presented in Figure 3.27. There are three major product groups dominating this figure: gasoline, ethane/LPG and diesel/

Figure 3.27
Growth in global oil demand by product between 2019 and 2025



Source: OPEC.

gasoil. Incremental demand for gasoline will be driven by the expanding number of vehicles, especially in developing countries. It is important to note, however, that the overall increase of 1.2 mb/d during the medium-term is significantly lower than the level of 1.6 mb/d projected a year ago. This is mainly due to reduced demand during 2020 but also the slower growth in passenger car numbers compared to last year's projections.

Growing demand for ethane/LPG reflects trends in the petrochemical and residential sectors. Demand for diesel/gasoil also grows but its increase during the 2019–2025 period is less than half of what was expected last year as GDP growth rates suffer from COVID-19 lockdowns, ongoing shifts in the structures of major economies, reduced use of diesel in maritime transport, and falling sales of diesel cars in Europe.

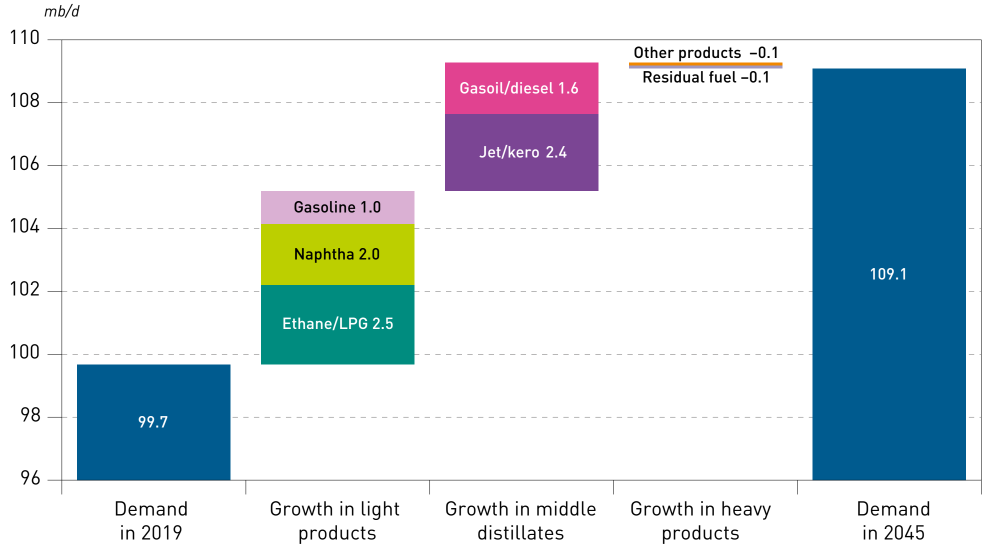
A similar range of downward revisions is also noticeable for jet/kerosene due to COVID-19 lockdowns and restrictions on air travel. A five-year forecast from last year indicated that demand for this product group would increase by 0.8 mb/d. However, this year's Outlook is for an increase of just 0.4 mb/d.

The relative weight of these product groups changes, however, when the entire forecast period is considered. This is presented in Figure 3.28. First, the global increase in gasoline demand over the long-term will be lower than that for the medium-term. This demand pattern for gasoline is driven by developments in the size and composition of the passenger fleet as discussed in Section 3.2.1.

Accordingly, after some growth during the medium-term, demand for gasoline not only decelerates in the period to 2030, but it starts plateauing and declining afterwards, losing around 0.5 mb/d by 2045 from the peak demand of close to 28 mb/d around 2030. This is a result of the broad trends in the passenger car segment where improving fuel efficiency and the increasing penetration of AFVs, primarily EVs, more than offset the potential demand increase resulting from the expansion in the number of vehicles.

Secondly, the role of ethane and LPG is amplified by extending the forecast period to 2045. In fact, this product group will cover the largest part of incremental demand, growing by 2.5 mb/d

Figure 3.28
Demand growth by product category between 2019 and 2045



Source: OPEC.

between 2019 and 2045. Similar to the medium-term period, continued strong growth in the petrochemical and residential sectors will provide support for these products.

In addition to ethane (and partly LPG), demand for naphtha is also strongly linked to the expanding petrochemical industry and will foster its role among leading refined products in the long-term. 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).

Significant demand additions are also projected for jet/kerosene as a result of the fast growing aviation sector. However, the outlook is much weaker for the major component in the category of middle distillates, diesel/gasoil, demand for which loses steam during the second part of the forecast period. In total, demand for diesel/gasoil is projected to increase by 1.7 mb/d to stay at around 30 mb/d in 2045. Since this product is used across a number of sectors, its final demand results from a combination of several factors. On the positive side, growing requirements for transportation services in the non-OECD grouping will lead to expanding fleets of trucks and buses, as well as primarily diesel-driven light-duty vehicles. Some demand growth is also projected in the industrial, residential and agricultural and rail and domestic waterways sectors.

Nevertheless, oil demand in these sectors is strongly linked to GDP which, driven by a sharp decline in 2020, is around 6% lower compared to pre-COVID-19 projections. This will pull diesel demand lower, adding to the diminishing demand from the declining share of diesel-based passenger cars, especially in Europe.

Turning to the demand for heavy products, these are projected to experience limited growth during the current decade, in the range of 0.3 mb/d each for residual fuel oil and 'other products'. After this period, however, demand for heavy products will slowly decline with the end-period levels broadly in line with the estimated demand in 2019.

Liquids supply

Key takeaways

- On the supply side, the impact of the COVID-19 pandemic, which resulted in a contraction of oil demand, led to an historic DoC downward production adjustment of nearly 10 mb/d, to remain in place, albeit tapered, until 2022. Production elsewhere was shut-in after it became uneconomic, including some 2–3 mb/d of US crude output. These combined measures have helped to return stability to oil markets as they gradually rebalance.

- Following a projected sharp decline of more than 3 mb/d in 2020, its first annual drop since 2016, non-OPEC liquids supply will grow again modestly in 2021 and pick up momentum in the following years, thus increasing from 65 mb/d in 2019 to 70.7 mb/d in 2025.

- Medium-term recovery is mainly driven by Brazil, which grows by 1.7 mb/d, the US (+1.4 mb/d), Norway (+0.8 mb/d), Guyana (+0.7 mb/d) and Kazakhstan (+0.5 mb/d).

- Despite being the most affected by shut-ins, due to its inherent responsiveness to price, US tight oil is also expected to recover quickly as market conditions improve, and will grow by 2.8 mb/d to 14.5 mb/d from 2019 to 2025. It will continue to grow modestly thereafter, plateauing at 15.8 mb/d around 2030, but is not expected to reach heights projected in previous Outlooks.

- In the longer-term, supply trends are not assumed to be much affected by the pandemic fallout, though there are many instances of upstream projects being postponed in the current uncertain environment. In other cases, decline in mature areas may be accelerated due to less investment, some shut-in wells never being re-activated, and a slightly weaker demand outlook.

- Only a handful of non-OPEC producers show meaningful supply growth post-2025, such as Canada, Qatar, Kazakhstan and Guyana. Many other non-OPEC producers see output stagnate or decline. As such, non-OPEC supply declines from a peak of 71.8 mb/d in 2027 to 65.4 mb/d by 2045, and thus is more or less flat over the entire 2019-2045 forecast period as a whole.

- As a result of continued long-term demand growth and peaking non-OPEC supply, OPEC liquids will increase from 33.8 mb/d in 2019 to 43.9 mb/d in 2045. This means that OPEC Member Countries' share of global liquids rises from 34% in 2019 to 40% in 2045.

- Possible downside risks to the global supply outlook could stem from reduced upstream investment, which is forecast to decline by over 30% in 2020, but will recover to 2019 levels by 2024/25, according to Rystad Energy. To meet global oil demand, future upstream spending will need to average $380 billion p.a. over the long-term. Cumulatively, this means $9.9 trillion (in 2020 dollars) will be required. Added to $1.5 trillion required in the downstream, and $1.2 trillion in the midstream, cumulative oil-related investments over the long-term will need to be $12.6 trillion.

This chapter describes the outlook for liquids supply from 2019 to 2045. As in previous Outlooks, the medium-term projections for 2019 to 2025 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 rather based upon an assessment of the available resource base. US tight oil is also modelled and discussed separately.

Moreover, it is important to note that all supply figures quoted in this Outlook reflect Ecuador having left OPEC on 1 January 2020. Naturally, this has led to a revision of the baseline for OPEC and non-OPEC oil production assessments, as well as projections, which should not be confused with actual changes to the outlook.

4.1 Global liquids supply outlook

Current and future liquids supply has been significantly affected by the COVID-19 pandemic, though by contrast with the demand side, rather as a result of the sharp decline in oil prices seen early in the crisis than by the effects of the lockdown *per se*. Thus, non-OPEC liquids supply is expected to contract sharply in 2020, for the first time since 2016, with output projected to decline by 3.3 mb/d (Table 4.1).

OPEC Member Countries and the non-OPEC countries participating in the DoC took a decisive step towards stabilising markets with their decision in April 2020 to sharply adjust oil production. In some cases, other mandated adjustments were made, while especially producers in the US and Canada shut in volumes due to individual wells and assets becoming uneconomic.

Thereafter, with the expected recovery in the global economy, resulting in re-invigorated oil demand and stabilized markets, non-OPEC liquids supply is anticipated to recover relatively rapidly, returning to growth from 2021. In this year's Reference Case, total non-OPEC liquids supply is projected to increase by 5.7 mb/d from 2019 to 2025, thus slightly exceeding demand growth in

Table 4.1
Medium-term global liquids supply outlook *mb/d*

	2019	2020	2021	2022	2023	2024	2025	Change 2019–2025
OECD	30.0	28.5	28.9	30.1	31.0	31.8	32.5	2.5
of which: US	*18.4*	*17.0*	*17.3*	*18.2*	*18.8*	*19.3*	*19.8*	*1.4*
of which: tight liquids	*11.7*	*10.9*	*11.2*	*12.2*	*13.0*	*13.8*	*14.5*	*2.8*
Non-OECD	32.8	31.2	31.5	32.6	33.7	34.7	35.9	3.1
Processing gains	2.3	2.1	2.2	2.3	2.3	2.3	2.4	0.1
Non-OPEC	**65.0**	**61.8**	**62.7**	**65.0**	**67.1**	**68.8**	**70.7**	**5.7**
of which: crude*	*45.9*	*43.5*	*43.9*	*45.8*	*47.6*	*48.8*	*50.0*	*4.1*
NGLs	*10.5*	*10.3*	*10.5*	*10.6*	*10.7*	*10.9*	*11.3*	*0.9*
global biofuels	*2.5*	*2.3*	*2.5*	*2.6*	*2.6*	*2.7*	*2.8*	*0.2*
other liquids	*3.8*	*3.6*	*3.7*	*3.7*	*3.9*	*4.1*	*4.3*	*0.5*
Total OPEC liquids	**33.8**	**30.7**	**33.8**	**34.3**	**34.1**	**33.8**	**33.2**	**–0.7**
World	**98.9**	**92.4**	**96.5**	**99.3**	**101.1**	**102.6**	**103.9**	**5.0**

* *The breakdown of non-OPEC supply does not include processing gains.*

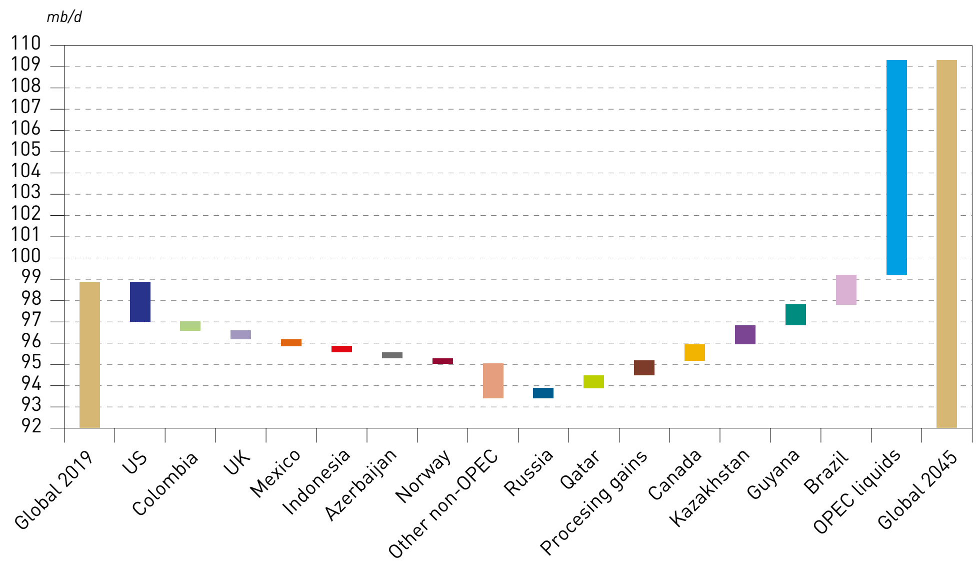
Source: OPEC.

this period, but expanding much less than anticipated in the WOO 2019, when non-OPEC supply was projected to increase by 9.9 mb/d between 2018 and 2024.

In the longer-term, however, some effects of the current pandemic-induced crisis will linger, causing some permanent shut-ins of mature wells and fields, but also curtailing investment in the upstream sector. As a result, non-OPEC supply will peak and plateau towards the end of the 2020s, and when viewing the entire 2019–2045 period, will remain essentially flat, as a result of declines in later years.

Consequently, the implication is that OPEC liquids will need to fill the gap, and will see an increase of some 10 mb/d over the entire 2019–2045 period, rising to around 44 mb/d by the end of the outlook (Figure 4.1).

Figure 4.1
Composition of long-term global liquids supply growth, 2019–2045



Source: OPEC.

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

Total non-OPEC liquids supply is projected to grow from 65 mb/d in 2019 to 70.7 mb/d in 2025, or by an average 0.9 mb/d p.a.(Table 4.2). This is despite a sharp contraction in 2020, when non-OPEC supply is expected to decline by 3.3 mb/d. Recovery will start in 2021, with expected growth of 0.9 mb/d, and gain strength in the remaining years of the medium-term period, with average annual growth of 2 mb/d in the period 2022–2025.

The anticipated reduction in non-OPEC supply in 2020 is a result of a combination of factors related to the COVID-19 pandemic, which caused oil prices to plummet from late February 2020, before recovering from late April 2020, as the impact of shut-in production began to become visible in oil markets.

First of all, OPEC and non-OPEC participating countries in the DoC, in an historic decision in early April, decided to make unprecedentedly large adjustments to supply, totalling commitments of nearly 10 mb/d. Other countries, including some G20 members and some OPEC Member

Table 4.2
Long-term global liquids supply outlook
mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2019–2045
OECD	30.0	28.5	32.5	32.3	30.8	29.1	27.7	–2.3
of which: US	*18.4*	*17.0*	*19.8*	*20.3*	*19.1*	*17.7*	*16.6*	*–1.8*
of which: tight liquids	*11.7*	*10.9*	*14.5*	*15.8*	*15.4*	*14.3*	*13.3*	*1.6*
Non-OECD	32.8	31.2	35.9	36.7	36.5	35.7	34.7	2.0
Processing gains	2.3	2.1	2.4	2.6	2.7	2.8	3.0	0.7
Non-OPEC	**65.0**	**61.8**	**70.7**	**71.5**	**69.9**	**67.6**	**65.4**	**0.4**
of which: crude*	*45.9*	*43.5*	*50.0*	*48.9*	*46.0*	*43.0*	*40.3*	*–5.6*
NGLs	*10.5*	*10.3*	*11.3*	*12.5*	*13.0*	*13.2*	*13.2*	*2.7*
global biofuels	*2.5*	*2.3*	*2.8*	*3.1*	*3.3*	*3.5*	*3.6*	*1.0*
other liquids	*3.8*	*3.6*	*4.3*	*4.6*	*4.9*	*5.1*	*5.4*	*1.6*
Total OPEC liquids	**33.8**	**30.7**	**33.2**	**35.9**	**39.2**	**41.9**	**43.9**	**10.1**
World	**98.9**	**92.4**	**103.9**	**107.4**	**109.1**	**109.5**	**109.3**	**10.4**

* *The breakdown of non-OPEC supply does not include processing gains.*
Source: OPEC.

Countries, also made additional, voluntary adjustments, while in other cases, economics, logistics, or short-term financial stress caused additional oil production volumes to be shut-in. Given lags in data reporting, only hindsight will tell, but current estimates suggest that as much as 10–15 mb/d was shut-in temporarily in terms of global supply. In addition, the planned duration of the DoC production adjustments is for an unprecedented period, as they are provisionally set to remain in place – should they remain necessary – for two years, until 2022, albeit gradually tapered. For the purpose of liquids supply modelling for this Outlook, full conformity with agreed production adjustments is assumed for DoC participating non-OPEC countries.

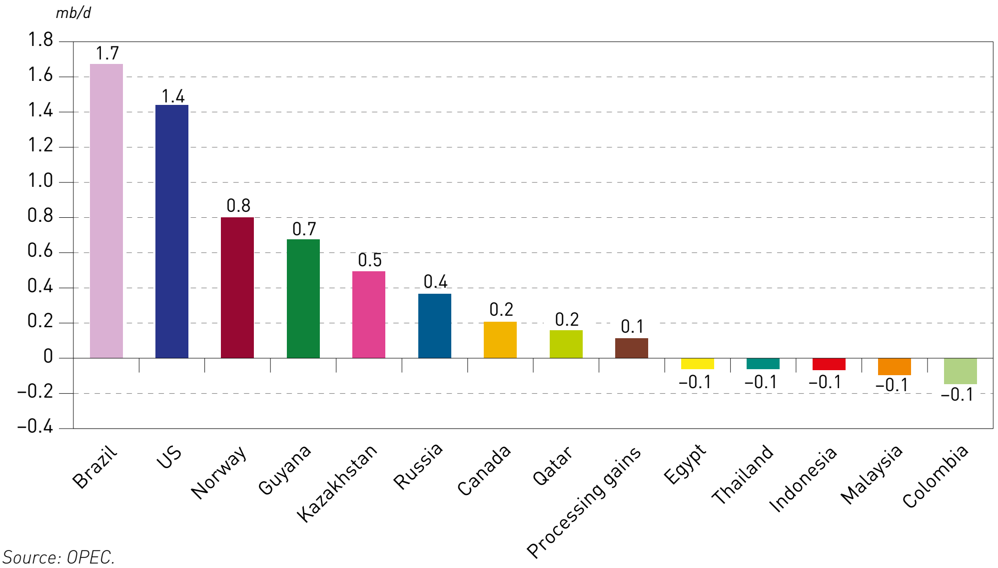
As a result, oil markets have visibly stabilized, alongside the first signs of demand recovery. On the supply side, the question now is how quickly and how sustainably production can recover or be ramped-up again, and to what extent some wells or even fields may no longer be technically or economically viable, or suffer some lasting damage due to the shutdown. In part, this trajectory depends on anticipated oil demand, in part on oil market and oil price stabilization, and also on upstream investment. Initial estimates show a cut in 2020 upstream capex of 32%, according to Rystad Energy.

Nonetheless, in this Outlook's Reference Case, it is assumed to some extent that total non-OPEC liquids will see a relatively rapid return to previously anticipated growth rates. As such, US tight oil growth, even while revised down, remains one of the main drivers of medium-term supply increases, in addition to longer-cycle areas with major, long-planned upstream projects, such as Brazil, Norway, Guyana and Kazakhstan. Some existing major producers, including Canada and Russia, also provide more modest increments (Figure 4.2).

However, some lasting effects of the unprecedented hit to global oil supply will remain. For instance, with regard to US tight oil, the pre-pandemic trend of the Permian Basin's increasing dominance will be reinforced, while none of the other major basins see output regain 2019 levels even as they remain prolific producers.

Mature fields and regions in other areas of the US, such as conventional onshore crude production, but also some producing assets in other mature producing areas – including other onshore North

Figure 4.2
Select contribution to non-OPEC total liquids change, 2019–2025



Source: OPEC.

America, the North Sea, and parts of Other Asia and Africa – are expected to see lower production profiles than previously anticipated, as a result of reduced investment, some older fields being retired earlier, higher decline rates and postponements or even cancellations of future upstream projects. To some extent, this is also true for non-crude liquids, including NGLs, biofuels and other liquids.

As a result, after US tight oil peaks in the late 2020s, broadly speaking, non-OPEC total liquids also plateau, with only a handful of countries registering supply growth, such as Canada, Qatar, Kazakhstan and Guyana. Many other non-OPEC producers see output stagnate or decline. As such, non-OPEC supply declines from a peak of 71.8 mb/d in 2027 to 65.4 mb/d by 2045, and thus is more or less flat over the 2019–2045 forecast period as a whole.

4.3 Breakdown of liquids supply outlook by main regions

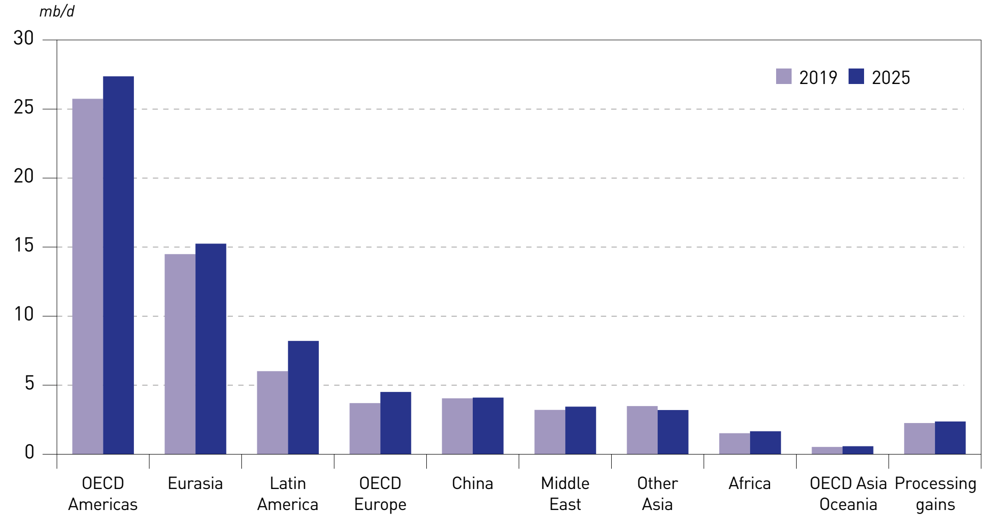
Regionally, the largest drivers of non-OPEC liquids supply in the medium-term are expected to be Latin America, OECD Americas, Eurasia and OECD Europe. Most other regions have far more modest growth, while Other Asia will see oil production decline in this period (Figure 4.3). While the actual regional increments have changed, this geographical distribution is similar to that fore-seen in the WOO 2019.

By contrast, in the long-term, while Latin America and Eurasia remain key drivers of non-OPEC liquids growth, OECD sub-regions the Americas and Europe see a decline in output. Meanwhile, the relative importance of the Middle East (non-OPEC) as a source of growth rises, largely on assumed long-term growth potential in Qatar associated with expansion of its LNG-exporting capabilities.

OECD

Collectively, OECD countries contribute around half of the projected non-OPEC supply growth in the medium-term, with output increasing by 2.5 mb/d, from 30 mb/d in 2019 to 32.5 mb/d in 2025.

Figure 4.3
Medium-term non-OPEC liquids supply outlook by region



Source: OPEC.

Table 4.3
OECD: Medium-term liquids supply outlook

mb/d

	2019	2020	2021	2022	2023	2024	2025	Change 2019–2025
US	18.4	17.0	17.3	18.2	18.8	19.3	19.8	1.4
of which: tight liquids	*11.7*	*10.9*	*11.2*	*12.2*	*13.0*	*13.8*	*14.5*	*2.8*
Canada	5.4	5.0	5.1	5.1	5.2	5.4	5.6	0.2
of which: oil sands	*2.9*	*2.7*	*2.8*	*2.8*	*2.9*	*3.1*	*3.3*	*0.4*
Mexico & Chile	1.9	1.9	1.8	1.8	1.9	1.9	1.9	0.0
OECD Americas	**25.7**	**23.9**	**24.2**	**25.1**	**25.8**	**26.6**	**27.4**	**1.6**
Norway	1.7	2.0	2.2	2.4	2.6	2.6	2.5	0.8
UK	1.1	1.1	1.2	1.2	1.2	1.2	1.1	0.0
Other OECD Europe	0.8	0.8	0.8	0.8	0.8	0.9	0.8	0.0
OECD Europe	**3.7**	**4.0**	**4.1**	**4.4**	**4.6**	**4.6**	**4.5**	**0.8**
OECD Asia Oceania	**0.5**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.1**
OECD	**30.0**	**28.5**	**28.9**	**30.1**	**31.0**	**31.8**	**32.5**	**2.5**

Source: OPEC.

The US, Norway and Canada drive this growth, with most other countries' output, and OECD Asia Oceania, flat in this period (Table 4.3).

In the long-term, the OECD as a whole sees a similar decline to its medium-term growth, with total liquids supply falling by 2.3 mb/d, from 30 mb/d in 2019 to 27.7 mb/d in 2045. This is largely a result of the projected peak and gradual decline in US tight oil production, but also as mature producing countries in OECD Europe and OECD Asia Oceania see output decline. Canada remains a source of long-term growth, with increases in oil sands capacity more than offsetting the decline in mature conventional onshore production (Table 4.4).

Table 4.4
OECD: Long-term liquids supply outlook

mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2019–2045
US	18.4	17.0	19.8	20.3	19.1	17.7	16.6	–1.8
of which: tight liquids	*11.7*	*10.9*	*14.5*	*15.8*	*15.4*	*14.3*	*13.3*	*1.6*
Canada	5.4	5.0	5.6	5.7	5.9	6.0	6.2	0.8
of which: oil sands	*2.9*	*2.7*	*3.3*	*3.6*	*3.8*	*4.1*	*4.3*	*1.4*
Mexico & Chile	1.9	1.9	1.9	1.8	1.8	1.7	1.6	–0.3
OECD Americas	**25.7**	**23.9**	**27.4**	**27.8**	**26.8**	**25.4**	**24.3**	**–1.4**
Norway	1.7	2.0	2.5	2.1	1.9	1.6	1.5	–0.3
UK	1.1	1.1	1.1	1.0	0.9	0.8	0.7	–0.4
Other OECD Europe	0.8	0.8	0.8	0.8	0.8	0.8	0.7	–0.1
OECD Europe	**3.7**	**4.0**	**4.5**	**4.0**	**3.5**	**3.2**	**3.0**	**–0.8**
OECD Asia Oceania	**0.5**	**0.6**	**0.6**	**0.5**	**0.5**	**0.4**	**0.4**	**–0.1**
OECD	**30.0**	**28.5**	**32.5**	**32.3**	**30.8**	**29.1**	**27.7**	**–2.3**

Source: OPEC.

4

Latin America

Latin America is projected to be the non-OPEC region with the second-largest medium-term increment, with total liquids supply set to increase from 6 mb/d in 2019 to 8.2 mb/d in 2025 (Table 4.5). The majority of this growth is to come from Brazil, which sees substantial investment and production increases in its ultra-deepwater pre-salt assets. The other major source of supply is newcomer Guyana, where output is projected to rise from zero to 0.7 mb/d in the medium-term.

Table 4.5
Latin America: Medium-term liquids supply outlook

mb/d

	2019	2020	2021	2022	2023	2024	2025	Change 2019–2025
Argentina	0.7	0.6	0.6	0.6	0.7	0.7	0.7	0.0
Brazil	3.5	3.7	3.9	4.1	4.5	4.9	5.2	1.7
of which: fuel ethanol	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.1*
Colombia	0.9	0.8	0.8	0.8	0.8	0.8	0.8	–0.1
Ecuador	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.0
Guyana	0.0	0.1	0.1	0.2	0.4	0.5	0.7	0.7
Other Latin America	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.0
Latin America	**6.0**	**6.1**	**6.4**	**6.7**	**7.2**	**7.7**	**8.2**	**2.2**

Source: OPEC.

On a net basis, Latin America is also expected to see growth over the long-term. From 6 mb/d in 2019, supply will grow to 7.8 mb/d in 2045, though regional production is expected to peak around 2030, when Brazilian liquids supply plateaus. Guyana too is expected to see output continue to rise beyond the medium-term. All other countries are projected to see supply decline in the long-term (Table 4.6).

Table 4.6
Latin America: Long-term liquids supply outlook *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Change 2019–2045
Argentina	0.7	0.6	0.7	0.7	0.7	0.6	0.6	0.0
Brazil	3.5	3.7	5.2	5.5	5.5	5.3	4.9	1.4
of which: fuel ethanol	*0.6*	*0.6*	*0.6*	*0.7*	*0.7*	*0.8*	*0.8*	*0.2*
Colombia	0.9	0.8	0.8	0.7	0.6	0.6	0.5	–0.4
Ecuador	0.5	0.5	0.5	0.5	0.5	0.4	0.4	–0.1
Guyana	0.0	0.1	0.7	0.9	1.0	1.0	1.0	1.0
Other Latin America	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.0
Latin America	**6.0**	**6.1**	**8.2**	**8.6**	**8.6**	**8.2**	**7.8**	**1.8**

Source: OPEC.

Eurasia

Eurasia is the second-largest non-OPEC producing region and the third-largest source of liquids supply growth both in the medium- and long-term. In the medium-term, output increases by 0.8 mb/d, to 15.2 mb/d. Kazakhstan is the major driver of incremental supply, with production growing by 0.5 mb/d to 2.3 mb/d. Russia also sees a 0.4 mb/d expansion to 11.8 mb/d in this period (Table 4.7).

Table 4.7
Eurasia: Medium-term liquids supply outlook *mb/d*

	2019	2020	2021	2022	2023	2024	2025	Change 2019–2025
Russia	11.4	10.3	10.4	11.0	11.4	11.7	11.8	0.4
Azerbaijan	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.0
Kazakhstan	1.8	1.7	1.7	1.8	1.9	2.0	2.3	0.5
Other Eurasia	0.4	0.4	0.4	0.4	0.4	0.4	0.4	–0.1
Eurasia	**14.5**	**13.1**	**13.1**	**13.9**	**14.4**	**14.8**	**15.2**	**0.8**

Source: OPEC.

In the long-term, Kazakhstan's supply is projected to continue to increase, while Russia's is relatively flat, albeit still showing an increase from 2019 to 2045. Azerbaijan's supply meanwhile is expected to decline marginally. Overall Eurasia liquids supply increases by 0.9 mb/d over the long-term (Table 4.8).

Table 4.8
Eurasia: Long-term liquids supply outlook

mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2019–2045
Russia	11.4	10.3	11.8	11.9	12.0	12.0	11.9	0.5
Azerbaijan	0.8	0.7	0.7	0.7	0.6	0.6	0.5	–0.3
Kazakhstan	1.8	1.7	2.3	2.5	2.6	2.7	2.7	0.9
Other Eurasia	0.4	0.4	0.4	0.4	0.3	0.3	0.3	–0.2
Eurasia	**14.5**	**13.1**	**15.2**	**15.5**	**15.5**	**15.5**	**15.4**	**0.9**

Source: OPEC.

Africa

Africa, excluding OPEC countries, is projected to see a very flat production outlook in the medium-term, with overall output increasing from 1.5 mb/d in 2019 to 1.7 mb/d in 2025 due mainly to a modest increment of 0.1 mb/d in Ghana in this period (Table 4.9).

Table 4.9
Africa: Medium-term liquids supply outlook

mb/d

	2019	2020	2021	2022	2023	2024	2025	Change 2019–2025
Chad	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Egypt	0.7	0.6	0.6	0.6	0.6	0.6	0.6	–0.1
Ghana	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.1
South Africa	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Sudan/South Sudan	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0
Other Africa	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0
Africa	**1.5**	**1.5**	**1.4**	**1.5**	**1.6**	**1.6**	**1.7**	**0.1**

Source: OPEC.

In the long-term, Africa is projected to see production remain flat. A slight decline in output in Egypt is offset by a small increase in Ghana (Table 4.10).

Table 4.10
Africa: Long-term liquids supply outlook

mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2019–2045
Chad	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Egypt	0.7	0.6	0.6	0.6	0.6	0.6	0.6	–0.1
Ghana	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.1
South Africa	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Sudan/South Sudan	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.0
Other Africa	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0
Africa	**1.5**	**1.5**	**1.7**	**1.7**	**1.6**	**1.6**	**1.5**	**0.0**

Source: OPEC.

Asia

Non-OECD Asia, including China, is the region expected to experience the most pronounced decline in liquids supply both in the medium- and long-term. Between 2019 and 2025, the region will see output fall from 7.5 mb/d to 7.3 mb/d, a drop of 0.2 mb/d as supply shrinks in a couple of mature Southeast Asian producers. Liquids supply in China, the region's largest producer, meanwhile stays flat at 4.1 mb/d in this period (Table 4.11).

Table 4.11
Asia: Medium-term liquids supply outlook *mb/d*

	2019	2020	2021	2022	2023	2024	2025	Change 2019–2025
Brunei	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
India	0.8	0.8	0.9	0.9	0.8	0.8	0.8	0.0
Indonesia	0.9	0.9	0.8	0.8	0.8	0.8	0.8	–0.1
Malaysia	0.7	0.6	0.6	0.7	0.6	0.6	0.6	–0.1
Thailand	0.5	0.5	0.5	0.5	0.5	0.5	0.5	–0.1
Viet Nam	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0
Other countries	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0
Other Asia	**3.5**	**3.3**	**3.3**	**3.3**	**3.3**	**3.2**	**3.2**	**–0.3**
China	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**0.0**
Non-OECD Asia	**7.5**	**7.4**	**7.4**	**7.4**	**7.4**	**7.3**	**7.3**	**–0.2**

Source: OPEC.

In the long-term, Asia's declining liquids supply is expected to be even more pronounced, with output falling in all major producers. Total liquids supply is projected to drop from 7.5 mb/d in 2029 to 6.3 mb/d in 2045. The single largest decline is expected in Indonesia, with output falling from 0.9 mb/d in 2019 to 0.6 mb/d in 2045 (Table 4.12).

Table 4.12
Asia: Long-term liquids supply outlook *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Change 2019–2045
Brunei	0.1	0.1	0.1	0.1	0.1	0.1	0.0	–0.1
India	0.8	0.8	0.8	0.8	0.8	0.8	0.7	–0.1
Indonesia	0.9	0.9	0.8	0.8	0.7	0.7	0.6	–0.3
Malaysia	0.7	0.6	0.6	0.6	0.5	0.5	0.5	–0.2
Thailand	0.5	0.5	0.5	0.5	0.4	0.4	0.4	–0.2
Viet Nam	0.2	0.2	0.2	0.2	0.2	0.2	0.2	–0.1
Other countries	0.2	0.2	0.2	0.2	0.1	0.1	0.1	–0.1
Other Asia	**3.5**	**3.3**	**3.2**	**3.1**	**2.9**	**2.7**	**2.4**	**–1.0**
China	**4.1**	**4.1**	**4.1**	**4.1**	**4.1**	**4.0**	**3.8**	**–0.2**
Non-OECD Asia	**7.5**	**7.4**	**7.3**	**7.1**	**7.0**	**6.6**	**6.3**	**–1.3**

Source: OPEC.

Middle East

Middle Eastern liquids supply (excluding OPEC Member Countries) is projected to show modest growth in the medium-term, rising from 3.2 mb/d in 2019 to 3.4 mb/d in 2025. Qatar is expected to see liquids supply grow by 0.2 mb/d on the back of increased production of NGLs related to gas production. Other Middle East will also experience an increase of 0.1 mb/d in this period (Table 4.13).

Table 4.13
Middle East: Medium-term liquids supply outlook *mb/d*

	2019	2020	2021	2022	2023	2024	2025	Change 2019–2025
Bahrain	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0
Oman	1.0	0.9	0.9	0.9	1.0	1.0	1.0	0.0
Qatar	2.0	2.0	2.0	2.0	2.0	2.0	2.1	0.2
Other Middle East	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Middle East	**3.2**	**3.1**	**3.1**	**3.2**	**3.2**	**3.3**	**3.4**	**0.2**

Source: OPEC.

In the long-term, Middle Eastern liquids supply will rise from 3.2 mb/d in 2019 to 3.8 mb/d in 2045. In this period, most growth will again stem from Qatar, which is projected to see further steady growth in NGLs output. Other Middle East will also experience growth of 0.1 mb/d in this period. Meanwhile, supply in mature producer Oman is expected to decline by 0.2 mb/d to 0.8 mb/d in the long-term (Table 4.14).

4

Table 4.14
Middle East: Long-term liquids supply outlook *mb/d*

	2019	2020	2025	2030	2035	2040	2045	Change 2019–2045
Bahrain	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.0
Oman	1.0	0.9	1.0	0.9	0.9	0.8	0.8	–0.2
Qatar	2.0	2.0	2.1	2.4	2.4	2.5	2.6	0.6
Other Middle East	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1
Middle East	**3.2**	**3.1**	**3.4**	**3.7**	**3.8**	**3.8**	**3.8**	**0.5**

Source: OPEC.

4.3.1 Major countries

US

As in previous Outlooks, US liquids remain key to the trajectory of non-OPEC supply. Due to its relatively high cost to produce, and unique elasticity to price, US tight oil supply has seen the largest shut-ins outside of the DoC. As much as 2–3 mb/d of US crude output was shuttered after prices declined sharply as a result of COVID-19 lockdown measures. At the same time, with markets having stabilized significantly since, not least as a result of the DoC voluntary adjustments, US tight oil production is expected to reach its nadir in the second half of 2020 and recover meaningfully in 2021 and beyond. In the medium-term, US total liquids supply will thus increase from 18.4 mb/d in 2019 to 19.8 mb/d in 2025, or an increment of 1.4 mb/d. Tight oil, including tight crude and unconventional NGLs, will increase by 2.8 mb/d in this period, more than offsetting declines in conventional crude oil, NGLs and biofuels (Table 4.15).

Table 4.15
US total liquids supply in the medium-term

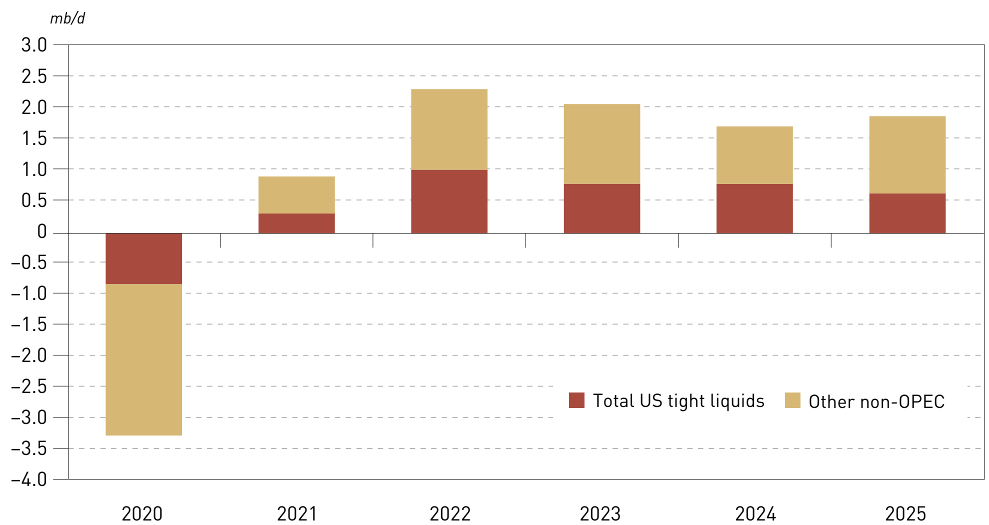
mb/d

	2019	2020	2021	2022	2023	2024	2025	Change 2019–2025
US tight oil	11.7	10.9	11.2	12.2	13.0	13.8	14.5	2.8
of which: tight crude	*7.7*	*6.9*	*7.1*	*7.9*	*8.6*	*9.3*	*9.8*	*2.0*
of which: unconventional NGLs	*4.0*	*4.0*	*4.1*	*4.3*	*4.4*	*4.5*	*4.7*	*0.7*
US Gulf of Mexico crude	1.9	1.9	1.9	1.9	1.9	1.8	1.8	–0.1
US Alaska crude	0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.0
US other crude	2.2	1.9	1.7	1.7	1.5	1.4	1.3	–0.9
US other NGLs	0.8	0.8	0.8	0.7	0.6	0.6	0.6	–0.2
US biofuels	1.1	0.9	1.0	1.1	1.1	1.1	1.1	–0.1
US other liquids	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0
Total US	**18.4**	**17.0**	**17.3**	**18.2**	**18.8**	**19.3**	**19.8**	**1.4**

Source: OPEC.

However, while this growth in US liquids supply is significant, its role in driving medium-term non-OPEC supply is diminished, compared to previous Outlooks. Even while the decline in non-US, non-OPEC supply in 2020 is greater than that of the US, in later years, non-US increments are now expected to be greater (Figure 4.4).

Figure 4.4
Composition of non-OPEC annual medium-term liquids supply growth



Source: OPEC.

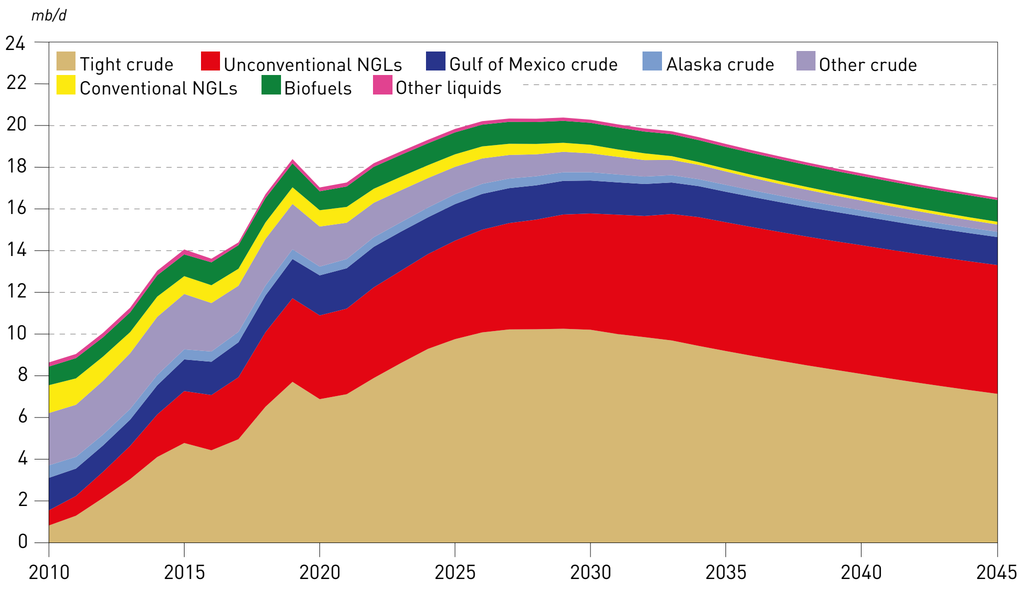
A more in-depth discussion of US tight oil developments and the outlook will follow in Section 4.5.2.

In the medium-term, US non-tight or conventional crude will decline by 1 mb/d. Alaska, after seeing temporary shut-ins in 2020, will see output rebound but remain flat at around 0.5 mb/d over the medium-term. Gulf of Mexico offshore crude is expected to remain robust in the near-term, as production from several new fields, including Mad Dog Phase 2, Vito and Kaskida, as well as the Thunder Horse South expansion, reaches capacity, but declines modestly thereafter to 1.8 mb/d. Other onshore crude output will continue its long-term decline, slightly accelerated by some 2020 shut-ins that are assumed to be permanent, including older, small 'stripper' wells where restarting output is simply uneconomic.

Meanwhile, conventional NGLs will decline modestly, even while unconventional NGLs from tight formations increase, in line with rising gas production. US biofuels, which mainly consist of fuel ethanol, will also see production decline slightly in the short-term, due to lower gasoline blending requirements and reduced margins. At the end of the medium-term, however, they recover to 2019 output levels of 1.1 mb/d.

After the mid-2020s, US total liquids production is projected to peak at 20.4 mb/d in 2029 as a result of tight liquids plateauing around the same time, at a total of 15.8 mb/d (Figure 4.5). Even while total crude production declines thereafter, NGLs will see continued, modest growth, while biofuels will remain flat. US total liquids are expected to decline to 16.6 mb/d by 2045.

Figure 4.5
US total liquids supply outlook



Source: OPEC.

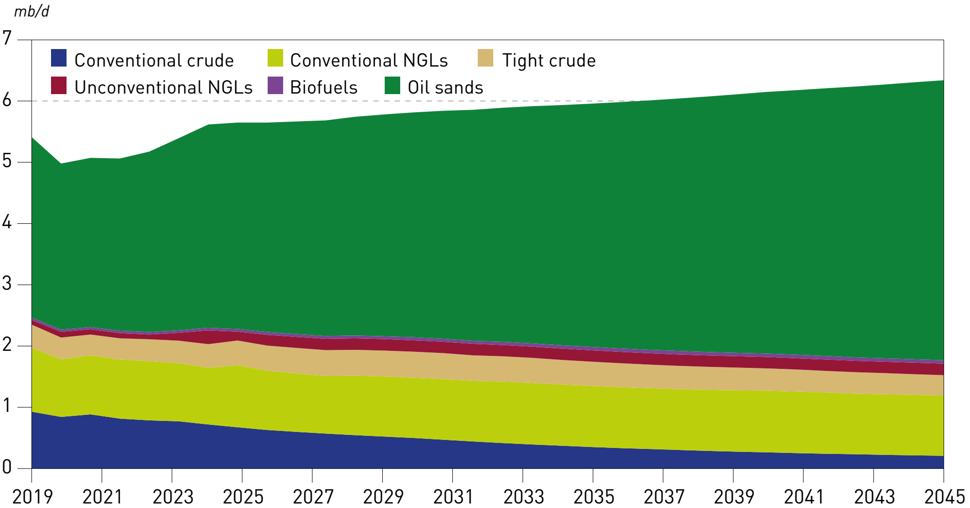
Canada

Canadian total liquids supply is projected to grow from 5.4 mb/d to 5.6 mb/d in the medium-term. Due to the COVID-19 pandemic-related price decline and also to some extent, congestion in the network of pipelines and regional storage related to export routes to the US, as much as 1 mb/d of supply was shut-in earlier this year. This is expected to return as markets stabilize and demand for Canadian heavy crude on the US Gulf Coast in particular recovers.

Thereafter, Canadian oil sands production returns to modest growth, with incremental supply from the Cold Lake, Meadow Creek East and May River projects. In terms of conventional crude, West White Rose will add 75 tb/d in the latter part of the medium-term, albeit later than previously expected. Meanwhile, a final investment decision on Equinor's 120 tb/d Bay du Nord project offshore the East Coast was shelved in March 2020 due to pandemic-related uncertainty.

In the longer-term, Canadian total liquids supply is expected to continue to grow (Figure 4.6), though at a slightly slower pace than previously estimated. Due to concerns related to the price outlook and lingering worries about pipeline export capacity expansion to the US and West Coast, which have led to heavy 'structural' discounts to local Canadian oil prices, some large-scale greenfield oil sands projects have been put on hold, including notably Imperial's Aspen project, with 75 tb/d, and Teck Resources' Frontier project, which with 260 tb/d, would have been one of the largest new oil sands projects in years. Nonetheless, volumes of oil sands-related output are expected to rise slowly, in addition to NGLs and tight crude production. Conventional crude production will experience a gradual decline, while biofuels output will remain flat. As a result, Canadian total liquids will rise to an estimated 6.2 mb/d by 2045, up from 5.4 mb/d in 2019, and thus still be one of the largest sources of long-term non-OPEC liquids supply growth.

Figure 4.6
Canada total liquids supply



Source: OPEC.

The ongoing saga concerning new or expanded pipeline capacity to export Canadian crude to the US, or its Pacific Coast, however, remains a possible constraint to further long-term supply growth. For instance, in April 2020, TC Energy, the developer of the 830 tb/d Keystone XL pipeline, announced its final investment decision to proceed with construction, to be completed by 2023. However, in the first half of 2020, US court decisions at least temporarily halted construction, claiming environmental reviews had been rushed. Given the likely more critical stance of a possible future Biden administration, the pipeline's future looks uncertain at the time of writing.

Meanwhile, after several challenges to the legality of the Trans Mountain pipeline's expansion from 300 tb/d to 890 tb/d in recent years, in mid-2020 the Canadian Supreme Court appeared to definitively allow the project to go ahead. Prior to the onset of the COVID-19 pandemic, the expansion was expected to be completed by mid-2022, though this date may now be delayed.

Mexico

Total liquids supply in Mexico is projected to remain relatively flat over the medium-term, averaging 1.9 mb/d, albeit with a dip to 1.8 mb/d in intervening years. Energy reforms announced in 2013 have resulted in new upstream investment, both by national oil company Pemex, as well as an assortment of other companies, which has successfully stemmed the long-term decline previously seen since the mid-2000s.

However, with a significant debt load, as well as new pressures resulting from the COVID-19 downturn, it appears that Pemex is struggling to meet its own commitments according to its business plan. In addition, political pressures to focus on cheaper, but potentially less prolific onshore fields, may mean that longer-term sustainable growth proves a challenge, especially in potentially bountiful deepwater areas. As such, this Outlook's projection is for Mexican liquids supply to modestly decline in the long-term, to 1.6 mb/d by 2045.

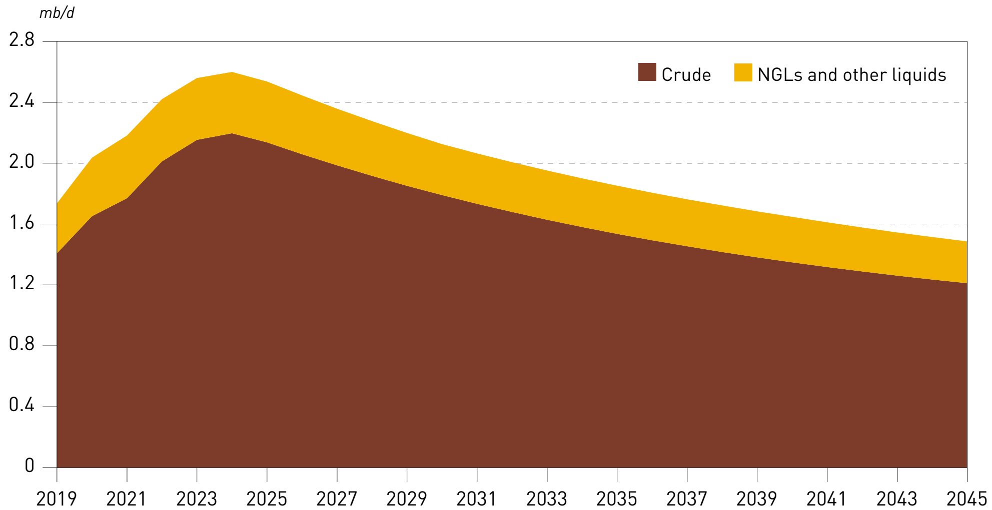
Norway

In the medium-term, Norway is projected to experience substantial supply growth, with total liquids rising from 1.7 mb/d in 2019 to 2.5 mb/d in 2025. A significant part of this growth is due to the giant Johan Sverdrup field, which started operating in late 2019 and is expected to reach Phase 1 capacity of 470 tb/d in the course of 2020. Phase 2 will add another 220 tb/d from 2022. Other field start-ups include Balder, further expansion of the Snorre field, Aerfugl and the large Johan Castberg field (200 tb/d), due to start production 2023.

Further support to medium-term developments will come from a tax break announced by the government in July 2020 in response to concerns about investment amid the COVID-19 pandemic. The government estimates it should effectively inject some $10 billion into the country's upstream sector in 2020 and 2021 by accelerating relief for capital spending.

In the long-term, after reaching an expected peak of 2.6 mb/d in 2024, natural decline in mature producing assets will result in Norwegian liquids production dropping again, to reach 1.5 mb/d in 2045 (Figure 4.7).

Figure 4.7
Norway total liquids supply



Source: OPEC.

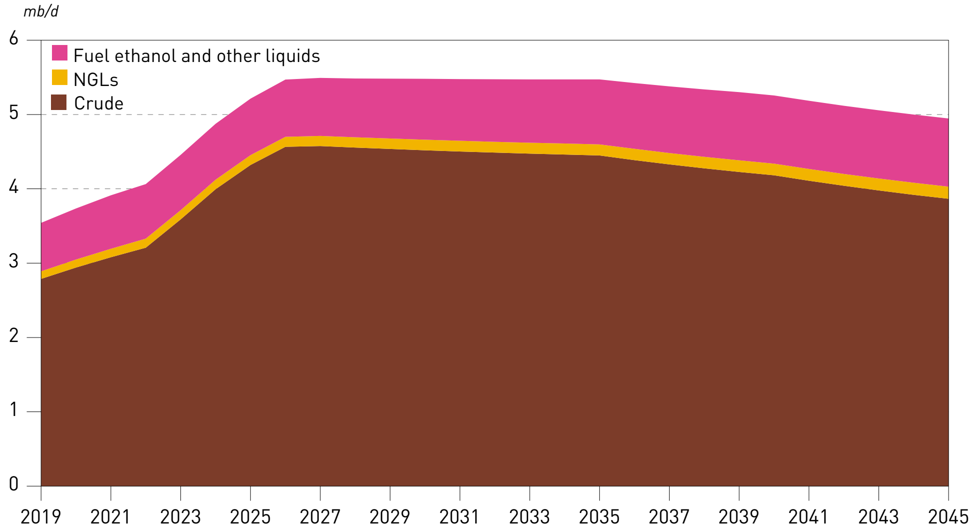
Brazil

Brazil is projected to make the single largest contribution towards non-OPEC supply growth, both in the medium- and long-term. With a string of large upstream projects mostly based upon the ultra-deepwater, pre-salt acreage in the Santos Basin, Brazil's total liquids supply is expected to grow from 3.5 mb/d in 2019 to 5.2 mb/d in 2025. Notable field start-ups in this period include further stages of the massive Buzios project (already the world's largest deepwater field), the Mero projects, Sepia, Lula Oeste and others. These large upstream additions – typically based around floating production, storage and offloading vessels (FPSOs) with a production capacity of 0.1–0.2 mb/d – will ensure strong growth, even as more mature production, either onshore or in the Campos Basin fields, sees relatively heavy natural decline.

Despite some project slippage due to the pandemic-induced price slump, beyond the medium-term, Brazil is projected to see further supply growth, as the resource base, well performance, economics and sheer economies of scale are likely to result in further investment in Brazil's pre-salt resources. Unlike other areas, even some upstream projects pencilled in to start up around the mid-2020s have not yet been taken off the drawing board. Moreover, expansions of production at existing blocks are likely to continue too, including at the aforementioned Buzios and Mero fields.

In addition to crude oil, fuel ethanol output is expected to continue to rise, albeit quite modestly. In sum, this means that Brazilian total liquids supply is projected to increase further beyond 2025, rising to a peak of 5.5 mb/d and plateauing at this level for around a decade before gradually declining again. As such, Brazilian total liquids is projected to average 4.9 mb/d in 2045, up from 3.5 mb/d in 2019 (Figure 4.8).

Figure 4.8
Brazil total liquids supply



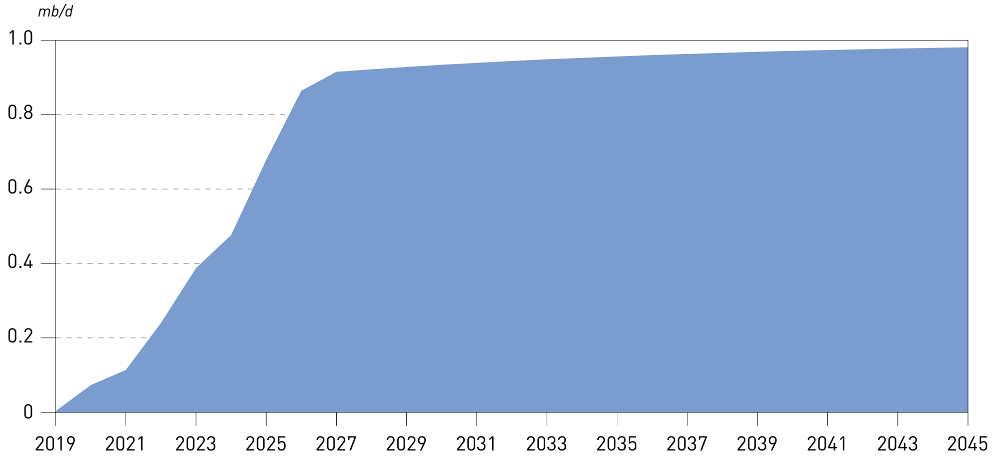
Source: OPEC.

Guyana

Guyana is on track to see its liquids production grow from zero in 2019 and around 0.1 mb/d in 2020, to 0.7 mb/d in 2025 (Figure 4.9), as output at the already-online Liza complex ramps up further and adds new stages in 2022 and 2024. Somewhat similar to Brazil further south, these are large 0.1–0.2 mb/d projects, and with some further upstream projects centred around the bountiful Stabroek block, will see production increase further.

Beyond 2025, further increments are expected to boost Guyana's total liquids production to 1 mb/d in the mid-2030s and plateau there. Further expansions are likely, given recent discoveries and prolific wells. However, until the country has absorbed its new-found oil income politically and economically – and on top of the current uncertain outlook given the COVID-19 pandemic – we are reluctant to project higher growth in the Reference Case.

Figure 4.9
Guyana total liquids supply



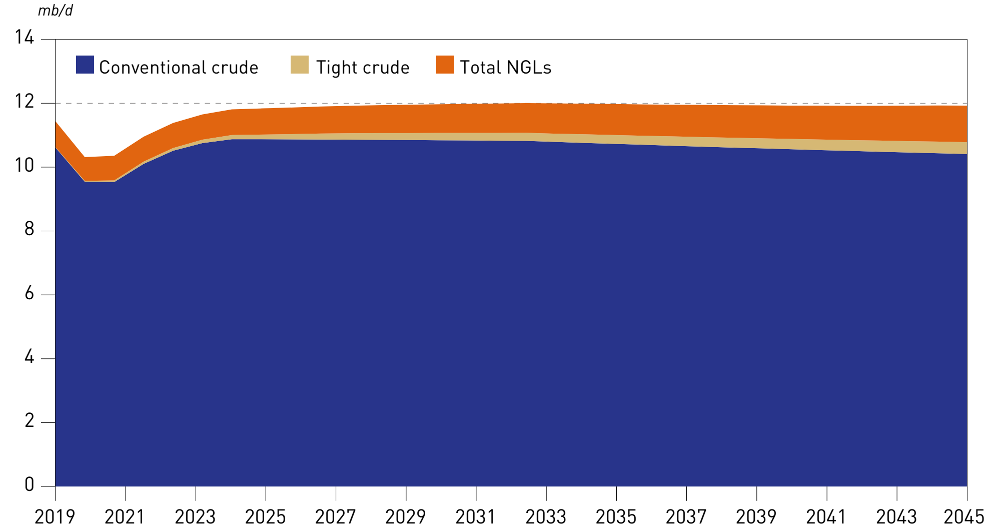
Source: OPEC.

4

Russia

Total liquids production in Russia is projected to grow from 11.4 mb/d in 2019 to 11.8 mb/d in 2025 on rising crude output (Figure 4.10). As the largest non-OPEC country participating in the voluntary DoC adjustments, Russia has adjusted production down sharply in 2020, with annual supply set to average 10.3 mb/d. In 2022, when the current DoC agreement is set to expire, Russia is expected to increase its output again, in addition to some new capacities coming online, including

Figure 4.10
Russia total liquids supply



Source: OPEC.

volumes from the Rakushechnoye, Tsentralnoye and Urengoiskoye projects. As a result, output will grow beyond restored volumes, rising to 11.8 mb/d by 2025.

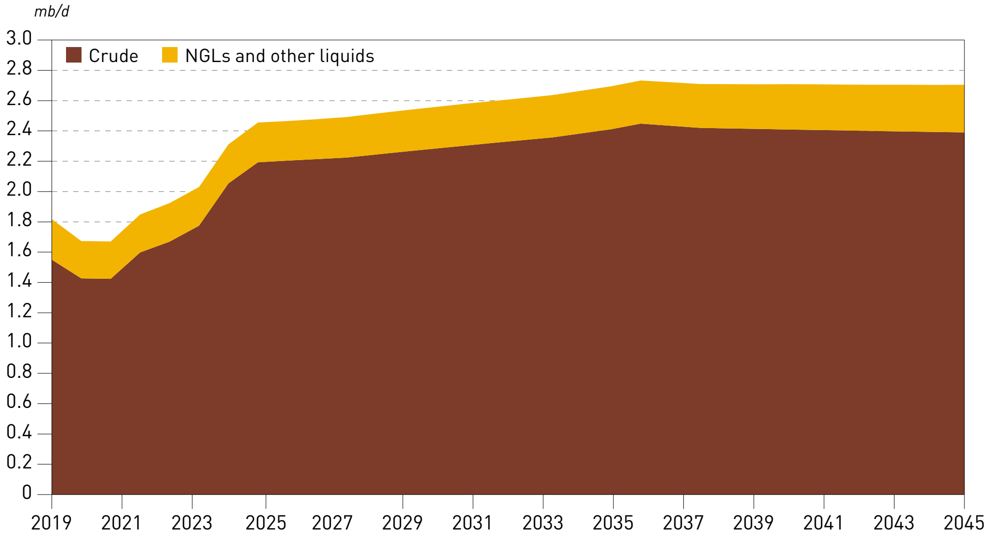
Thereafter, and in the long-term, despite having to offset decline at mature fields, Russia's total liquids production is expected to creep even slightly higher, peaking at 12 mb/d around 2030 and essentially plateauing there for the remainder of the forecast period.

Russia still hopes to develop assets in eastern and Arctic regions, which to some extent depends upon further support from the fiscal regime – and indeed, wider political support. In July 2020, Shell and Gazprom Neft agreed on a joint venture to explore and develop hydrocarbons on the Gydan peninsula in Russia's Arctic. As such, in the long-term, Russia's liquids supply will rise from 11.4 mb/d to 11.9 mb/d in 2045.

Kazakhstan

Similar to Russia, Kazakhstan is a major contributor to the DoC's voluntary production adjustments of April 2020. As such, its total liquids supply will dip from 1.8 mb/d in 2019 to below 1.7 mb/d in 2020. In the latter part of the medium-term period, increased output from further development stages of the huge Kashagan complex will serve to hike production. While the Tengiz Future Growth Project has now been delayed for a year, it will nonetheless add around 250 tb/d from 2023. In sum, Kazakhstan's output will rise to 2.3 mb/d in 2025, up by 0.7 mb/d from 2019 (Figure 4.11).

Figure 4.11
Kazakhstan total liquids supply



Source: OPEC.

In the longer-term, assumed modest further expansion of existing fields will see total liquids supply rise to some 2.7 mb/d in the next decade and remain there. As such, over the entire forecast period, Kazakhstan's total liquids supply rises from 1.8 mb/d in 2019, to 2.7 mb/d in 2045, or by 0.9 mb/d, making it one of the largest contributions to long-term non-OPEC supply growth.

4.4 Breakdown of liquids supply by type

Breaking down future non-OPEC liquids supply by type, several different and partly countervailing trends are observable. In the medium-term, crude oil drives growth, increasing by 4.1 mb/d, of which around half is US tight crude. In contrast, growth in NGLs, other liquids and biofuels is more modest volumetrically, with respective increments of 0.9 mb/d, 0.5 mb/d and 0.2 mb/d.

In the long-term, by contrast, non-OPEC crude oil declines by 5.6 mb/d. In part this reflects reduced US tight crude, which is projected to peak in the late 2020s. More broadly, however, it is a result of decline in many mature producing non-OPEC areas, including the North Sea and much of the onshore production in Africa, Latin America and Asia. Non-OPEC crude oil production thus declines from 45.9 mb/d in 2019 to 40.3 mb/d in 2045.

Meanwhile, non-OPEC NGLs production rises by a substantial 2.7 mb/d, from 10.5 mb/d in 2019 to 13.2 mb/d in 2045. A full 80% of this growth stems from unconventional NGLs production increases in the US. Another notable source is Qatar, where NGLs output is projected to increase by 0.5 mb/d in the long-term.

Meanwhile, other liquids production is projected to increase by 1.6 mb/d in the long-term, and global biofuels by 1 mb/d. At a collective 9 mb/d by 2045, this results in a 14% share of total non-OPEC, or 8% of global liquids supply (Table 4.16).

Table 4.16
Long-term global liquids supply outlook by type

mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2019–2045
Non-OPEC*	**65.0**	**61.8**	**70.7**	**71.5**	**69.9**	**67.6**	**65.4**	**0.4**
Crude	*45.9*	*43.5*	*50.0*	*48.9*	*46.0*	*43.0*	*40.3*	*–5.6*
NGLs	*10.5*	*10.3*	*11.3*	*12.5*	*13.0*	*13.2*	*13.2*	*2.7*
Global biofuels	*2.5*	*2.3*	*2.8*	*3.1*	*3.3*	*3.5*	*3.6*	*1.0*
Other liquids	*3.8*	*3.6*	*4.3*	*4.6*	*4.9*	*5.1*	*5.4*	*1.6*
Total OPEC liquids	**33.8**	**30.7**	**33.2**	**35.9**	**39.2**	**41.9**	**43.9**	**10.1**
World	**98.9**	**92.4**	**103.9**	**107.4**	**109.1**	**109.5**	**109.3**	**10.4**

* *The breakdown of non-OPEC supply does not include processing gains.*
Source: OPEC.

Non-OPEC biofuels are projected to grow from 2.5 mb/d in 2019 to 3.6 mb/d by 2045. Increments are spread globally, with Other Asia, Latin America, China and parts of the OECD making contributions. The US will remain a large producer of fuel ethanol, though it is expected to see a modest dip in output in the long-term, as gasoline demand moderates. Brazil, the second-largest producer of fuel ethanol globally, is projected to see output grow by 0.2 mb/d to 0.8 mb/d by 2045 (Table 4.17).

Biofuels growth in Other Asia and OECD Europe is rather driven by biodiesel, which will increase by 0.4 mb/d and 0.1 mb/d in those regions respectively. Globally, biodiesel output will rise to 1.3 mb/d by 2045, remaining at around one-third of global biofuels, while fuel ethanol is expected to increase to 2.3 mb/d in the long-term.

Table 4.17
Long-term non-OPEC biofuels supply outlook

mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2019–2045
OECD Americas	1.2	1.0	1.1	1.1	1.1	1.1	1.1	–0.1
of which: US fuel ethanol	*1.0*	*0.8*	*1.0*	*0.9*	*0.9*	*0.9*	*0.9*	*–0.1*
OECD Europe	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.1
OECD Asia Oceania	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
OECD	**1.5**	**1.3**	**1.5**	**1.5**	**1.6**	**1.6**	**1.6**	**0.1**
Latin America	0.7	0.8	0.9	0.9	1.0	1.0	1.0	0.3
of which: Brazilian fuel ethanol	*0.6*	*0.6*	*0.6*	*0.7*	*0.7*	*0.8*	*0.8*	*0.2*
China	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.2
Other Asia	0.2	0.2	0.3	0.4	0.5	0.6	0.6	0.4
Non-OECD	**1.1**	**1.1**	**1.3**	**1.5**	**1.8**	**2.0**	**2.0**	**0.9**
Non-OPEC	**2.5**	**2.3**	**2.8**	**3.1**	**3.3**	**3.5**	**3.6**	**1.0**
of which: fuel ethanol	*1.8*	*1.6*	*1.9*	*2.1*	*2.2*	*2.3*	*2.3*	*0.5*
of which: biodiesel	*0.7*	*0.7*	*0.9*	*1.0*	*1.1*	*1.3*	*1.3*	*0.6*

Source: OPEC.

Non-OPEC other liquids, which include unconventional barrels such as Canadian oil sands, coal-to-liquids (CTLs) and gas-to-liquids (GTLs), as well as minimal volumes of additives, oil shale and extra-heavy crude oil, are projected to rise from 3.8 mb/d in 2019 to 5.4 mb/d in 2045, or by 1.6 mb/d. The bulk of this is incremental supply of Canadian oil sands, which will rise from 2.9 mb/d in 2019 to 4.3 mb/d in 2045. CTLs and GTLs, meanwhile, see modest increments of 0.2 mb/d and 0.1 mb/d over the long-term (Table 4.18).

Table 4.18
Long-term non-OPEC other liquids supply outlook

mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2019–2045
OECD Americas	3.1	2.9	3.5	3.7	4.0	4.2	4.4	1.3
OECD Europe	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0
OECD	**3.4**	**3.1**	**3.7**	**4.0**	**4.2**	**4.4**	**4.7**	**1.3**
Africa	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Middle East	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	0.3	0.3	0.3	0.1
Non-OECD	**0.4**	**0.5**	**0.5**	**0.6**	**0.7**	**0.7**	**0.7**	**0.3**
Non-OPEC	**3.8**	**3.6**	**4.3**	**4.6**	**4.9**	**5.1**	**5.4**	**1.6**
of which: Canadian oil sands	*2.9*	*2.7*	*3.3*	*3.6*	*3.8*	*4.1*	*4.3*	*1.4*
of which: GTL	*0.2*	*0.2*	*0.2*	*0.2*	*0.3*	*0.3*	*0.3*	*0.1*
of which: CTL	*0.3*	*0.3*	*0.4*	*0.4*	*0.5*	*0.5*	*0.5*	*0.2*
of which: Other non-conventional liquids	*0.4*	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	*–0.1*

Source: OPEC.

4.5 Tight oil: US and other countries

4.5.1 Global tight oil supply outlook

The outlook for global tight oil supply remains overwhelmingly shaped by the US. In total, global tight oil liquids (tight crude and unconventional NGLs) will rise from 12.3 mb/d in 2019 to 15.4 mb/d by 2025, driven by growth in the US and, to a lesser extent, in Canada and Russia. Some further growth will push the global total to a peak of 17 mb/d in 2030. In the long-term, output will decline again, reaching 14.8 mb/d by 2045. Nonetheless, this implies global tight liquids rise from 19% of total non-OPEC supply in 2019 to 23% by 2045 (Table 4.19).

Table 4.19
Global tight liquids supply outlook

mb/d

	2019	2020	2025	2030	2035	2040	2045	Change 2019–2045
US	11.7	10.9	14.5	15.8	15.4	14.3	13.3	1.6
Canada	0.5	0.4	0.6	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	0.1	0.1	0.1	0.1	0.1	0.1
Total tight liquids	**12.3**	**11.4**	**15.4**	**17.0**	**16.7**	**15.7**	**14.8**	**2.5**

Source: OPEC.

4.5.2 US tight oil outlook

US tight liquids are projected to rise from 11.7 mb/d in 2019 to 14.5 mb/d by 2025. Besides concerted production adjustments by OPEC and non-OPEC countries participating in the DoC, as well as a handful of other countries that mandated some form of production shut-ins, the US tight oil sector saw the sharpest and quickest response to the lower oil price environment as a result of the COVID-19 pandemic, with crude oil production slumping by around 2–3 mb/d from pre-pandemic levels. Company statements for a while suggested even higher volumes of shut-ins, as oil prices fell below average bandwidths generally cited as breakeven thresholds for various producing areas in the US, including the Permian, Bakken, Eagle Ford and others.

Other measures of activity were similarly stark, including a decline in total oil rigs deployed, which fell from around 680 in mid-March to around 180 in early August 2020, their lowest since mid-2009, when oil markets were still recovering from the recession, and lower than the nadir of around 320 reached in mid-2016, when oil prices slumped the last time. Fracking activity, wells drilled, spudded, completed, frac crews active and other measures commonly cited were all similarly down in this period.

Amid news of severe cutbacks in investment, operations and staff, companies clamoured for support from the federal government. For the first time in nearly half a century, the Texas Railroad Commission seriously considered a mandated production cut, though in the end this was rejected. The idea of the US government buying crude oil to top up its Strategic Petroleum Reserve (SPR) was also floated, though in the end also rejected – though agreements were reached to store crude oil on behalf of Australia and India.

By contrast, liquids supply in other US producing regions, e.g. the US Gulf of Mexico offshore, was less affected, with only modest output reductions reported, and fewer future upstream projects postponed. Alaskan output was curtailed for a while, but has recovered.

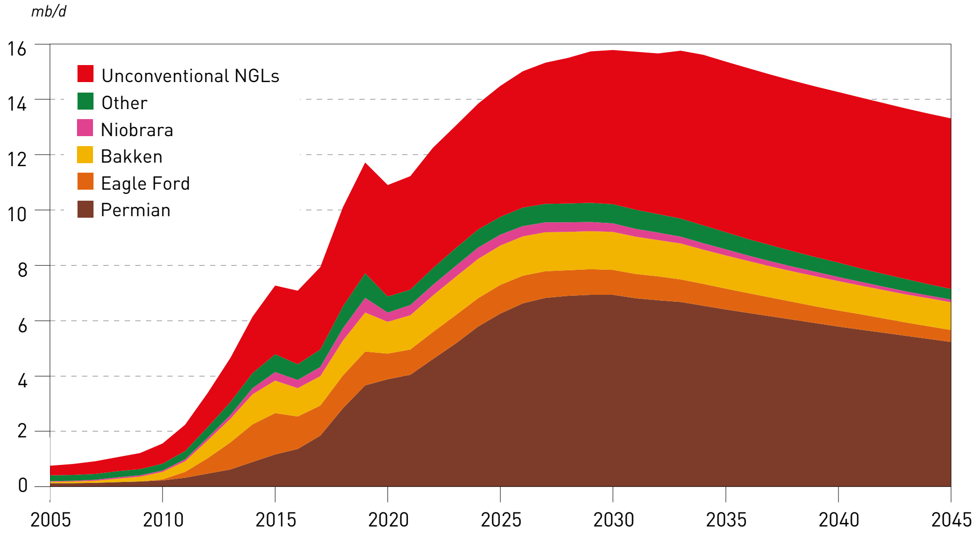
Another much-noted area of concern is upstream capital expenditure. As the pandemic hit, US-based E&Ps could hardly keep up with announcing cuts in spending, amid some much-discussed bankruptcies. In June, Chesapeake, one of the earliest and most successful participants in the shale boom, announced its bankruptcy despite having completed the transition from a focus on gas to a focus on liquids.

But the shale sector's responsiveness to price also works in reverse. At the time of writing, preliminary data suggested US crude oil production had stabilized, and rig counts and other measures also indicated a steadying of the situation in the US shale patch, after prices showed a period of relatively low volatility around $40/b throughout June, July and August 2020.

Furthermore, data provided by the EIA shows that even while rig counts dropped massively in the March–June period, productivity by and large remained high. According to Rystad Energy, this is because "new well productivity is increasing continuously due to the rise in average lateral length, high-grading of drilling locations in an environment of capital discipline, and a growing share of basins with more productive wells".

Moreover, larger integrated oil companies and the majors remain committed to shale, as a complementary, short-cycle/high-volume offset to their longer-cycle, capital-intensive mega-projects in deepwater, LNG, frontier areas, oil sands and the like. ExxonMobil and Chevron's much-discussed plans to produce around 1 mboe/d each of tight liquids in the US by 2024 in principle remain in place. Chevron also made headlines in the summer with its decision to buy independent Noble Energy, thus increasing its US shale production by nearly 0.2 mb/d and total proven oil and gas reserves by nearly 20%, compared to 2019.

Figure 4.12
US tight oil production breakdown



Source: OPEC.

Thus, in a more supportive oil market environment, projections are for a relatively rapid return to increased activity and resumed growth in US tight liquids supply. As such, the outlook is for US total tight liquids supply, following its sharp decline in 2020, to grow by 0.3 mb/d in 2021 and, as it gains momentum, by even larger average annual increments of 0.8 mb/d in the subsequent years. Thus by 2025, US total tight liquids supply will grow to 14.5 mb/d.

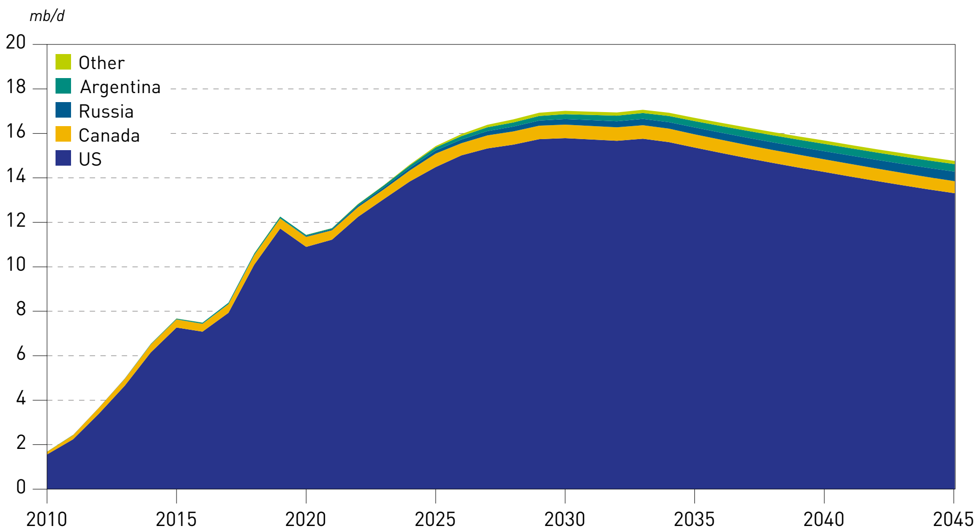
Thereafter, it will continue to grow, reaching a peak of 15.8 mb/d around 2030, and then plateauing for several years. Eventually, despite a modest increase in unconventional NGLs, output will decline gradually, to average 13.3 mb/d by 2045 (Figure 4.12).

4.5.3 Tight oil outlook for other countries

Tight liquids supply outside of the US will remain at modest volumes. Canada is projected to remain the second-largest tight oil producer behind the US, with supply growing to peak output around 0.6 mb/d.

Russia is expected to see the strongest growth in output, with volumes rising from currently very modest production to 0.4 mb/d in the long-term, as companies seek to develop new resources in order to keep production high. Argentina will also see tight liquids production rise significantly, averaging over 0.3 mb/d in the long-term, albeit less than previously forecast. With very modest volumes of tight liquids in Bahrain and China, global tight oil supply will rise from 12.3 mb/d in 2019 to a peak around 17 mb/d in 2030, and averaging 14.8 mb/d in 2045 (Figure 4.13).

Figure 4.13
Global tight liquids supply by country

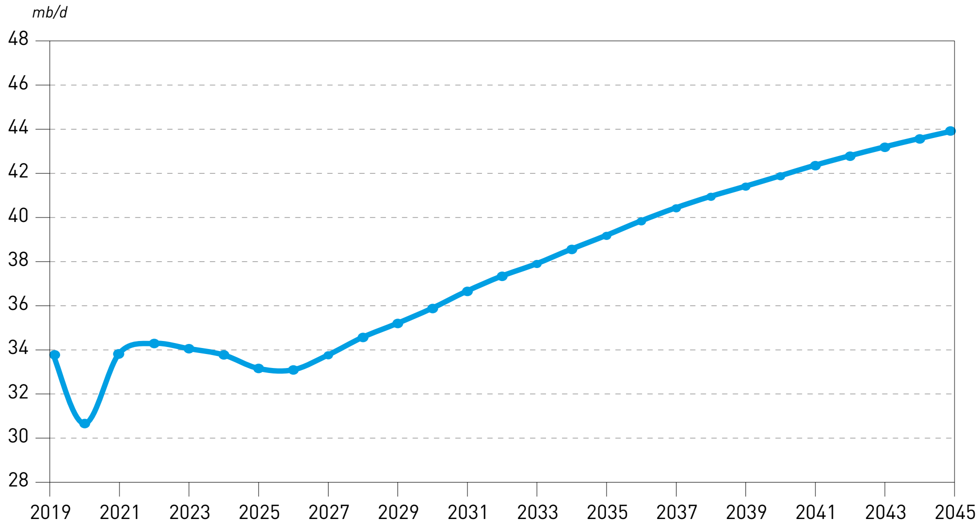


Source: OPEC.

4.6 OPEC liquids supply

Total OPEC liquids supply averaged 33.8 mb/d in 2019. After falling by over 3 mb/d in 2020 due to the production adjustments agreed, it is seen to recover thereafter, averaging just under 34 mb/d in the medium-term. As non-OPEC liquids supply growth begins to wane, total OPEC liquids supply is expected to increase again steadily, eventually rising to 43.9 mb/d in 2045, up by just over 10 mb/d over the entire outlook period (Figure 4.14). This means that as a share of global supply, OPEC total liquids rises from 34% in 2019 to 40% by 2045.

Figure 4.14
OPEC total liquids supply



Source: OPEC.

Box 4.1

The DoC: a vital platform for lasting market stability

The DoC, with its strong foundation, effective role and wide recognition, has been instrumental in countering the unprecedented impact of COVID-19 on the oil market. The DoC's successful engagement at the highest levels, including with the G20, further strengthened its firm response to the crisis.

The DoC has contributed to global market stability for nearly four years, and has played an especially significant role during the COVID-19 crisis.

The DoC came about as a result of the severe market downturn of 2014-2016, when the supply-driven imbalance upturned market fundamentals and led to much higher volatility by 2016. The acute imbalance, huge stock overhang and fallout of one of the worst price cycles in decades required urgent attention to help restore balance and stability to the market.

The landmark decision taken at the 170th (Extraordinary) Meeting of the OPEC Conference in Algiers, Algeria, held on 28 September 2016, was a culmination of many rounds of consultative meetings and intensive deliberations in Doha, Teheran, Paris and Algiers during 2016.

In the run-up to the Algiers Meeting, it was acknowledged that solidarity among OPEC Member Countries and cooperation with non-OPEC producing countries was of vital importance. Building on extensive and well-coordinated consultations, along with high levels of commitment and compromise, the 24 participating OPEC and non-OPEC producing nations signed the landmark DoC on 10 December 2016 at the OPEC Secretariat in Vienna, Austria.

The DoC's Joint Ministerial Monitoring Committee and the Joint Technical Committee, assisted by the OPEC Secretariat, have been instrumental in providing the transparency required to achieve the full, equitable and timely implementation of DoC decisions on voluntary production adjustments, which took effect for the first time on 1 January 2017.

Since then, the DoC has been a reliable instrument to help stabilize the market. OPEC and non-OPEC countries have proven time and again that participating countries can voluntarily adjust production as necessary, either up or down, to help address market fluctuations. The steady contributions of the DoC to market stability were reflected in the remarkable conformity level that, on average, has been above 100%.

Given their sustained success in addressing market conditions, the DoC participating countries endorsed the CoC on 2 July 2019 to extend their voluntary collaboration to other issues of common concern, such as climate change and the oil industry's continued importance in the world's evolving energy mix.

The proactive stance and effective engagement of the DoC and acclaimed success in supporting market stability provided a strong foundation to address the challenge of the COVID-19 pandemic. Governments took extreme but necessary measures to contain the pandemic, with inevitable consequences on the global economy.

The resulting deep recession caused a 20% contraction in world oil demand in the second quarter of 2020, intensifying commodity volatility, especially in oil, and causing prices to plunge to levels last seen in the late 1990s. Similarly, stocks and equities, especially energy-related assets, have been hit hard and in a manner not seen since the financial crisis of 2008 and 2009. The COVID-19 crisis and 2014–2016 oil market downturn have drained revenues and caused huge financial losses that ultimately threaten investment across the oil industry.

The magnitude of the observed oil glut has resulted in a persistent global oil imbalance. The decisions taken at the 10th (Extraordinary) OPEC and non-OPEC Ministerial Meeting on 12 April 2020 was historic both in magnitude and in duration. The crude oil production adjustments of 9.7 mb/d, followed by tapered adjustments until April 2022, represent the largest production adjustments ever undertaken by DoC participants, and the largest in oil industry history.

It is estimated that if the DoC had not acted in a decisive manner, the oversupply could have added a further 1.3 billion barrels to global crude oil stocks, exhausting available global crude oil storage capacity and reaching tank tops by June 2020.

In their June 2020 meeting, the Ministers reaffirmed their commitment to the production adjustments, including a compensation scheme to enable full conformity by each participating country. The global nature of the oil demand collapse, and the impact being felt by all producers, has created a stage for broader dialogue with other producers, as well as with consumers. This was illustrated by the strong support for the OPEC-led efforts at the G20 Extraordinary Energy Ministers Meeting held on 10 April 2020.

The G20 Energy Ministerial Meeting of 27 and 28 September 2020, meeting under the Presidency of the Kingdom of Saudi Arabia, reaffirmed the spirit of solidarity shown throughout the year to support energy security and market stability amid the impact of COVID-19. The establishment of the Energy Focus Group is a continuation of the historic G20 efforts on market stability, which are aligned in part with the DoC.

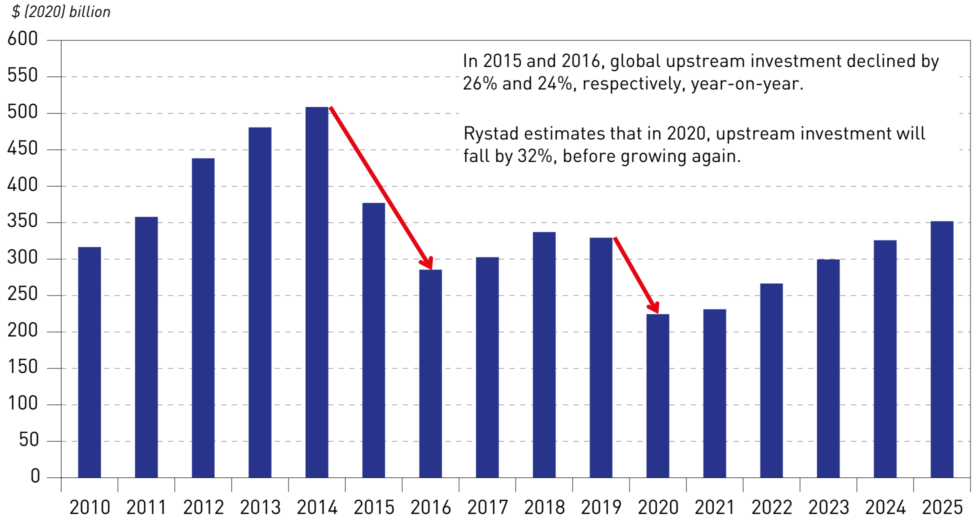
Under such unparalleled market conditions and the impact of the massive supply and demand imbalance in 2020, the DoC once again proved to be an agile and effective platform with timely, credible and swift actions. Furthermore, these efforts were recognized and supported by other energy stakeholders to benefit all consumers, the oil industry, investors and the world economy at large.

4.7 Upstream investment requirements

Upstream capital expenditure is expected to take a serious hit in 2020, as a direct response to the uncertainty surrounding the COVID-19 pandemic and the resulting sharp decline in oil prices. Relatively quickly in the emerging crisis, and in response to stakeholder concerns, energy companies started making announcements about significant cuts in overall spending, including in the upstream sector. Rystad Energy estimates that global upstream spending will decline by 32% in 2020, which exceeds the already dramatic annual declines seen in the previous downturn, when investment fell by 26% and 24% in 2015 and 2016, respectively.

However, Rystad Energy also expects a relatively rapid recovery in spending, with investment growing again from 2021, albeit taking time to pick up pace. By 2024/25, global annual spending should have recovered to 2019 levels, according to this outlook (Figure 4.15).

Figure 4.15
Global upstream (oil only) capital expenditure



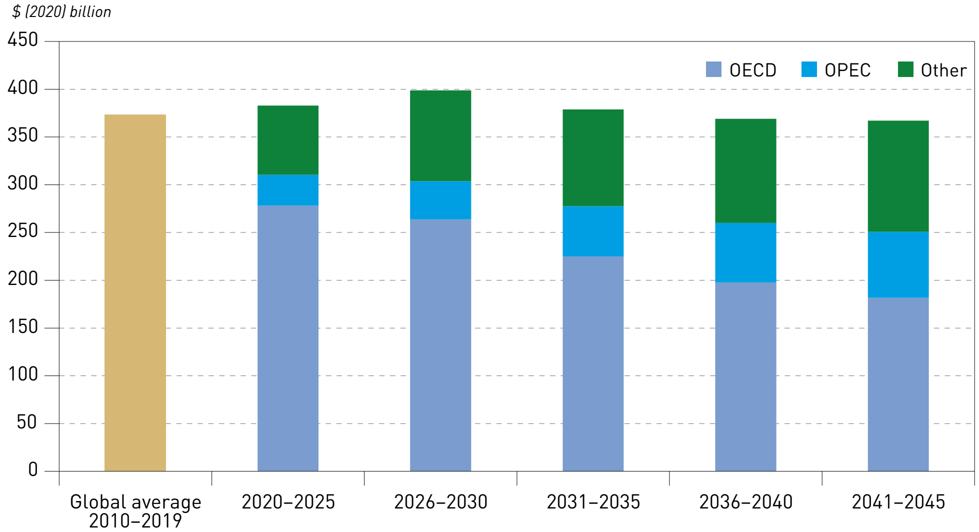
Source: Rystad Energy.

Perhaps unsurprisingly, US tight oil has been hit first and hardest, resulting in a sharp but brief downturn (see Section 4.5.2). Investments to maintain current production, including in-fill drilling and smaller tie-backs to existing hubs, will likely be less affected. Those upstream projects that are near completion will also go ahead. Many future projects meanwhile have been postponed by one to two years, though only few actually cancelled. Especially promising large-scale projects, including those in Brazil and newcomer Guyana, are expected to go ahead, albeit with some delays in the succession of start-ups at new fields. All of this assumes a supportive price environment.

According to OPEC's own calculations, based upon the supply projections in this Outlook, required future upstream spending will need to rise to a modestly higher annual average of $380 billion (in 2020 dollars) over the long-term. This includes a five-year period in 2026–2030 in which investment requirements will average $400 billion p.a.

The bulk of these investment requirements will be needed in OECD countries, reflecting the relatively high cost of developing and sustaining production in the US shale sector, Canadian oil sands and North Sea offshore production. However, over time, as their share in global production rises, investment in OPEC Member Countries will also need to step up, rising from an average requirement of $32.4 billion in the 2020–2025 period, to nearly $70 billion p.a. in 2041–2045 (Figure 4.16).

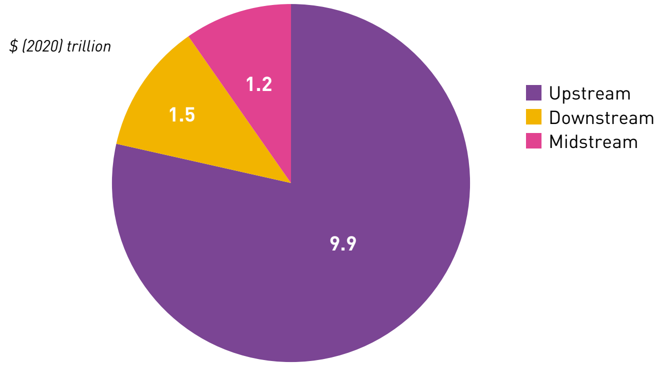
Figure 4.16
Annual upstream investment requirements



Source: Rystad Energy and OPEC.

Cumulatively, required global upstream capital expenditure over the full 2019–2045 Outlook horizon totals $9.9 trillion (in 2020 dollars). Added to an estimated $1.5 trillion required in the downstream, and a further $1.2 trillion in the midstream sector, this means cumulative oil-related investments over the long-term will need to be in the range of $12.6 trillion (Figure 4.17).

Figure 4.17
Cumulative oil-related investment requirements by sector, 2019–2045



Source: OPEC.

Refining outlook

Key takeaways

- The medium-term outlook projects crude distillation capacity additions of 5.2 mb/d for the period 2020–2025, of which 3.8 mb/d is expected to become operational by 2022, though delays are possible due to the COVID-19 pandemic.

- The downstream sector was severely impacted by COVID-19 and the related decline in oil demand, leading to a drop in utilization rates to record low levels during the first half of 2020.

- Around 80% of distillation capacity additions in the medium-term will be located in the Asia-Pacific (2.1 mb/d), the Middle East (1.3 mb/d) and Africa (0.8 mb/d).

- In the long-term (2020–2045), around 15.6 mb/d of new distillation capacity will be added, of which almost 13 mb/d will be located in the Asia-Pacific, the Middle East & Africa, in line with demand growth trends.

- Refinery additions in the long-term face gradual decline over time, in line with a slow-down in demand. The average annual addition between 2040 and 2045 is projected at 350 tb/d, down from 0.9 mb/d in the medium-term.

- In the long-term, around 7.9 mb/d of new conversion capacity, 17.7 mb/d of desulphurization capacity and 5 mb/d of octane units are projected to be commissioned.

- Due to the demand drop related to the COVID-19 outbreak, the cumulative gap between potential refining capacity and required refining capacity will be around 8.5 mb/d in 2020, narrowing to around 4.8 mb/d and 4.3 mb/d in 2021 and 2022, respectively.

- As demand increases and capacity expansion slows, the gap between potential and required refining capacity is expected to narrow to around 2.8 mb/d by 2025, mostly in Europe, the Middle East and Russia & Caspian.

- In the long-term, refinery throughputs are projected to increase from just below 82 mb/d to 87.3 mb/d in 2035. However, runs are expected to decline slightly and reach 87 mb/d in 2045, in line with the demand slowdown and the rising share of non-refinery streams. Consequently, the average utilization rate will decline from around 80% in 2019 to almost 75% after 2045 (assuming no closures beyond 2025).

- Projected refinery closures are at around 2.5 mb/d in the medium-term, mostly in Europe and the US & Canada. Even higher closures in the medium-term are possible, given the significance of COVID-19 related effects. Further closures of around 6 mb/d will be needed between 2025 and 2045 to keep average utilization rates at sustainable levels.

- Total required investments in the downstream sector between 2020 and 2045 are calculated at around $1.5 trillion of which $415 billion is needed for new refinery capacities and some $1.1 trillion for maintenance and replacement.

This chapter presents the outlook for the refining sector in the period to 2045. It takes the oil supply (Chapter 4) and demand (Chapter 3) projections and examines how different factors could impact the global refining sector. The analysis is conducted in two time frames – the medium-term (2020–2025) and long-term (2020–2045).

It first presents recent developments in the downstream sector, followed by an updated assessment of current 'base' capacity by region, as well as new refining capacity projections in the medium- and long-term.

Furthermore, the analysis in this chapter shows how the market balance changes in the medium-term on the global and regional level based on the projected refining capacity additions and oil demand outlook. The so-called 'call-on-refining' is compared to potential refining capacity. As a result, significant differences between regions will become visible, with different consequences for the downstream sector. In the long-term, based on the modelling cases of the global downstream sector, refinery throughputs and utilization rates are projected.

Refinery closures are also projected. In the medium-term, the projection is based on announcements and the assessment of potential closures by 2025. In the long-term and based on the projected regional utilization rate, the analysis gives an indication of the level of necessary closures to keep utilization rates at sustainable levels.

Secondary capacity is also analyzed 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 discussed.

Based on the projected refinery additions (primary and secondary), the necessary investment volume is calculated. Finally, this chapter looks at the key uncertainties to this Outlook and highlights 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

Following several years with rather modest refining capacity additions, 2019 was the first year with relatively high capacity expansions. Around 2 mb/d of new refining capacity was commissioned and/or became operational, largely in the Asia-Pacific and the Middle East. However, weaker-than-expected oil demand growth, the unexpected shutdown of one refinery in the US (the PES refinery on the East Coast), in combination with the continuous rise of non-refinery streams during 2019, led to only relatively low increases of refinery throughputs. Consequently, the global refinery utilization rate was calculated just above 80% in 2019, declining from 81.7% in 2018.

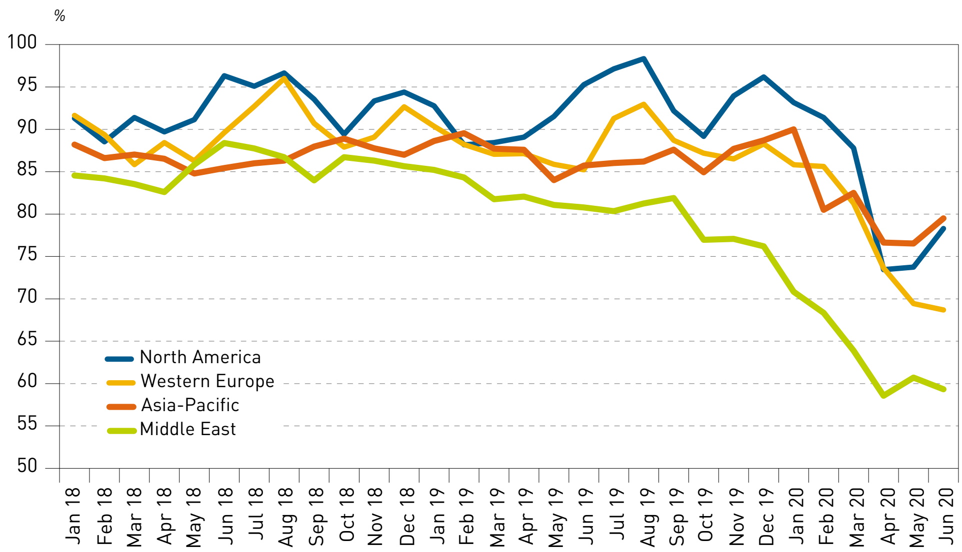
There was already a taste of an emerging refining overcapacity in 2019. Indeed, many market participants projected a looming age of consolidation in the medium-term. However, in late 2019, the focus of the refining industry was directed at the implementation of the International Maritime Organization (IMO) Sulphur Rule as of 1 January 2020, which was expected to provide some support to refining margins during 2020 and possibly even 2021. The IMO itself triggered several capacity additions (restarts) aimed at producing IMO-compliant fuels. Furthermore, there was general expectation for increasing demand growth in 2020 relative to 2019. This is why most market participants were bullish for the year 2020.

The bullishness of the market was quickly overshadowed in early 2020, however, once it became clear that the spread of COVID-19 would have a significant effect on global oil demand. Unprecedented demand decline in all major regions during first half of 2020 was the consequence (see Chapter 3).

At the time of writing this Outlook, 2020 demand is expected to be some 9 mb/d lower than 2019. As demand was declining and stocks were filling up, refinery runs in all major refining hubs plunged to levels well below 80% (Figure 5.1). Refinery throughputs plunged by nearly 12 mb/d in the second quarter of 2020 (y-o-y). Following the easing of restrictions in all major consuming regions from May 2020, oil demand also picked up with refinery runs increasing significantly. Nevertheless, refinery throughputs were still well below last year's levels.

Although refinery margins profited somewhat from lower operable refining capacity, as well as declining crude oil prices during March and April 2020, margins fell during May and June 2020 as oil prices recovered and refining capacity resumed.

Figure 5.1
Refinery utilization rates in selected regions



Source: OPEC.

Even though the refining sector immediately reacted with lower throughputs during 2020, the scale of the demand decline during the first half of 2020 led to significant product stock builds (including floating storage). The estimated refinery throughput was around 75 mb/d for 2020, including the aforementioned stock builds. While the flexibility of the market helped to increase commercial product stocks and thus prevent even lower refinery utilization rates during 2020, the potential stock draws during the second half of 2020 and 2021 are likely to hamper for a swift recovery of refinery margins and utilization rates.

The recovery of the downstream market will in the first place depend on demand recovery during 2020 and 2021. However, the overhang of refining capacity will remain an issue in the months and years to come. The analysis below will shed more light on the possible developments in the downstream market in the medium- and long-term.

5.1.2 Base refinery capacity in 2020

This section provides a detailed update to base capacity assessments (distillation and secondary capacity, including condensate splitters) of refineries worldwide. It includes additions to existing refineries, new refineries that came on stream, as well as closures that occurred in 2019. Both primary (distillation) capacity and secondary processing are covered.

The OPEC Secretariat's approach is that refineries, unless officially closed, are included in the database of 'nameplate' capacity, though 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 refinery capacity could be relied upon entirely. The quality and availability of capacity reporting varies by refinery so there is always an element of determining at a 'best estimate' for base capacity, as well for new projects and closures.

Distillation capacity

Table 5.1 provides details by region and process on the 102.6 mb/d of assessed base refinery capacity in January 2020. This level represents a significant increase from the 100 mb/d listed in WOO 2019 for January 2019. The difference derives from over 2 mb/d of new capacity additions combined with certain refinery restarts and capacity adjustments, notably 0.3 mb/d of additional base capacity identified in Russia.

Table 5.1
Assessed available base capacity as of January 2020

mb/d

	US & Canada	Latin America	Africa	Europe	Russia & Caspian	Middle East	China	Other Asia-Pacific	World
Distillation									
Crude oil (atmospheric)	20.7	7.7	3.8	16.1	7.6	10.2	17.0	19.4	102.6
Vacuum	9.4	3.4	1.1	6.7	3.2	3.0	5.1	6.1	38.0
Upgrading									
Coking	2.9	0.8	0.1	0.8	0.5	0.4	2.2	1.1	8.9
Catalytic cracking	5.8	1.6	0.2	2.3	0.9	1.1	3.9	3.6	19.3
Hydro cracking	2.5	0.2	0.2	2.2	0.6	0.9	2.2	1.6	10.4
Visbreaking	0.1	0.4	0.2	1.5	0.6	0.6	0.2	0.5	4.1
Solvent deasphalting	0.4	0.1	0.0	0.2	0.0	0.2	0.1	0.2	1.2
Gasoline									
Reforming	3.9	0.6	0.5	2.5	1.0	1.2	2.0	2.7	14.3
Isomerization	0.8	0.1	0.1	0.7	0.3	0.5	0.2	0.2	2.9
Alkylation	1.3	0.2	0.0	0.2	0.0	0.1	0.1	0.3	2.4
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	0.1	0.1	0.3
Desulphurization									
Naphtha	4.8	0.8	0.6	3.2	1.1	2.0	1.6	3.2	17.2
Gasoline	3.0	0.5	0.1	0.7	0.2	0.4	1.5	1.1	7.5
Middle distillates	6.7	2.1	0.8	5.8	2.2	2.9	4.0	6.2	30.8
Heavy oil/Residual fuel	3.0	0.4	0.0	1.8	0.2	0.7	0.8	2.7	9.7
Sulphur (short tons/day)	43,761	7,242	3,889	20,301	6,626	14,318	20,006	31,232	147,375
Hydrogen (million scf/d)	6,598	1,217	397	5,001	1,353	3,281	7,020	5,557	30,424

Source: OPEC.

As Table 5.1 illustrates, regional capacity differences are large, but also shifting. Over the past two years, the Middle East and Asia-Pacific combined have added around 4 mb/d of new capacity, to total over 46.5 mb/d or 45.5% of the global total. In contrast, refinery distillation capacity has remained flat in the US & Canada (20.7 mb/d or 20%). The latter occurred despite large increases in domestic crude and condensate production and essentially halted a creeping expansion that had been ongoing since 2000. Capacity in Europe has declined by 0.5 mb/d to 16.1 mb/d (15.7%) in the same period through ongoing rationalization, more than offsetting limited additions, while the Russia & Caspian region has risen by the same amount. Latin America and Africa have registered declines in capacity. In short, while capacity globally shows continued growth at a moderate pace, the picture varies noticeably from region to region.

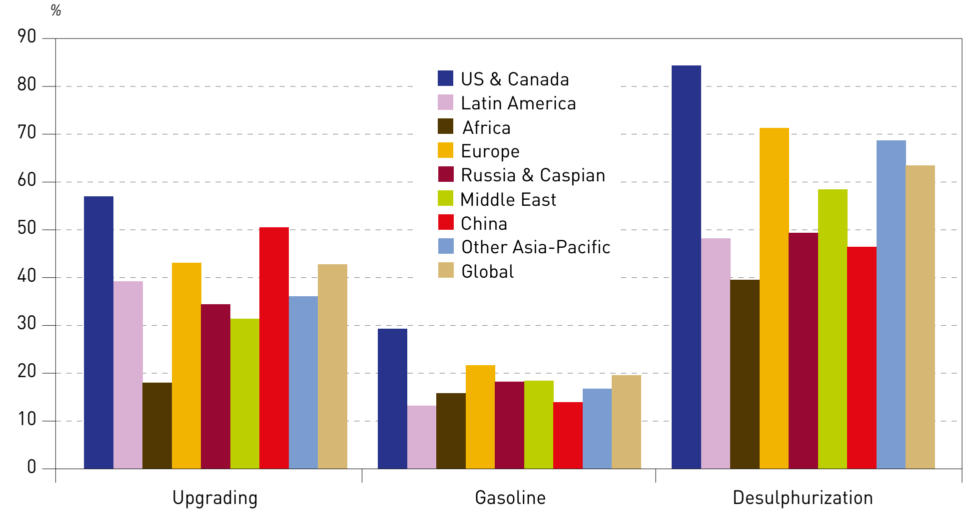
Secondary capacity

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.

The underlying drivers of this are the long-term shift towards incremental demand predominantly for light clean products, an associated gradual decline in the demand for residual fuel oil and increasingly stringent regulations on fuel quality. 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 37% of crude (atmospheric) distillation capacity, upgrading at 42.8%, gasoline octane units at 19.6% and desulphurization at 63.5%. A review of data from previous years confirms these ratios reflect a steady increase over time. These trends will also increase in the medium- and long-term.

Figure 5.2 summarizes the data from Table 5.1 as percentages of crude distillation capacity. The table highlights the variations in refinery complexity in different regions. On the three measures of upgrading, gasoline production and desulphurization relative to distillation, the US & Canada region represents the extreme with a traditionally very complex refining system. However,

Figure 5.2
Secondary capacity relative to distillation capacity, January 2020



Source: OPEC.

continued state-of-the-art refinery capacity additions in some developing countries have led to a rising share of secondary capacity, coming close to the levels in the US & Canada.

For upgrading capacity, the US & Canada has the highest ratio, which is around 57% of distillation capacity, followed by China, which is at around 51%. All other regions show values below 50%, in the range from 31% to 43%, apart from Africa at 18%.

Within the upgrading category, 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. 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 (21-31%) 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 29% of distillation capacity, which is in line with the region's exceptionally high gasoline consumption. Europe is at around 22%, illustrating the presence of the capacity installed before the switch to dieselization in Europe and leading to a gasoline surplus. Other regions show the share of gasoline units in the range of 13% to 18%.

Desulphurization levels vary widely across regions, depending on the fuel standards, as well as typical crude slates. The highest share of desulphurization is seen in the US & Canada at 84%, which is more than double that of the lowest region, Africa, at 40%. Refineries in the US & Canada had traditionally been using heavy and medium-sour crudes, produced locally, but also imported from other regions such as Latin America and the Middle East. However, since the uptake of the light-sweet tight oil production in recent years, the share of heavier crudes in the slate has declined significantly. Europe and Other Asia-Pacific are each around 70% and the Middle East is at 58%. In the remaining regions – Latin America, Russia & Caspian and China – the level is just under 50%. In Europe, as is the case in the US & Canada, the high ratio reflects the long-established implementation of ultra-low sulphur (ULS) fuel standards, while in the Other Asia-Pacific and the Middle East, the high/rising levels reflect a situation where large new refineries are invariably built for high levels of clean fuel output, generally 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 expected 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

Refining capacity additions between 2020 and 2025 are estimated at around 5.2 mb/d based on the review of announced and planned refinery projects. Following the pattern of previous outlooks, the majority of new capacity will be added in developing regions led by the Middle East and Asia-Pacific. Significant capacity additions are also expected in Africa in the medium-term period. Additions of new refining capacity are clearly in line with oil demand growth expectations, which show positive trends in most developing countries.

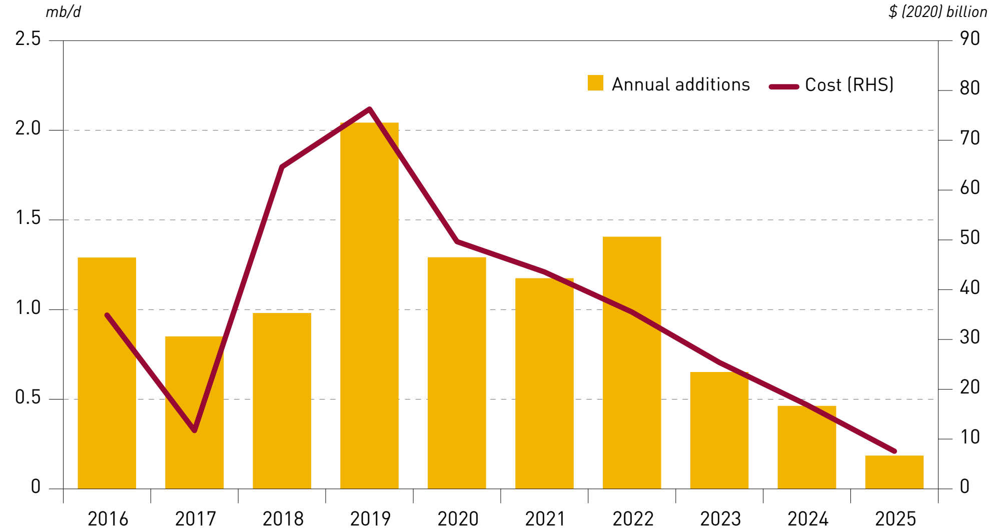
While annual additions in recent years were at levels of around 1 mb/d, 2019 saw significant expansion of around 2 mb/d as several large projects came online. Looking forward, the rate of expansion is expected to materialize at somewhat lower levels. The demand drop in 2020 due to the outbreak of COVID-19 will contribute to this trend. The average addition rate for the period 2020–2025 is likely to reach levels of 0.9 mb/d.

Figure 5.3 shows the annual capacity additions expected to come online for 2020–2025, as well as assumed annual investments. The figure does not account for assumed closures in this period as these are discussed separately (Section 5.2.5). Figure 5.3 also does not include minor additions at existing refineries for debottlenecking purposes.

However, in line with trends observed in last year's Outlook, the medium-term projection sees front-loaded capacity new builds (Figure 5.3). In the period 2020–2022, average annual additions are expected at around 1.3 mb/d. This is significantly higher compared to the average addition rate of 450 tb/d for the period 2023–2025. In 2025 alone additions are projected at only 0.2 mb/d. The slowdown in expected annual additions is the result of the uncertainties related to oil demand, the path of the economic recovery and projected oversupply in the downstream market in the medium-term period.

It also needs to be noted that there is a great deal of uncertainty. The crisis caused by the outbreak of COVID-19 may lead to delays of some projects in this outlook, thus shifting commissioning dates from the first period towards the second half of the medium-term. Furthermore, the uncertainty is even higher for projects in the second half of the medium-term period. Consequently, it is possible that some projects expected to go online in the medium-term period may become operational only after 2025.

Figure 5.3
Annual distillation capacity additions & total projects investment



Source: OPEC.

Projected additions of 5.2 mb/d for the period 2020–2025 are significantly lower compared to the outlook of 7.95 mb/d estimated for the period 2019–2024. The extreme uncertainty related to oil demand development as described above is clearly one of the reasons for the more pessimistic outlook. However, the rising overhang of refining capacity from previous years is also one of the reasons for the slowdown. For instance, during 2019 additions of around 2 mb/d were recorded, while at the same time the increase in crude throughputs was minimal (around 0.2 mb/d).

Table 5.2 and Figure 5.4 illustrate projected capacity additions by region and by year. As described before and in line with previous Outlooks, the majority of capacity additions are expected in the Middle East and Asia-Pacific. The major driver is the expected oil demand growth, as well as the shift to increase product exports (mostly in the Middle East). Combined, the Middle East and Asia-Pacific are projected to add around 3.4 mb/d of new refining capacity, which is roughly 65% of total additions in the medium-term. This is accounted for by several large projects scheduled to come online in the coming years, including the Al-Zour refinery in Kuwait, the Duqm refinery in Oman, several plants that focus on petrochemicals in China, as well as new refineries in Malaysia and Indonesia.

Table 5.2
Distillation capacity additions from existing projects by region *mb/d*

	US & Canada	Latin America	Africa	Europe	Russia & Caspian	Middle East	China	Other Asia Pacific	World
2020	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.5	1.3
2021	0.0	0.1	0.0	0.0	0.2	0.6	0.1	0.1	1.2
2022	0.1	0.0	0.6	0.0	0.1	0.2	0.2	0.1	1.4
2023	0.1	0.0	0.1	0.0	0.0	0.1	0.2	0.2	0.7
2024	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.5
2025	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2
2020–2025	**0.3**	**0.2**	**0.8**	**0.0**	**0.4**	**1.3**	**0.9**	**1.2**	**5.2**
%	*6.3*	*4.5*	*15.0*	*0.7*	*8.3*	*24.9*	*17.7*	*22.6*	*100.0*

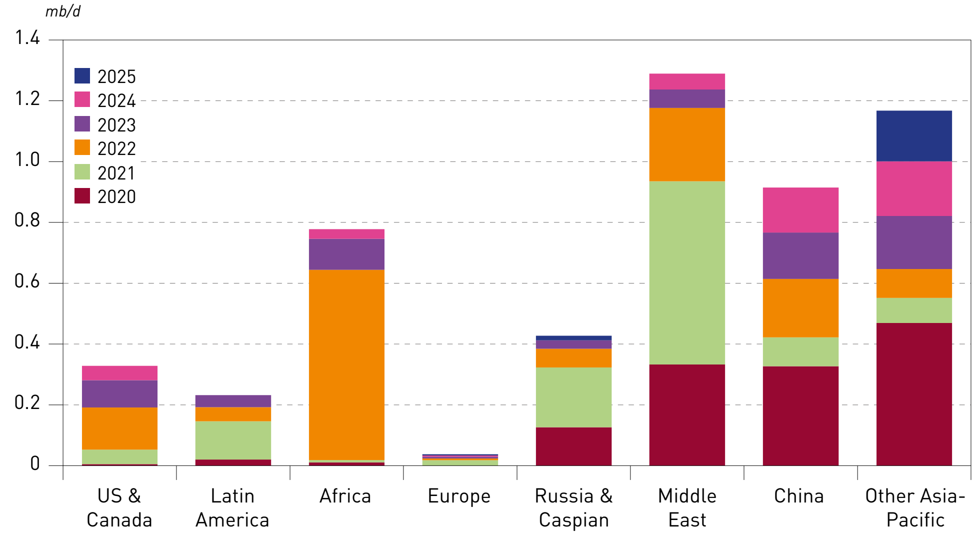
Source: OPEC.

Significant additions are expected in Africa, totalling around 0.8 mb/d or 15% of the global volume. The largest project expected to come online is the Dangote refinery in Nigeria in 2022, as well as several smaller projects in Egypt and Algeria. This significant increase in refining capacity is somewhat larger than incremental demand in the medium-term and could help to reduce product imports, especially in West Africa.

Other regions, including the US & Canada, Russia & Caspian, Europe and Latin America, are projected to add around 1 mb/d combined, less than 20% of the total additions in the medium-term. In the US, ExxonMobil is expected to finalize its Beaumont refinery in Texas in the medium-term. Initially planned for 2022, the refinery may be delayed by one year due to the current demand drop and efforts to reduce capital expenditures in coming years. Elsewhere, although the supply/demand balance would support expansion of the refining system in Latin America, the projection is for only around 0.2 mb/d of new capacity in the medium-term. Continuous delays in the past and the recent cuts in capital expenditures following the outbreak of COVID-19 are the major reason for low refinery additions in the medium-term. In the Russia & Caspian region total additions are projected to reach around 0.4 mb/d by 2025, which consist of several smaller projects, partly expansions of existing refineries.

As every year, this Outlook needs to be taken with a degree of caution. This is required when analyzing capacity additions – even for known refining projects – as most of these projects have long lead times between first announcement and project finalization. The tendency is for refinery projects to 'slip' for various reasons, including delays in financing or technical difficulties. This is why the project evaluation process undertaken annually entails a 'risking' of both the probability of, and the time frame for, completion. This year, the level of uncertainty is even higher, bearing in mind the shock of the COVID-19 pandemic and its consequences on the global economy, including energy and oil markets.

Figure 5.4
Distillation capacity additions from existing projects, 2020–2025



Source: OPEC.

Finally, it is important to note that 5.2 mb/d of 'firm' refining distillation capacity in the medium-term (2020–2025) compares to around 30 mb/d for the significantly higher volume of announced projects or projects in the planning stage. Around 75%, or almost 3.9 mb/d, of total 'firm' capacity is considered to be in the construction phase or close to this stage. The rest, or around 1.3 mb/d, consists of projects that are still not close to the construction phase, but are seen advanced enough in terms of engineering, financing and overall support to be accorded a high probability of coming on stream by 2025. The risk is clearly to the downside as there is little probability that some projects will be built by 2025, while some of the 'firm' projects may be shifted to after 2025 or cancelled.

5.2.2 Long-term distillation capacity additions

Unlike the outlook for refining capacity in the medium-term, the long-term outlook is based on the modelling of the global refining market taking into account world oil demand (Chapter 3) and supply (Chapter 4), base refining capacity (Section 5.1), medium-term refining capacity additions (Section 5.2.1), as well as assumed refining closures in the medium-term (Section 5.2.5). Modelling results are summarized in Table 5.3. 'Assessed projects' refers to refining projects that are considered 'firm' as described in Section 5.2.1.

As shown in Figure 5.5, the rate of additions (not including closures) is projected to slow from more than 5 mb/d in the period 2020–2025 to just below 3 mb/d in the period 2030–2035 and finally to a level around only 1.8 mb/d in 2040–2045. In other words, refinery additions are clearly front-loaded, implying that less capacity will be needed in the latter part of the period. This is in line with the slowdown in oil demand growth, but also with the increase in the supply of non-refinery streams such as NGLs, biofuels, CTLs and GTLs between 2020 and 2045.

The calculated annualized additions in the period 2020–2022 are still relatively high at around 1.3 mb/d. However, annualized additions are projected to decrease gradually towards 0.5 mb/d in the period 2030–2035. The trend continues and annualized additions on the global level are calculated at only 350 tb/d in the last five years of this Outlook. This means with projected annual additions of 350 tb/d on the global level, the expansion of existing capacity may be more common than the construction of new greenfield refineries.

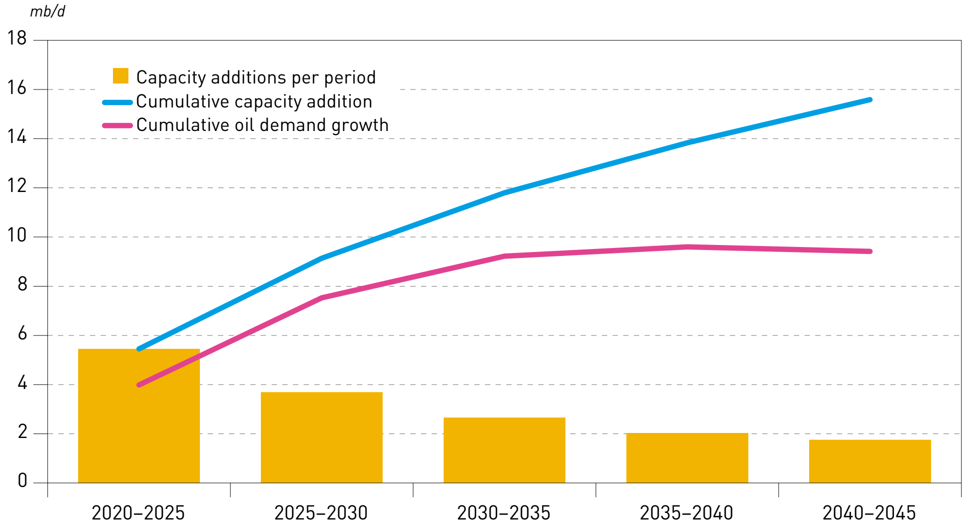
Table 5.3
Global demand growth and refinery distillation capacity additions by period *mb/d*

	Global demand growth	Distillation capacity additions starting 2020			
		Assessed projects*	New units	Total	Annualized
2019–2025	4.0	5.2	0.2	5.4	0.9
2025–2030	3.5	0.0	3.7	3.7	0.7
2030–2035	1.7	0.0	2.7	2.7	0.5
2035–2040	0.4	0.0	2.0	2.0	0.4
2040–2045	–0.2	0.0	1.8	1.8	0.4
	Global demand growth	Cumulative distillation capacity additions			
		Assessed projects*	New units	Total	Annualized
2019–2025	4.0	5.2	0.2	5.4	0.9
2019–2030	7.5	5.2	3.9	9.1	0.8
2019–2035	9.2	5.2	6.6	11.8	0.7
2019–2040	9.6	5.2	8.6	13.8	0.7
2019–2045	9.4	5.2	10.4	15.6	0.6

* *Firm projects exclude additions resulting from capacity creep.*
Source: OPEC.

However, it is important to note that while global oil demand growth is minimal after 2030, there are still significant refining additions needed (Figure 5.5). The major driver is the considerable demand growth in developing countries, where new refining capacity is projected to come online. Demand growth in the Asia-Pacific, without OECD Asia Oceania, is expected to increase by more than 14 mb/d between 2019 and 2045. Strong demand growth is also projected for the Middle East and Africa, with a combined increase of almost 6.5 mb/d in the same period. Moderate oil demand growth is also seen in Latin America in the same period.

Figure 5.5
Distillation capacity additions and oil demand growth, 2020–2045



Source: OPEC.

At the same time, demand projections for developed regions are showing negative trends throughout the outlook period. Demand in OECD regions is projected to decline by around 13 mb/d between 2019 and 2045 (mostly in the US & Canada and Europe). This implies fundamental shifts for the downstream industry in these regions, leading to either rising product exports to other regions or refinery closures if lower utilization rates are to be avoided. Furthermore, declining demand in these regions would also lead to lower product imports, affecting exporting regions such as the Middle East and Russia & Caspian, with some of these volumes being redirected elsewhere.

Furthermore, the driver of capacity additions is not only local demand, but also strategic investment in order to increase product exports. This is clearly the case for oil exporting countries in the Middle East, with efforts to replace crude oil exports with refined product exports. Furthermore, several Middle Eastern oil companies are participating in downstream projects in the Asia-Pacific, including India and China, with the aim to penetrate downstream markets in these countries.

The clear consequence of the widening gap between refining capacity additions and oil demand growth on the global level is the declining average utilization rate. While the utilization rate was just below 82% in 2019, it is projected to drop by almost 7 pp and reach levels of around 75.5% in 2045. This will clearly call for consolidation of the downstream market and potentially refinery closures, especially in the regions with declining long-term demand. Refinery utilization trends, as well as refinery closures, will be discussed in more detail later.

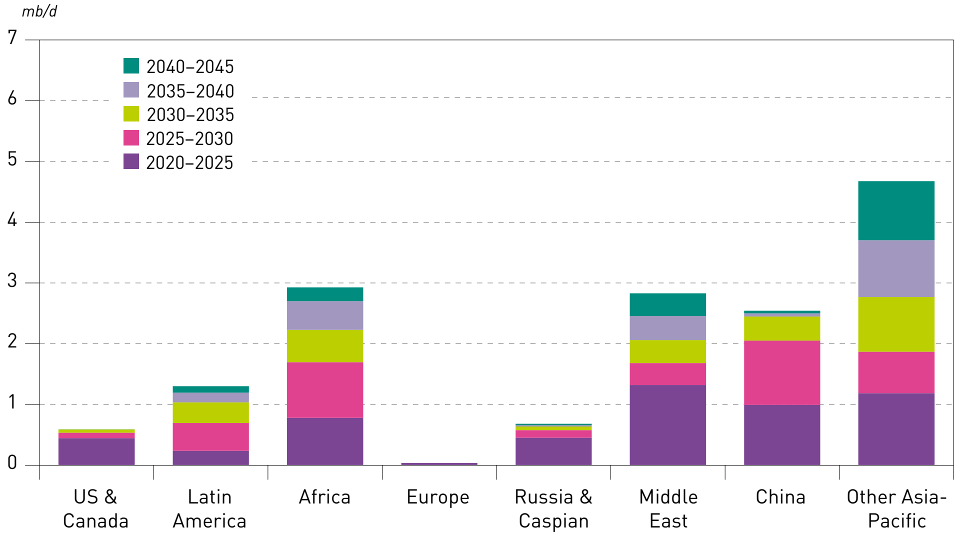
That being said, the slowing pace of 'necessary' long-term refinery capacity additions remains evident, meaning that whoever invests first in new capacity may be in a better competitive position compared to those who try to justify major investments in later years when demand growth is expected to be lower.

Regional additions

As shown in Figure 5.6, the distribution of refinery capacity additions is concentrated in non-OECD regions including the Asia-Pacific, Middle East, Africa and Latin America. There are also some additions in developed countries, but they remain limited mostly to the expansion of existing

5

Figure 5.6
Crude distillation capacity additions, 2020–2045



Source: OPEC.

refineries, including debottlenecking. Similar to the medium-term outlook, the share of refinery additions in the Asia-Pacific and the Middle East is projected at around 65% (about 10 mb/d) between 2020 and 2045. Projected additions in Africa are also significant, accounting for almost 20% (2.9 mb/d) of the total projected volume, while in Latin America around 1.3 mb/d (8%) of new capacity is expected. The US & Canada, as well as Russia & Caspian make up around 4% each of the total refinery additions, while in Europe only minor capacity expansion is projected.

Other Asia-Pacific (excluding China) is the region with the most capacity additions in the long-term, reaching 4.7 mb/d by 2045. In the medium-term, additions are projected at around 1.2 mb/d, which is almost identical to the demand growth in this period. As the medium-term balance shows a slight overhang of refining capacity relative to refined product demand, additions are projected to slow in the period 2025–2030 to around a cumulative 0.7 mb/d. However, as the demand in this region continues to grow at healthy rates, refinery capacity increments are seen at levels of around 0.9 mb/d to 1 mb/d for each of the five-year periods from 2030 onwards. There are several potentially large projects in the region that may materialize in the long-term, such as the 1.2 mb/d project in India (with cooperation between Saudi Aramco, ADNOC, Indian Oil Corp, Bharat Petroleum and Hindustan Petroleum) and several projects in Viet Nam, Indonesia and Pakistan. However, the COVID-19 pandemic and the associated drop in demand and oil prices during 2020 could lead to postponements or even cancellations of some previously planned projects.

In **China**, following additions of 1 mb/d (including debottlenecking) in the period 2020–2025, another 1 mb/d is projected for the period 2025–2030, driven by still relatively strong demand. However, in line with the demand growth slowdown in China from 2030 onwards, refinery additions are also projected to decline to around 0.4 mb/d in the period 2030–2035. Refinery additions post-2035 are limited only to minor expansions, which are also due to the fact that demand for refinery fuels plateaus after 2030 and the share of non-refinery streams rises (e.g. biofuels and CTL). Consequently, total additions in China are projected at around 2.5 mb/d between 2020 and 2045.

In the **Middle East,** refinery capacity additions are clearly front-loaded with around 1.3 mb/d of new capacity between 2020 and 2025, which is considerably higher relative to the demand increase in the same period. Additions in the post-2025 period are expected to level off in line with the gradual decline in demand growth, with expected additions in the range of 0.3 mb/d to 0.4 mb/d for each of the five-year periods after 2025. In total, expected refinery additions in the Middle East are seen at around 2.8 mb/d between 2020 and 2045.

Africa is projected to add 2.9 mb/d of distillation capacity by 2045. While the refining capacity additions in the medium-term are estimated at 0.8 mb/d, refinery additions in the period 2025–2030 are expected to be above 0.9 mb/d. Expected additions of 1.9 mb/d by 2030 are likely not only to cover the projected demand growth in Africa, but also to slightly reduce product imports from other regions. Even after 2030, demand growth remains the major driver of distillation capacity additions, which are expected to decline from around 0.5 mb/d in the period 2030-2035 to only around 0.2 mb/d between 2040 and 2045.

It is important to note that modelling results post-2025 indicate the need for additional refining capacity based on demand and supply patterns. However, the implementation and management of new projects in terms of planning, financing and construction may remain a challenge. Furthermore, there is a need for refurbishment of a large number of existing old and inefficient refineries in order to improve utilization rates in the long-term.

In **Latin America**, total distillation capacity additions by 2045 are estimated at around 1.3 mb/d, which is broadly in line with the expected demand growth after deducting the projected growth in non-refinery fuels such as ethanol (e.g. in Brazil). While additions in the medium-term are minimal, at around 250 tb/d, they are expected to increase somewhat and reach almost 0.5 mb/d in the period 2025–2030. However, the gradual slowdown in demand growth combined with the growth in non-refinery fuels results in gradually slowing refinery additions from 2030–2040. Between 2040 and 2045 additions are projected at only 0.1 mb/d.

In the **Russia & Caspian** region, oil demand is expected to increase somewhat between 2019 and 2030, which, to some extent, drives the expansion of the refining capacity in this period. On top of the expected additions of around 0.5 mb/d in the medium-term, further additions of 150 tb/d are projected for the period 2025–2030. However, refinery capacity additions after 2030 remain minimal, totalling only 0.1 mb/d, in line with peaking oil demand in this region, as well as in traditional export regions such as Europe. In total for the period 2020-2045, distillation capacity additions are projected at 0.7 mb/d.

For the **US & Canada**, the largest share of anticipated refinery additions is expected to occur in the medium-term with around 450 tb/d of new capacity coming online. In the period after 2025, refinery additions remain limited, totalling around 150 tb/d, which can be mostly attributed to debottlenecking additions in existing plants. The major reason for this pattern in distillation capacity additions is that demand is expected to peak after the medium-term and decline steadily towards the end of the projection period. This decline is arguably responsible for the lack of additional capacity after 2025.

In **Europe**, only minor additions are projected in the medium-term with no expected additions after 2025. The main reason is declining demand and exposure to competition from other regions such as the US & Canada, Russia and the Middle East. This means that Europe is likely to see closures to prevent low utilization rates after 2025.

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 the section 5.2.1 and compares this with the so-called 'call-on-refining' (relative to the base year, i.e. 2019). The long-term outlook looks into modelling results over the period 2025–2045 and projects refinery throughputs and respective utilization rates on the regional level, including crude and product movements (to be discussed in 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 some 5.2 mb/d. The assumption (based on the modelling results) is that by 2025 around 250 tb/d of 'creep capacity' (i.e. debottlenecking) will be needed, which is added in stages throughout the medium-term period. The majority of debottlenecking additions are expected in the US & Canada region, 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 assessment. As a result, total additions (nameplate capacity) in the medium-term period are estimated at 5.5 mb/d by 2025. As per the methodology applied, refinery closures are not taken into consideration at this stage, but are highlighted later.

The methodology also assumes that the new refining capacity may reach the maximum assumed utilization rate of 90%. This assumption provides an insight into the potential incremental crude runs on an annual basis between 2020 and 2025. Furthermore, as this Outlook is done on an annual basis, this methodology tries to capture uncertainty 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).

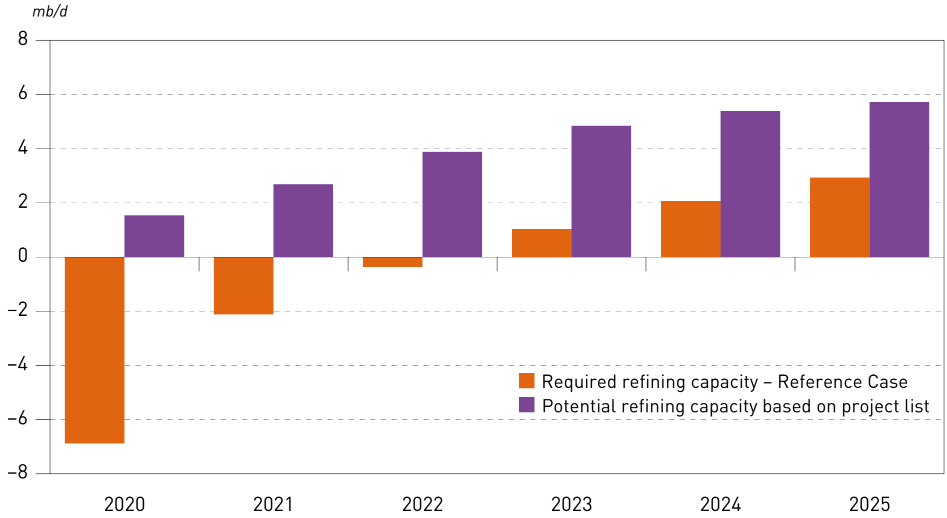
In the following step, the maximum potential incremental crude runs are calculated with incremental refined product demand or 'call-on-refining'. The call-on-refining is the result of demand patterns that take into account non-refinery fuels such as NGLs, biofuels, CTLs and GTLs (e.g. NGLs used directly in the petrochemical industry), which surpass refinery processing. This section covers balances from the perspective of distillation capacity, crude runs and total demand without consideration of specific product demand.

In the final step, the potential incremental crude runs are compared with the cumulative incremental refined product demand on the annual level. The analysis is done on the global and regional level. 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 has to be noted that the analysis throughout this sub-section also includes assumptions on the product stock change throughout the period 2020–2025. Given the large imbalance of the market during 2020, a large product stock build for 2020 was assumed, with gradual stock draws from 2021 onwards. This somewhat alters the picture, which is based solely on the oil demand patterns and changes in non-refinery fuel supply as described above.

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. Potential refining capacity is set to increase throughout the period, rising strongly in the first half to reach levels of around 4 mb/d by 2022. Based on the slowdown in refining capacity additions, the potential refining capacity increases slower in the second half of the period and reaches 5.7 mb/d in 2025. At the same time, the severe drop in the required refining capacity in 2020 is estimated at around 7 mb/d in 2020 relative to 2019 (including assumed product stock build). In 2021, as demand recovers, the call-on-refining is set to increase by around 4.8 mb/d, but still remains below 2019 levels. The call-on-refining is projected to recover only in 2022 and reach levels just below those seen in 2019. In the period 2023–2025, the required refining capacity increases gradually, to levels of around 2.9 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.

The excess refining capacity on the global level (relative to 2019) will remain persistent throughout the medium-term, especially between 2020 (around 8.5 mb/d) and 2022 (4.3 mb/d). Although the situation is expected to improve towards the end of the period, the gap between the potential and required refining capacity is projected to remain and will reach levels of around 2.8 mb/d in 2025. This would certainly lead to lower utilization rates and more international competition in product markets, causing lower refining margins. Consequently, consolidation of the refining sector, including closures, is one of the highly possible outcomes (as discussed in more detail below).

This outlook is fundamentally different from those of previous years. In several previous editions of the WOO, the downstream market outlook was more balanced in the first half of the period, with the gap between required and potential refining capacity opening up in the second half, thus signalling rising oversupply towards the end of the medium-term.

Furthermore, 2020 was expected to be a strong year for the refining sector due to the implementation of the IMO Sulphur Rule, which became effective as of 1 January 2020. However, the sudden drop in demand (including marine bunkers demand) and refinery throughputs, as well as an oversupply of products, wiped out all possible upsides for the refining sector in the early phase of the IMO Sulphur Rule implementation.

This means that the earlier projections (e.g. WOO 2019 or WOO 2018) pointing to oversupply of refining capacity towards the end of the respective medium-term period will materialize much earlier with a much more severe imbalance of the downstream market. The WOO 2018 projected capacity oversupply of around 2.5 mb/d for 2023, while the WOO 2019 saw capacity oversupply increasing to around 4 mb/d in 2024. This is compared with projected oversupply of 8.5 mb/d in 2020 and more than 4 mb/d in 2021 and 2022 in the current Reference Case.

Finally, while the global outlook for the downstream market balance is bleak, the regional perspective is different. The downstream market is set to show the largest imbalance in developed regions, while developing regions are expected to see more positive sentiment given the demand development. The downstream market outlook for major regions is discussed below. The standard caveat applies; this cumulative overhang would be lower if refinery projects slip, and higher, should demand growth prove less than expected.

Medium-term regional balances

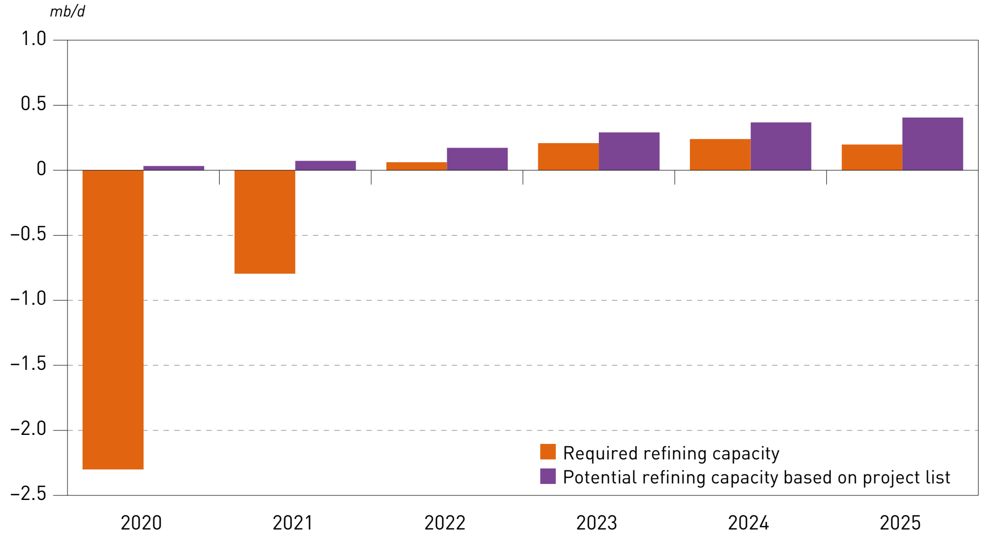
At the regional level, contrasts in the refining supply/demand balances remain stark. Figures 5.8 to 5.15 present a comparison of data drawn for all major regions in the period 2020–2025.

Figure 5.8 shows the medium-term outlook for the US & Canada region. After the drop of around 2 mb/d in required refining capacity in 2020, the situation is set to improve in line with rising demand. The required refining capacity is in positive territory from 2022 (relative to 2019) and peaks at above 0.2 mb/d in 2024. Given only minor refinery capacity expansion in the region, the potential capacity is only slightly above the required volume from 2022. In 2025, the gap between the potential and required refining capacities is around 0.2 mb/d.

The large gap between the required and potential refining capacity in 2020 (2.3 mb/d) and 2021 (0.9 mb/d), as well all pressure due to probable stock draws in 2021, is set to put pressure on refining utilization rates and consequently put some existing refineries at risk in this period. Some traditional export markets such as Europe are set to come under pressure, which could have a negative effect on US product exports to this region. Finally, given that the US supply growth is currently under pressure, this could result in a narrower WTI/Brent spread relative to levels seen in 2018 and 2019. This means that the advantage of the relatively cheap feedstock for US refiners could disappear, giving more reasons to believe that some refineries could be closed in this region during the medium-term.

Source: OPEC.

Figure 5.8
Additional cumulative crude runs in US & Canada, potential and required

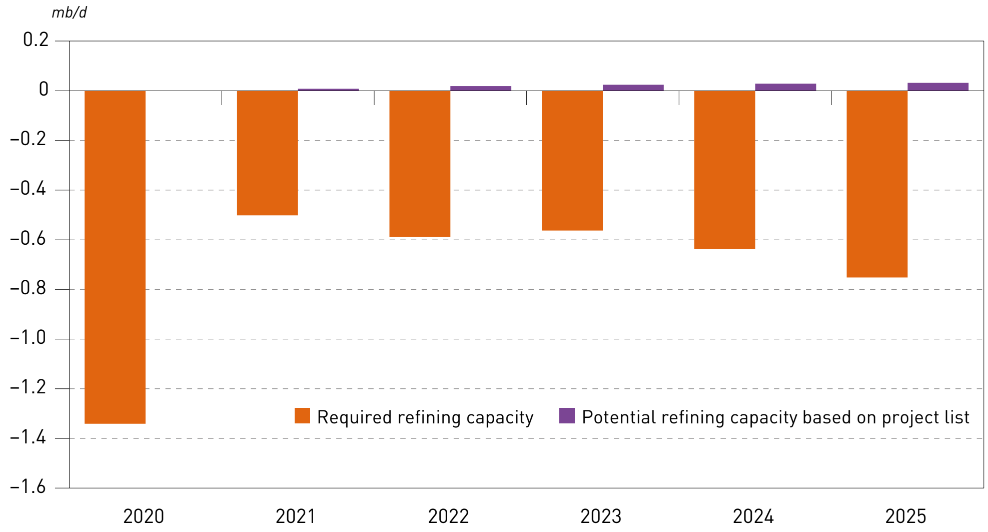


Source: OPEC.

The picture in **Europe** (Figure 5.9) looks much gloomier relative to the US & Canada. As Europe has only minor refining capacity additions in the medium-term period (reaching barely 50 tb/d), potential refining capacity remains almost zero throughout the period. At the same time, the drop in demand in 2020 causes the decline in required refinery capacity to around –1.35 mb/d.

The gap between required and potential refining capacity is expected to improve in 2021 as demand increases, reaching levels of around –0.5 mb/d. However, the gap starts widening again from 2022

Figure 5.9
Additional cumulative crude runs in Europe, potential and required

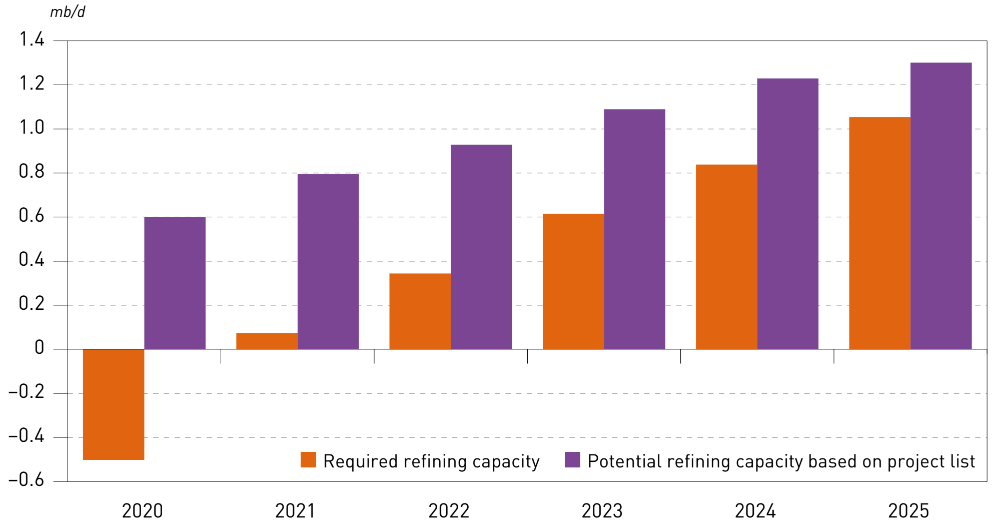


Source: OPEC.

as demand decreases and non-refinery fuels increase (including biofuels). Consequently, the gap increases to almost –0.8 mb/d in 2025, signalling a large oversupply of refining capacity relative to call-on-refining throughout the period. Further pressure comes from Africa, with expected start-up of new refining capacity in the medium-term, which could reduce exports from Europe to the continent.

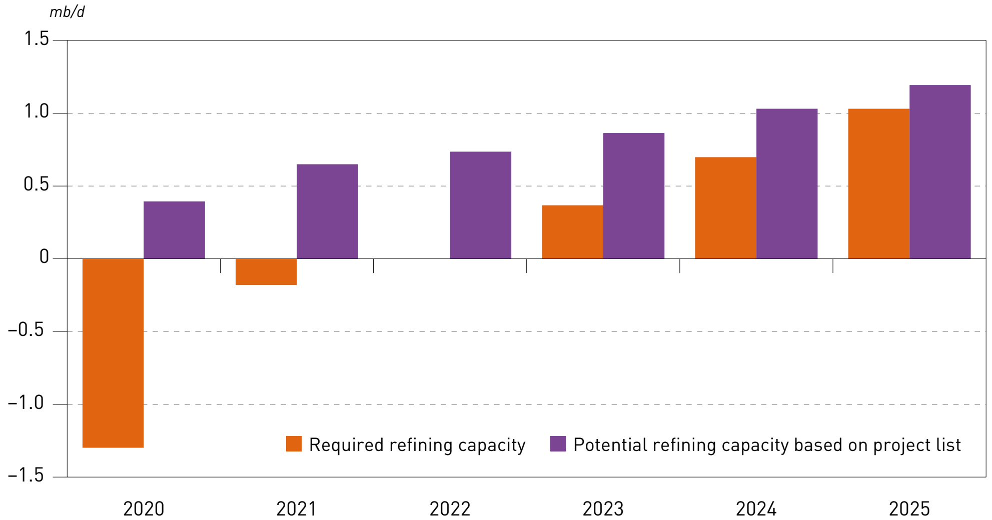
Figures 5.10 and 5.11 show the medium-term outlooks for the **Asia-Pacific**. To provide more detailed analysis of this large region, Figure 5.10 shows only China and Figure 5.11 illustrates the projections for the Asia-Pacific excluding China. Both sub-regions show significant new potential

Figure 5.10
Additional cumulative crude runs in China, potential and required



Source: OPEC.

Figure 5.11
Additional cumulative crude runs in Asia-Pacific (excl. China), potential and required



Source: OPEC.

refining capacity, as well as considerable demand growth. Nevertheless, even though this region is likely to witness high demand growth, the medium-term outlook still shows an increasing overhang of potential refining capacity.

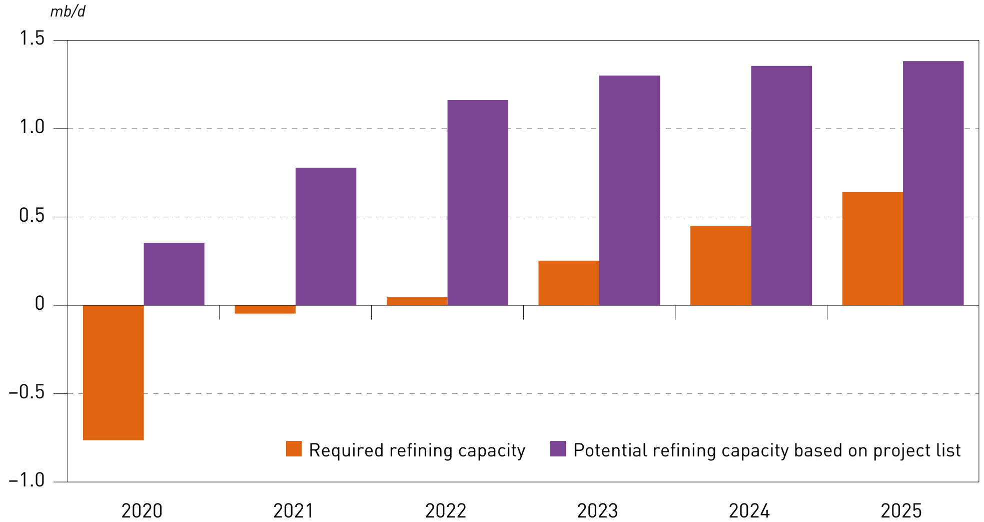
In **China** (Figure 5.10), expected refining additions continue to add potential capacity. Although somewhat lower compared to last year's Outlook, China's potential refining capacity is expected to increase towards 1.3 mb/d by 2025. However, projected refining additions in the period 2020-2025 come on top of already significant additions of nearly 1 mb/d during 2019. At the same time, required refining capacity is expected to reach levels of around 1.1 mb/d in 2025, resulting in a gap of around 0.2 mb/d at the end of the medium-term period.

Given that the refining capacity additions are front-loaded and demand is still under pressure in 2020 and 2021, the gap between potential and required refining capacity remains high in the first three years of the outlook, declining from 1.1 mb/d in 2020 to around 0.6 mb/d in 2022. This significant refining overcapacity in the first half of the medium-term period may lead to economic pressure on some players in the market, especially for independent smaller and less efficient refiners (teapot refiners).

The **Asia-Pacific** (excluding China) is similar to China (Figure 5.11). The gap between potential and required refining capacity is estimated at around 1.7 mb/d in 2020 and is expected to narrow to around 850 tb/d in 2021 and 750 tb/d in 2022. In line with the growing demand in the region, the gap is projected to narrow further and reach only 150 tb/d in 2025, signalling a balanced market by the end of the period. Similar to China, the front years of the medium-term outlook are likely to bring refinery utilization rates under pressure with more competition within the region, but also with more exports from China.

In the **Middle East** (Figure 5.12), the picture in the medium-term is similar to what was shown in previous publications. Potential refining capacity is expected to increase strongly in the coming years, reaching levels of around 1.4 mb/d. However, required refining capacity, attributed to domestic demand, reaches only 650 tb/d by 2025, leaving the gap at around 750 tb/d. This is in line with the strategy of some countries to increase product exports in the medium-term, with some of the new refining projects in the region clearly export-oriented.

Figure 5.12
Additional cumulative crude runs in the Middle East, potential and required

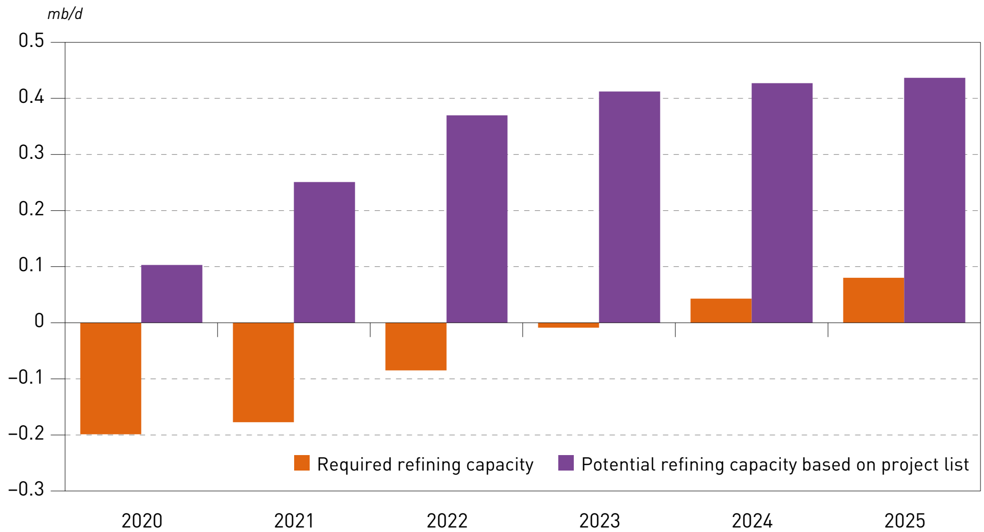


Source: OPEC.

The gap between potential and required refining capacity is even higher in the front years of the outlook, above 1 mb/d in 2020 and 2022. Given the large refining capacity overhang in all neighbouring markets such as Asia-Pacific and Europe, this may mean more competition for Middle Eastern refiners, especially between 2020 and 2022, with the situation improving somewhat in the second half of the period.

In the **Russia & Caspian** region (Figure 5.13), the required refining capacity increases gradually after an initial drop in 2020 and is expected to reach levels of around 0.1 mb/d in 2025. At the same time, the potential refining capacity is increasing to levels just around 450 tb/d. Consequently, the gap between potential and required refining capacity remains flat throughout the medium-term at levels between 0.3 and 450 tb/d.

Figure 5.13
Additional cumulative crude runs in the Russia & Caspian, potential and required



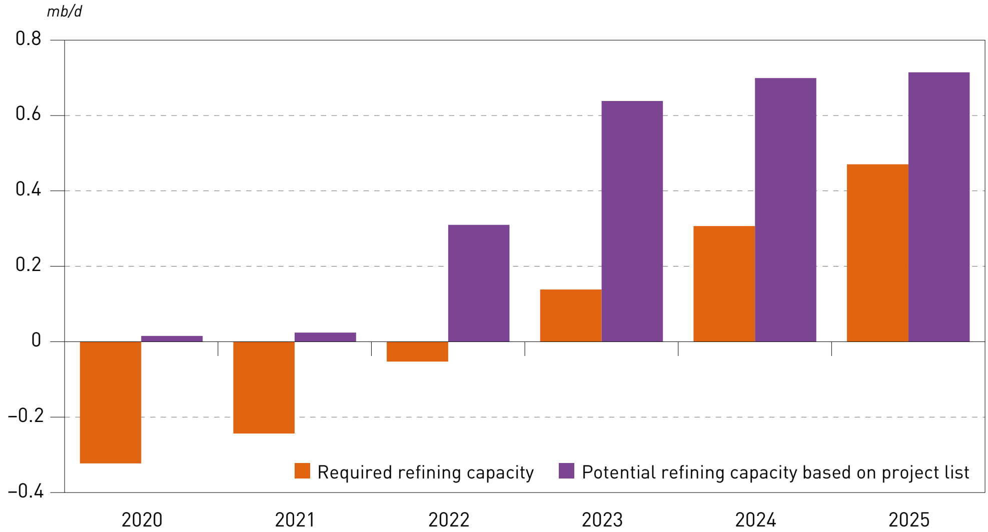
Source: OPEC.

As this approach accounts only for the local demand, it is important to note that the Russia & Caspian region will feel even more pressure as demand declines in Europe, which is the traditional export market for Russian refiners. The pressure comes together with planned tax reform, which would remove indirect subsidies for Russian export refineries. This exposes them to international competition, which now seems even tougher than before the COVID-19 pandemic.

In **Africa** (Figure 5.14), the drop in required refining capacity in 2020 is estimated at around 0.3 mb/d, which is followed by a gradual recovery with the call-on-refining reaching 450 tb/d in 2025, supported by healthy demand growth in the region. While relatively low in the early years of the outlook, the potential refining capacity increases strongly after 2020, in line with the new capacity coming online.

Potential refining capacity reaches levels of around 0.7 mb/d in 2025. The gap between potential and required refining capacity peaks in 2023 at almost 0.5 mb/d and declines towards 250 tb/d in 2025. Assuming that the new refining capacity will be fully utilized, the negative product net trade may improve relative to 2019 with lower product imports needed.

Figure 5.14
Additional cumulative crude runs in Africa, potential and required

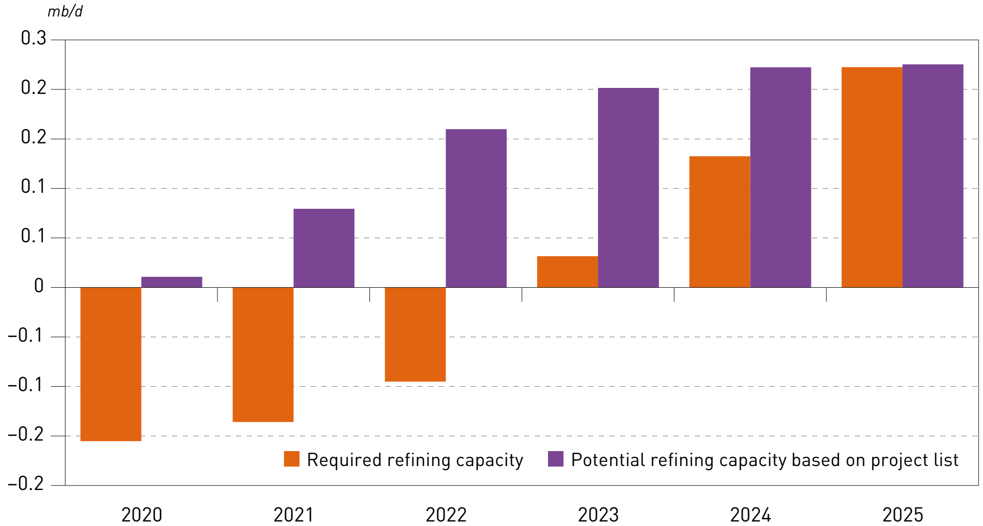


Source: OPEC.

In the early years of the outlook, the picture in **Latin America** looks similar to other regions with the required refining capacity in negative territory in 2020 and 2021 relative to 2019 (Figure 5.15). However, as demand recovers, the required refining capacity increases to around 250 tb/d in 2025. The potential refining capacity in the medium-term reaches levels just below 250 tb/d in 2025, which is due to low capacity additions as described earlier in this chapter. Thus, Latin America is the only region that is in balance in the second half of the medium-term.

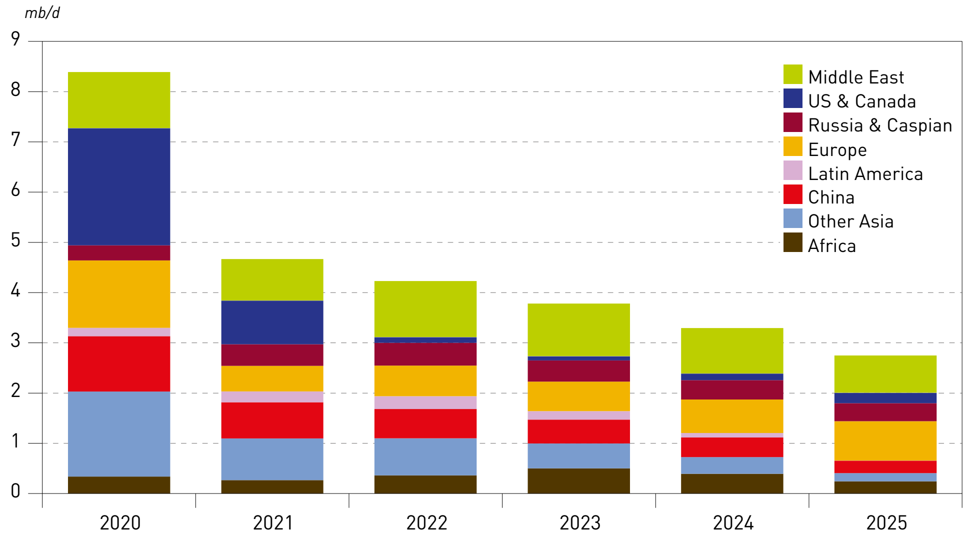
Finally, Figure 5.16 illustrates the cumulative gap between the incremental potential and required refining capacity for all regions in the period 2020–2025.

Figure 5.15
Additional cumulative crude runs in Latin America, potential and required



Source: OPEC.

Figure 5.16
Net cumulative regional refining potential surplus/deficits *versus* requirements



Source: OPEC.

As discussed above, almost all regions show surpluses of potential refining capacity in the medium-term. What is different to previous Outlooks is the shape of the curve. While previous publications showed overcapacity towards the end of the medium-term, this Outlook sees the largest surplus of potential refining capacity in 2020 and then 2021–2022.

Due to the demand shock in 2020, the expected cumulative overhang for all the regions is almost 8.5 mb/d, with largest gaps in the US & Canada, Europe, the Middle East, China and Other Asia-Pacific. The surplus of potential refining capacity is expected to decline from 2023 onwards to levels of around 2.7 mb/d in 2025, mostly in Europe and the Middle East.

Some of the new projects could be delayed for a couple of years due to missing demand and financial constraints. This could lead to a narrower gap between potential and required refining capacity in the medium-term. Furthermore, the severity of the current situation could lead to refinery closures, which may come earlier than expected (as discussed below). These closures would help to consolidate the downstream market and increase average utilization rates.

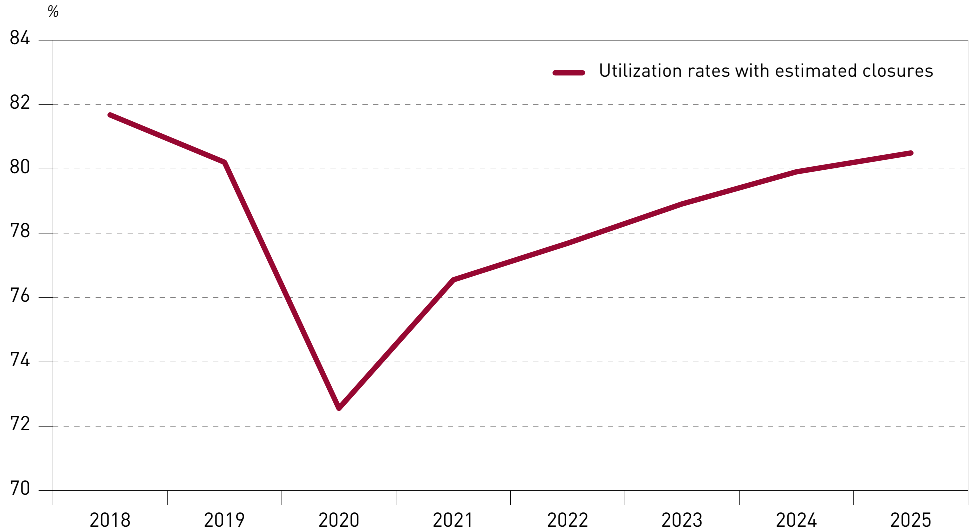
Medium-term refinery utilization and throughputs outlook

The analysis below broadens the perspective shown above in the medium-term outlook for distillation capacity, showing the estimated utilization rate under assumed closures, as well as estimating 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. In 2018, the average global utilization rate was estimated at around 81.7%, which was followed by a drop towards 80% in 2019. During 2019, refinery throughputs increased only marginally, accompanied by refinery additions at around 2 mb/d, thus pressuring the average utilization rate.

The severity of the demand shock caused by the COVID-19 pandemic is projected to push the average utilization rate to below 73% for 2020, with enforced shutdowns of production and shifted

Figure 5.17
Historical and projected global refinery utilization, 2018–2025



Source: OPEC.

maintenance closures. While utilization is expected to recover in 2021 and 2022, it is not likely to rise above levels of 78%, which is due to significant refining capacity additions in this period, as already described. Global refinery utilization is likely to reach levels above 80% (comparable to 2019) only in 2025 and under assumed closures in the range of some 2.5 mb/d throughout the medium-term (discussed in more detail later).

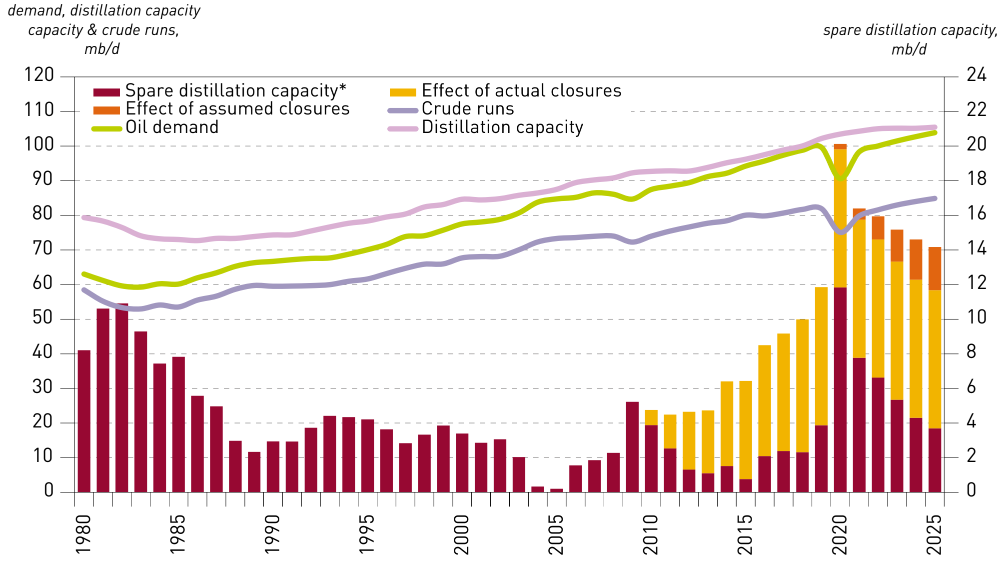
If there are no closures between 2020 and 2025, the average utilization rate would stay permanently at levels below the 80% threshold, which is considered to be at a sustainable average global level. This is why a wave of closures seems inevitable in the near future.

Figure 5.18 shows the trajectory of oil demand, crude runs and the level of available distillation capacity since 1980. Furthermore, the effect of past closures and future (assumed) closures is shown. Although total distillation capacity is almost converging with total liquids demand, the actual required refining capacity is considerably lower, as significant parts of oil demand are accounted for by non-refinery fuels and processing gains. Historically, the gap between installed capacity and total liquids demand was significantly higher, but was reduced partly due to several closures of old and inefficient plants.

Projected crude runs are expected to drop sharply in 2020, in line with demand drops as described above. From just below 82 mb/d in 2019, global crude runs are projected at around 75 mb/d in 2020 and 79.8 mb/d in 2021. Crude runs are expected to reach pre-crisis levels only in 2023. Finally, crude runs are seen at almost 85 mb/d in 2025, which is more than 1 mb/d lower compared to last year's WOO.

The right-hand axis of Figure 5.18 shows historical refinery closures, as well as closures expected in the medium-term. Based on the total closures, as well as available distillation capacity assuming an average availability rate of 84%, refining spare capacity is calculated. The estimated refining spare capacity in 2019 was at around 4 mb/d, rising strongly from levels of around 2.5 mb/d in 2017 and 2018. This was mainly due to strong refining additions during 2019 with a minimal increase in refinery crude runs during the same year. Based on the demand drop in 2020 and further refining additions, spare capacity rises to around 12 mb/d in 2020, illustrating a gigantic capacity

Figure 5.18
Global oil demand, refining capacity and crude runs, 1980–2025



* *Effective 'spare' capacity estimate based on assumed 84% utilization rate, accounting for already-closed capacity.*
Source: OPEC.

oversupply. Although the situation improves in the following years, spare capacity remains higher compared to figures before 2020. Calculated refining spare capacity is at around 7 mb/d and 6.5 mb/d in 2021 and 2022, respectively, before declining towards 3.7 mb/d in 2025.

5.2.4 Long-term balance for the refining sector

This section focuses on global and regional refinery throughputs and utilization for the period 2019–2045. The outlook is based on the modelling of the global downstream market and takes into account global and regional oil demand and supply as described in Chapters 3 and 4.

As shown in Table 5.4, global refinery throughput is expected to increase in the period 2019–2035, in line with rising global oil demand in this period. Global crude runs rise from just below 82 mb/d in 2019 to 87.4 mb/d in 2035. This increase is not uniform, but, similar to demand growth, front-loaded. In the period 2019–2025, global crude runs are expected to increase by almost 3 mb/d, or around 0.5 mb/d annually on average. In the period 2025–2030, the crude runs increase is estimated at only around 1.5 mb/d or some 0.3 mb/d p.a. on average. Finally, the growth of crude runs decreases to 1 mb/d in the period 2030–2035, which means that the average annual increase in crude runs is only around 0.2 mb/d.

Following the slowdown in demand growth and continuous growth in non-crude supply, global average refinery runs decline towards 87.3 mb/d in 2040 and 87.1 mb/d in 2045. The supply of biofuels and GTLs/CTLs increases by almost 0.5 mb/d in the period 2035-2045, while NGLs are set to increase by around 1 mb/d in the same period.

In line with regional demand, refinery run development looks quite different on the regional level. While some regions should see significant increase in crude throughputs, other regions are expected to experience a strong decline.

Table 5.4 highlights the variation in outlooks between major regions. In the US & Canada, crude runs are projected to decline slightly in the medium-term, reaching 18 mb/d in 2025. This is in line with demand, which is expected to remain broadly stable in this period. However, post-2025 refinery runs are projected to start dropping and reach 17.6 mb/d in 2030 and continue declining towards just below 16 mb/d in 2045. Overall, refinery runs are expected to fall more than 2.5 mb/d in the period 2019–2045.

This is, however, significantly less than the decline in domestic demand, which drops by around 6 mb/d in the same period. This is why US & Canada net product exports are expected to increase significantly (as discussed in Chapter 6), which is in line with the competitiveness of the US refining system in the international downstream market. In other words, refiners in the US will be able to compensate for the loss of the domestic demand and look for additional market outlets elsewhere (e.g. Europe and Africa).

Nevertheless, declining refinery throughputs in this region are expected to lead to lower utilization rates, going from a relatively high level of around 88.5% in 2019 to 77% in 2045. This indicates potential for closures in the long-term on top of the assumed closures of around 0.6 mb/d in the medium-term.

Table 5.4
Crude unit throughputs and utilization rates

	Total crude unit throughputs *mb/d*								
	Global	**US & Canada**	**Latin America**	**Africa**	**Europe**	**Russia & Caspian**	**Middle East**	**China**	**Other Asia-Pacific**
2019	81.9	18.3	4.3	2.4	12.6	7.0	7.4	13.1	17.0
2025	84.9	18.0	5.2	2.8	12.0	6.8	8.6	14.2	17.3
2030	86.4	17.6	5.6	3.6	11.8	6.6	9.2	14.6	17.5
2035	87.4	16.6	6.1	4.0	11.5	6.5	9.4	14.6	18.6
2040	87.3	16.2	6.3	4.5	10.2	6.4	9.8	14.5	19.3
2045	87.1	15.9	6.7	4.8	9.6	6.1	10.2	14.7	19.1
	Crude unit utilizations *% of calendar day capacity*								
	Global	**US & Canada**	**Latin America**	**Africa**	**Europe**	**Russia & Caspian**	**Middle East**	**China**	**Other Asia-Pacific**
2019	79.9	88.5	55.4	62.2	77.8	91.1	72.7	76.7	87.8
2025	80.5	87.9	69.0	63.5	77.5	87.7	74.5	79.9	84.4
2030	79.2	85.4	69.9	66.0	76.6	83.8	77.2	77.6	82.6
2035	78.2	80.3	72.6	68.3	74.7	82.2	76.4	76.4	84.4
2040	76.7	78.4	74.4	70.9	66.0	80.1	77.4	75.6	84.2
2045	75.4	77.0	77.5	72.7	62.4	76.4	77.9	76.4	79.7

Source: OPEC.

In **Europe**, the situation in the downstream sector looks worse relative to developments in the US & Canada. Crude runs are projected to decline continuously throughout the forecast period. This is in line with the expected decline in oil demand, which drops by around 4 mb/d between 2019 and 2045. Consequently, refinery runs are set to decline from around 12.6 mb/d in 2019 to 9.6 mb/d in 2045. This means that the average utilization rate will decline from around 78% in 2019 to just 62.5% in 2045, taking into account projected medium-term closures of around 0.6 mb/d. This projection illustrates the need for significant closures in Europe after the medium-term, if refinery runs are to be kept at sustainable levels of close to 80%.

In the **Asia-Pacific (excluding China)**, refinery runs will increase steadily throughout the outlook period, from around 17 mb/d in 2019 to just above 19 mb/d in 2045. The increase of more than 2 mb/d in refinery runs already includes expected declines in the OECD Asia-Oceania sub-region (e.g. Japan and South Korea), where demand is expected to decrease in the long-term.

The majority of the growth is expected in the Rest of Asia sub-region (led by India) and followed by the Pacific High Growth sub-region. However, it is anticipated that additional refinery runs will cover only part of the expected demand increase in the Asia-Pacific region, while the rest will covered by rising product imports throughout the forecast period.

In the case of **China**, refinery runs are forecast to increase from around 13.1 mb/d to about 14.6 mb/d in 2035, driven by strong demand and possibly rising exports to Asian countries. After 2035, runs are expected to remain stable until the end of the forecast period, in line with the slowdown of demand growth in China. The slowdown in projected refinery runs relative to growing demand in the projection period indicates rising product imports into China in the long-term.

Refinery utilization rates are expected to increase in the medium-term, from below 77% in 2019 to almost 80% in 2025, but then decline gradually towards 76.5% at the end of the period. This also indicates potential closures in the long-term affecting mostly older and inefficient independent refiners (so-called teapot refineries). However, governmental policies will play a crucial role in whether or not these refineries shut down.

In the **Russia & Caspian** region, crude runs are projected to decline from around 7 mb/d in 2019 to 6.1 mb/d in 2045. While the region is likely to see a moderate demand increase, thus supporting refinery runs, the major export market, Europe, is projected to see a significant demand drop in the long-term. Furthermore, the Russian government's tax reforms (referred to as the Tax Manoeuvre) have reduced support to the refining sector, thus exposing Russian refiners to more international competition. These are the major reasons for the decline of refinery runs in the Russia & Caspian region. The utilization rate, which was very high in 2019 at levels of around 91%, is anticipated to decline to below 80% in 2045, thus potentially leading to some closures of refining capacity.

In the **Middle East**, refinery runs are expected to increase by some 2.7 mb/d between 2019 and 2045, reaching levels above 10 mb/d. While rising domestic demand is one of the reasons for this increase, some Middle Eastern countries are increasingly turning to product exports. Refinery utilization rates are set to increase from below 73% to around 74.5% by 2025 and further to around 77% in 2030. In the post-2030-period, utilization rates remain in the 77–78% range.

Finally, in **Latin America** and **Africa**, refinery throughputs are expected to rise by 2.4 mb/d each between 2019 and 2045. Both regions have fairly low runs relative to domestic demand, which is the result of a relatively inefficient refining system. However, with new refining projects, throughputs should increase in the long-term.

This is also valid for utilization rates, which were at levels of around 55% (Latin America) and 62% (Africa) in 2019. Utilization rates in these two regions will increase significantly to levels above

70% in 2045. However, even these levels illustrate the relatively large share of plants with low utilization, which may be closed in the long-term or, as an alternative, refurbished. Refurbishment would help to increase refinery throughputs even more and consequently reduce product imports.

5.2.5 Refinery closures

Refinery closures in the medium-term

This section reviews the recent history of refinery closures at a regional level, as well as the prospects for additional closures and refinery capacity considered at risk of closure by virtue of recent sales or other announcements. The section provides an updated assessment of total refinery closures from 2020 to 2025. The year 2025 was selected as the 'end date' for actively estimating closures since anything beyond that time horizon is considered too uncertain. As will be addressed later, the long-term modelling results indicate potential closures from 2025 to 2045.

Table 5.5 and Figure 5.19 summarize closures since 2012 and projected closures through 2025. From 2012 through 2018, some 5.7 mb/d of refinery closures occurred worldwide, mainly in Europe, the Asia-Pacific and the Middle East. In 2019, the primary closures were those of the 355,000 b/d Philadelphia Energy Solutions facility in the US after a severe fire, and the 44,000 b/d INA refinery in Sisak, Croatia, as part of a consolidation of processing into INA's Rijeka plant.

Table 5.5
Net refinery closures, recent and projected, by region *mb/d*

	Total 2012–2019	2020	2021	2022	2023	2024	2025	Total 2019–2025
US & Canada	1.2	0.4	0.0	–	0.2	–	–	0.6
Latin America	0.3	0.0	0.1	0.1	0.1	0.0	0.0	0.4
Europe	1.7	0.1	0.2	0.1	0.0	0.1	0.2	0.6
Russia & Caspian	0.2	0.1	0.0	0.2	0.1	0.0	–	0.3
Africa	0.1	–	0.1	0.0	–	0.0	–	0.1
Middle East	0.8	–	–	–	–	–	–	–
Asia-Pacific	1.7	0.1	0.1	0.1	0.0	0.1	0.1	0.5
Total	**6.0**	**0.6**	**0.5**	**0.4**	**0.4**	**0.3**	**0.3**	**2.5**

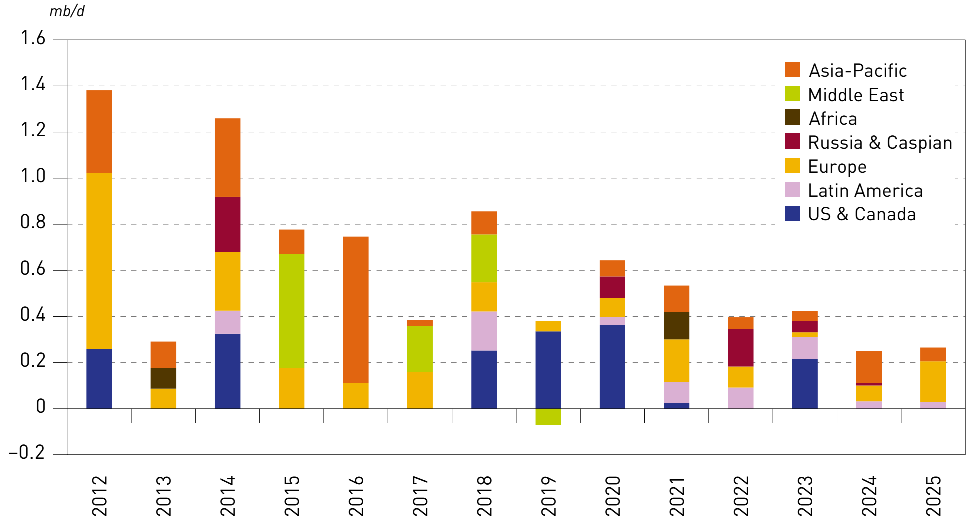
Source: OPEC.

These closures were partially offset by the reopening of the Al-Sumoud (formerly Baiji) refinery in Iraq, leading to a net total for 2012-2019 of 6 mb/d. This equated to an average annual rate of closure of 740 tb/d in this period.

For the period 2020–2025, total closures are estimated at 2.5 mb/d. It is clear the COVID-19 pandemic will have an adverse effect on refinery viability, especially if the recovery is slow.

The pandemic has already begun to precipitate a rash of closures. What is not yet known is whether this signals a new period of sustained, major reductions or whether the initial surge in closures will be enough to induce still-operating refiners to struggle on.

Figure 5.19
Net refinery closures, recent and projected, by region



Source: OPEC.

A number of firm closures were announced in mid-2020 and the owners of several other refineries have said their operations are at risk. In the US, two refineries in California are being closed. Marathon is shutting its 166,000 b/d Martinez facility and Phillips 66 has begun repurposing its linked 120,000 b/d Rodeo and Santa Maria (San Francisco) facilities to produce renewable fuels. In addition, Marathon is closing a small refinery in Gallup, New Mexico, and HollyFrontier shut its Cheyenne, Wyoming, refinery in August 2020 with a plan to produce renewable diesel. All told, these closures will remove over 350,000 b/d of refining capacity.

In Europe, Gunvor announced it is closing its 115,000 b/d Antwerp refinery while Total is considering converting its 93,000 b/d Grandpuits refinery to biofuels production. Several more European facilities, totalling 0.5–1 mb/d, have been listed as at risk of closure. At least one of the four remaining refineries in Australia was reported as a potential candidate for closure, as was the Marsden Point facility in New Zealand. Upgrading requirements to meet new fuel standards and growing competition from large new refineries elsewhere in Asia are cited as reasons. Refineries in Japan, with its progressively declining domestic demand, are also considered at risk. JXTG decided in 2019 to close its 115,000 b/d Osaka refinery in October 2020 after the expiry of a joint venture. In August 2020, Shell decided to permanently close its 110,000 b/d Tabangao refinery in the Philippines.

The Caribbean is also witness to a number of instances where refineries are struggling to remain in or return to operation. On the positive side, the nearly $2 billion revamp of the Limetree Bay (formerly HOVENSA) refinery on St. Croix was reported to be nearly complete and was due to restart in the third quarter of 2020 with a capacity of 210,000 b/d. A stated goal has been to 'catch the wave' of the need for lower-sulphur marine fuels now that the IMO MARPOL Annex VI 2020 Sulphur Rule is in effect. There also have been reports that the 168,000 b/d TRINTOC Pointe-á-Pierre refinery in Trinidad, which closed in 2018, could restart. After reportedly receiving numerous expressions of interest to operate the refinery, Trinidad's government selected a consortium. There are several challenges, including the need to invest at least $500 million in order to refurbish the loss-making refinery and complete construction of a 40,000 b/d ULS diesel unit.

In Curacao, state-owned Refineria di Korsou is seeking a new partner to operate the idled 320,000 b/d refinery and the large Bullen Bay crude terminal. In Jamaica, the government's decision to close the Petroleum Corporation of Jamaica has added to the likelihood that the struggling 35,000 b/d Kingston refinery could be shut down. The government of Aruba has received proposals for refurbishing the dismantled 235,000 b/d San Nicolas refinery, previously owned by Valero. These proposals address both re-establishing the refinery's fuels production and developing new activities including petrochemicals, LNG trans-shipment and renewable fuels. Recognizing the uncertainties, it was assumed for modelling purposes that the Limetree Bay and Curacao refineries would restart while the others discussed above would not.

At 2.5 mb/d, the projected level of medium-term closures (2020–2025) equates to an average annual rate of 0.5 mb/d. This is below the 750 tb/d p.a. rate of closures that occurred from 2012 to 2019, which included very extensive rationalizations in Europe and other industrialized regions. Actual closures across the medium-term could be higher or lower, but the former is now more likely because of the COVID-19 pandemic and oil demand implications. The pandemic is most likely to adversely impact refineries that are old and small; lack specialty products, petrochemicals and/or local crude supply; and which are fully exposed to international markets, as in coastal locations. It is notable that these factors are starting to play out in the announcements of actual and potential closures. Many of the refineries being closed or reported as at risk of closure are around 0.1 mb/d of capacity or less.

Refinery closures in the long-term

Results for modelling cases in the long-term provide a means to 'back calculate' the implied closures required within a region to reach a user-input level of utilization. It is important to note that modelling cases already include assumptions on refinery closures in the medium-term as described above. The parameter for estimating closures in the long-term is set at 80%, representing the lowest utilization level considered viable. Thus, model results will indicate some level of implied closures for any region with projected average annual utilization levels below 80%. This modelling feature is especially useful for assessing the potential need for additional closures by region over the long-term.

The results provide a cross-check on whether the assumed level of closures by 2025 is appropriate, or whether there is a need to indicate more or fewer. The global average utilization by 2025 is projected at 80.5% (Table 5.4). However, this level of global utilization still appears plausible and assumed closures seem to be at the lower end of what is actually needed in the medium-term to keep utilization levels at a reasonable level.

Beyond 2025 and until 2045, the Reference Case illustrates the need for continuous closures in several regions. This is in line with a declining global utilization rate from around 80.5% in 2025 to 75% in 2045. As noted before, declining oil demand in developed regions – including Europe, the US & Canada and those in the Asia-Pacific (e.g. Japan and South Korea) – will possibly lead to additional closures in the long-term.

Based on the modelling cases, around 6 mb/d of refinery closures will be needed between 2025 and 2045 if refinery utilization is to be at levels of around 80%. The majority of global closures should take place in Europe, around 3.5 mb/d, which is due to declining oil demand, as well as rising competition from other regions such as the Middle East and the US.

The US & Canada could also see closures in the range of up to 1 mb/d between 2025 and 2045. The utilization rate is still well above the 80% threshold in 2025 and declines gradually by 2045. Nevertheless, refineries in the US & Canada are in a better competitive position relative to Europe due to higher complexity and availability of domestic crude supplies.

In the Russia & Caspian region it is also assumed that closures of an estimated 0.5 mb/d will be needed beyond 2025 as refinery throughputs decline. The position of the Russian refinery sector depends to a large extent on export markets such as Europe, where demand declines significantly over the coming years.

Following the slowdown of oil demand, the Chinese refinery sector is likely to see stable refinery runs after 2035. The plateauing market in combination with rising capacity elsewhere (e.g. Other Asia-Pacific) may lead to limited closures in China. This may predominantly affect some old and inefficient plants (i.e. teapots). According to recent news reports, some Shandong-based teapot plants may be closed, transferring their crude import quotas to a larger and more complex petrochemical project – Yulong.

In Latin America and Africa, there are a number of old and inefficient refineries that have relatively low utilization rates. The new refining capacities, which are projected to come online in the medium- to long-term, may increase pressure on these existing plants with two ways out – either closure or refurbishment. Both markets are expected to grow considerably, which would support refurbishment of older plants. However, due to the lack of financing and rising internal competition, some of these plants may be closed in the coming years. As per modelling results and with the average utilization target of 80%, around 1 mb/d of total refining capacity in Latin America and Africa should be closed by 2045.

As a result, total required refinery closures between 2025 and 2045 are in the range of around 6 mb/d. Total required closures for the period 2020–2045 are estimated at around 8 mb/d, led by Europe, which accounts for approximately half of these closures.

5.3 Secondary capacity

5.3.1 Medium-term secondary capacity additions

New refineries and major expansions almost invariably incorporate substantial amounts of new secondary processing, while existing refineries with limited or no added distillation capacity are undergoing selective secondary capacity additions.

The goal of achieving a high degree of conversion, desulphurization and other quality improvements ties into the aim of producing predominantly light, clean products that meet stringent specifications. Indeed, the vast majority of incremental demand is for clean products – naphtha, gasoline, jet fuel and diesel – and standards, especially for transport fuels, continue to be tightened.

The 5.2 mb/d of new distillation capacity from assessed projects through to 2025 (Table 5.2) is expected to be accompanied by an additional 3.2 mb/d of conversion units, 5.4 mb/d of desulphurization capacity and 1.4 mb/d of octane units (Table 5.6).

As of early 2020, the total conversion capacity in place – coking, fluid catalytic cracking (FCC), hydrocracking and visbreaking – equates to 42% of global crude distillation capacity, desulphurization to 64% and octane units to 19.6%. With respect to current firm projects, conversion additions are projected at over 62% of distillation capacity additions over the period to 2025. This is well above the ratio for existing capacity and results from a sustained boost in conversion additions from 2020 through 2023, totalling an added 2.7 mb/d.

Likewise, desulphurization unit projects, at 105% of new distillation and octane units at 28%, also comprise additions appreciably above their current levels relative to distillation capacity. The high levels of desulphurization additions are more than matched by the rates of projected additions for hydrogen and sulphur recovery plants. These are projected through 2025 to run at nearly three times their historical ratios relative to crude capacity and point to a surge in anticipated sulphur removal. The 2020 IMO Sulphur Rule, with its need to remove several thousand tonnes per day of

Table 5.6
Secondary capacity additions from existing projects, 2020–2025 *mb/d*

	By year		
	Conversion	Desulphurization*	Octane units
2020	0.9	1.2	0.2
2021	0.5	1.5	0.3
2022	0.9	1.1	0.4
2023	0.5	0.7	0.3
2024	0.3	0.6	0.2
2025	0.1	0.2	0.1
	By region		
	Conversion	**Desulphurization***	**Octane units**
US & Canada	0.0	0.3	0.1
Latin America	0.1	0.2	0.1
Africa	0.6	0.5	0.2
Europe	0.1	0.1	0.0
Russia & Caspian	0.6	0.5	0.1
Middle East	0.4	1.7	0.3
China	0.7	0.8	0.4
Other Asia	0.8	1.3	0.3
World	**3.2**	**5.4**	**1.4**

* *Desulphurization capacity in this table includes naphtha desulphurization.*

Source: OPEC.

sulphur from heavy fuel, would appear to be one major driver, another is the continuing shift to low and ULS standards for transport and heating fuels.

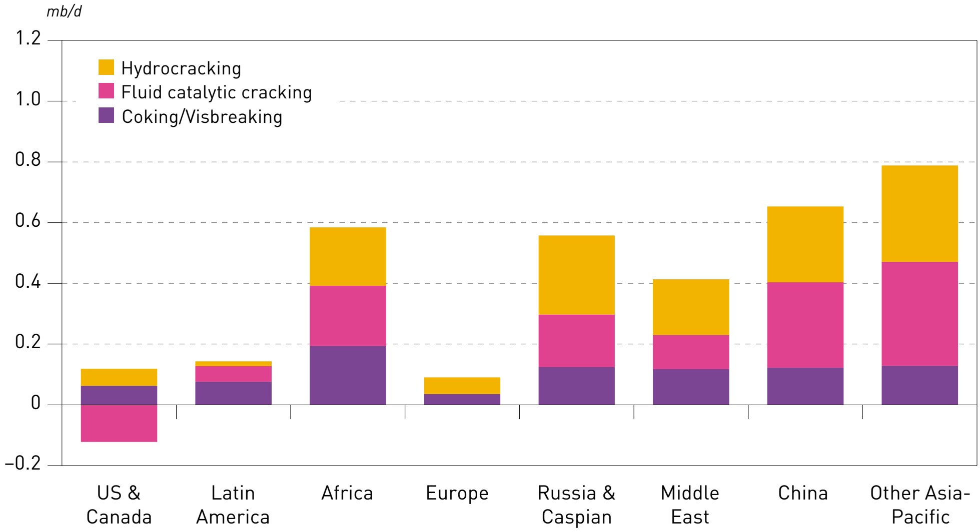
Conversion units

Figure 5.20 highlights the geographic distribution of conversion capacity additions by major unit category. The 3.2 mb/d in new global conversion units for the period 2020-2025 are spread across each of the three main unit categories: 41% for hydrocracking at 1.3 mb/d, 27% for coking/visbreaking (essentially all coking) at 0.9 mb/d and 32% for FCC/residue fluid catalytic cracking (RFCC) capacity at just over 1 mb/d.

The figures represent a moderate shift back from hydrocracking to FCC additions, with the proportion of coking/visbreaking staying stable. This may reflect refiners reacting to an expected easing in gasoil/diesel demand growth that was anticipated previously and/or an increase in the use of the FCC unit as a source of petrochemical feedstock, notably propylene, in expectation of sustained petrochemical demand growth.

Additions in each of the three conversion unit categories are expected in all regions except Europe and the US & Canada. In the US & Canada, FCC unit closures are occurring despite recent (pre-pandemic) increases in gasoline demand because the growth in light tight oil production has boosted the supply of naphtha for use as a gasoline blend stock via catalytic reforming and

Figure 5.20
Conversion projects by region, 2020–2025



Source: OPEC.

isomerization; also because refiners have been adding hydro-cracking units which divert feedstock away from the FCC unit. In Europe, the substantial regional gasoline surplus provides little incentive to add to the gasoline supply, hence the lack of any FCC expansion. In both regions, resulting conversion additions are minor.

Latin America is the one other region where a lack of firm refinery projects results in only minor projected conversion additions over the medium-term (150 tb/d). In all other regions, conversion additions are projected in the 0.4 to 0.8 mb/d range. Just as they account for the bulk of distillation projects, the Middle East, China and Other Asia-Pacific together account for nearly 60% (1.85 mb/d) of total conversion additions through 2025.

The regions with significant conversion projects – namely Africa, Russia & Caspian, the Middle East, China and Other Asia-Pacific – all display a mix of coking, FCC and hydrocracking additions, with the two catalytic processes (FCC and hydrocracking) leading the way. In the Middle East, conversion additions (0.4 mb/d) are geared towards both meeting growing regional demand and supplying clean products for export. In Africa (0.6 mb/d), China (650 tb/d) and Other Asia-Pacific (0.8 mb/d), the conversion additions are geared more towards satisfying domestic demand. In the Russia & Caspian region (0.6 mb/d) the additions continue to derive from recent changes in tax policy designed to encourage refiners to upgrade away from heavy fuel oil production. Geographically, the additions are widespread, but are heavily focused on developing regions where there is significant demand growth.

Desulphurization units

Medium-term desulphurization unit additions are expected to equate to 5.4 mb/d, 105% of new distillation capacity. Of this projected additional capacity, 1.2 mb/d is for naphtha processing, 0.6 mb/d for gasoline, and 2.3 mb/d for distillates and over 1.2 mb/d for heavy streams (vacuum gasoil and residuum).

The naphtha desulphurization additions stem mainly from the 0.9 mb/d of new global catalytic reforming capacity. The gasoline additions relate primarily to the processing of FCC naphtha to ULS standards. The distillate additions (43% of the total) reflect the current drive, in developing regions especially, to implement low and ULS standards for diesel. The vacuum gasoil/resid additions reflect mainly a mixture of FCC and RFCC pre-treatment, and resid desulphurization in the Middle East and the Asia-Pacific, plus minor lube oils processing.

Responding to the 2020 IMO Sulphur Rule to produce more 0.5% sulphur marine diesel and heavier fuel (VLSFO) is another driver. The desulphurization additions are heavily 'front-loaded', with 3.8 mb/d of the 2020–2025 total occurring from 2020 to 2022. Again, this would appear consistent with refiners reacting to the MARPOL Annex VI Sulphur Rule which came into effect on 1 January 2020. Longer-term, the continuing shift of non-OECD countries towards the Euro 3/4/5/6 standards is the main force driving global capacity expansion of hydrotreating.

This effect is evident in the desulphurization projects. Projected additions in the US & Canada total only 0.3 mb/d and in Europe only 0.1 mb/d over the medium-term period. In contrast, additions in the Middle East total 1.7 mb/d and 2.1 mb/d in Asia as an array of new refinery projects and upgrades come online with a major drive towards high refinery complexity and the ability to produce fuels generally to Euro 5 standards. Additions in the Russia & Caspian region are forecast at 0.5 mb/d. They are driven, as with conversion additions, by the effects of the new tax regime, as well as regulations to meet ULS gasoline and diesel standards. New desulphurization capacity in Africa is projected at 0.5 mb/d, indicating further progress on the continent towards tighter 'AFRI' fuel standards, while Latin America lags at 0.2 mb/d.

The concentration of additions in mainly non-OECD countries reflects trends towards cleaner domestic products, but also the efforts of export-oriented refineries to provide products that better comply with advanced standards, generally Euro 5 or Euro 6.

Octane units

Octane unit additions are estimated at over 27.5% of incremental distillation in the medium-term. As noted, this is well above the 19.6% level for base global refinery capacity as of early 2020 and reflects the fact that octane levels are being raised and/or total gasoline output is being increased across essentially all developing regions.

In line with this, the Middle East and Asia continue to dominate additions (at 0.3 and 0.7 mb/d, respectively), plus 0.5 mb/d in Africa, but only around 50 tb/d in Latin America. In Europe, essentially no additions are expected and, in Russia & Caspian, they are below 0.1 mb/d, in each case reflecting minimal gasoline demand growth. In the US & Canada, the outlook is similar, but with a shift towards a lighter crude slate and the resulting need to process incremental naphtha leading to limited additions of somewhat under 0.1 mb/d.

The 1.4 mb/d of octane unit additions is comprised mainly of catalytic reforming at over 0.9 mb/d, or 66% of the total. The remainder is split between isomerization (0.2 mb/d), alkylation (0.2 mb/d) and methyl or ethyl tertiary butyl ether (MTBE/ETBE) units (0.1 mb/d). 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

Refining capacity is generally denoted by 'primary' distillation capacity. However, it is the 'secondary' capacity, which includes conversion and product quality improvement units, that is crucial for processing crude fractions into finished products – and which delivers 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.

Today, essentially all major projects for new refineries and large expansions comprise complex facilities with high levels of upgrading, desulphurization and related secondary processing.

Smaller projects at existing refineries are generally directed towards the same upgrading goals of reducing residual fuel output and achieving quality improvements for clean products. Again, the driver is that most incremental fuels demand is for light, clean products.

Condensate splitters, which currently are being built primarily 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 future outlooks for refining, and especially future processing needs by type of unit, the modelling has to manage a number of challenges. One is the evolution of refinery process technology. This tends to be stable, with only gradual change, mainly as catalysts slowly improve. That said, it is necessary to monitor for significant improvements and novel technologies. For example, some refineries are starting to install new-generation 'condensation' processes, which convert light LPG/naphtha streams into middle distillates. In another instance, the 2020 IMO Sulphur Rule, together with a broader need for upgrading and desulphurization, have spurred a number of partial upgrading/desulphurization research and development projects that have the potential to reach the commercial stage.

Over the next several years, these developments and others could start to materially impact on installed refinery configurations. The current refinery modelling represents proven processes and allows for gradual improvement in efficiency. Novel processes are incorporated only once these are commercially proven and are able to have some level of meaningful volume impact.

The emerging trend to increase yields of petrochemicals 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 petrochemicals 'mega-projects' continues to rise, especially in the Middle East and Asia. It is now not uncommon for a new complex to be designed to produce 40% or more of petrochemical feedstock and one company, Reliance in India, has declared a long-term goal to convert its large refineries to produce only petrochemicals and jet fuel.

Potentially far-reaching is the emergence of direct crude-oil-to-chemicals processing. A number of major oil companies, including Saudi Aramco, have developed such technologies and have projects planned. Integrated crude-to-chemicals facilities and projects have started to appear in China. The processes generally focus on production of mainly light olefins and aromatics and may include direct use of crude oil as a steam cracker feedstock.

With regard to petrochemicals, the modelling undertaken to project the outlook for refining is designed to match demand for 'liquids' as projected by OPEC and other statistical sources. But the modelling does embody the more common petrochemical interactions, including: potential for use of the FCC unit as a source of propylene, using catalytic reformers to feed aromatics (BTX) extraction units, and meeting demand for naphtha and LPG, which is then used as a feedstock to steam crackers, in turn leading to by-products being returned into the refinery as fuel blend stocks.

As in recent Outlooks, this year's projections for future required secondary processing through 2045, summarized in Table 5.7, 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 2.5 mb/d of refinery net closures assumed for the period 2020–2025. These not only remove distillation, but in many cases, associated secondary unit capacity. As a result, projected total additions are somewhat higher than they would have been had no closures been assumed.

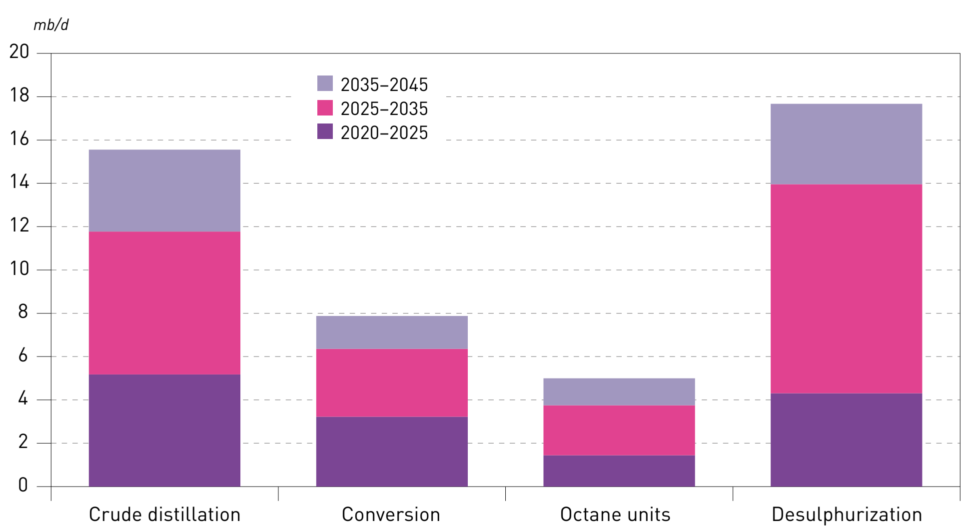
Table 5.7
Global capacity requirements by process, 2020–2045

mb/d

	Existing projects to 2025*	Additional requirements 2025–2035	Additional requirements 2035–2045	Total additions to 2045
Crude distillation	**5.2**	**6.6**	**3.8**	**15.6**
Conversion	**3.2**	**3.1**	**1.5**	**7.9**
Coking/visbreaking	0.9	0.5	0.4	1.7
Catalytic cracking	1.04	1.4	0.6	3.1
Hydrocracking	1.3	1.3	0.4	3.1
Desulphurization**	**4.3**	**9.6**	**3.7**	**17.7**
Gasoline	0.6	0.7	0.4	1.6
Distillate	2.5	8.4	1.6	12.4
VGO/residue	1.3	0.6	1.8	3.7
Octane units***	**1.4**	**2.3**	**1.2**	**5.0**
Catalytic reforming	1.0	1.3	0.7	3.0
Alkylation	0.2	0.6	0.3	1.1
Isomerization	0.2	0.2	0.1	0.4
MTBE	0.1	0.3	0.1	0.5

* *Existing projects exclude additions resulting from 'capacity creep'.*
** *Naphtha desulphurization not included.*
*** *New units only (excludes any revamping).*
Source: OPEC.

Figure 5.21
Global capacity requirements by process type, 2020–2045



Source: OPEC.

At the global level, projections indicate the need to add some 7.9 mb/d of conversion units, 17.7 mb/d of desulphurization capacity and 5 mb/d of octane units in the period 2020-2045 to go with 15.6 mb/d of new distillation capacity. It is important to bear in mind that several factors will influence whether all these additions are necessary – or indeed if more will be needed. The overall level of global liquids demand; the extent to which this embodies growth or 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 will all impact the additions needed.

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 are sensitive to the extent to which the 2020 IMO 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.

As discussed in Chapter 3, this year's outlook on scrubber penetration is somewhat more conservative because of the uncertainties surrounding their use that have arisen within the past year. As a result, the number of scrubbers expected to be installed and used has been cut back somewhat. Any further turn away from scrubber use would increase the call on the refining industry to add VGO/residue desulphurization, and/or upgrading plus distillate desulphurization capacity relative to what is included in this Outlook.

Conversion units

As shown in Table 5.6, existing projects to 2025 have conversion additions at over 62% of new distillation capacity. Table 5.7 and Figure 5.21 indicate that this high level will not be maintained through 2045. Nonetheless, additions will remain substantial at 40% to 50% of new distillation capacity.

Expectations for additions of 0.9 mb/d of coking/visbreaking capacity – predominantly coking – to 2025 leads to somewhat lower, but sustained additions of 0.5 mb/d from 2025 to 2035, then 0.4 mb/d from 2035 to 2045. The slowdown in additions between 2025 and 2035 reflects the large project additions to 2025, combined with a relatively stable global crude slate quality and a modest projected recovery in residual fuel demand driven by a gradual increase then a plateau in the use of on-board scrubbers. As a result, global coking utilizations are projected to drop moderately during the period to 2035.

Then, from 2035 to 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 together with a reduction in residual fuel demand.

Somewhat over half 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 gradual, but sustained growth in the western Canadian oil sands are projected to be primary drivers behind this. (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 mainly in Asia and the Russia & Caspian. The underlying driver for the latter region would appear to be a projected decline between 2019 and 2045 of over 250 tb/d in residual fuel demand, partly within the region itself, but mainly within Europe, the main outlet for Russian products.

Future coking additions and utilization 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 in fact evolves.

The 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 growth in oil sands output leads to continued growth in imports into the US. Likewise, the projected recovery in Latin American heavy crude production leads to a gradual rise in such crudes being exported to the US as their historical primary export market. As a result, coker utilzations are expected to be high (in the 85–90% range) in the US over the long-term while those in other regions are projected to be somewhat lower.

Catalytic cracking (FCC) additions are driven primarily by gasoline demand. Globally, this is projected to rise from 26.4 mb/d in 2019 to a plateau of almost 28 mb/d in 2030, which is sustained until there is a moderate drop after 2040. However, this seemingly static picture masks major differences in the evolution of demand between industrialized and developing regions. In the former (US & Canada, Europe, Japan and Australasia), gasoline demand of around 15.6 mb/d in 2019 and again in 2021 subsequently enters a sustained decline and this accelerates post-2030.

In contrast, in developing regions (Latin America, Africa, the Middle East and developing Asia-Pacific) demand grows by 2.7 mb/d from 2019 to 2030 and an additional 2.4 mb/d from 2030 to 2040, slowing to 0.5 mb/d for the period 2040–2045. In short, the loss in gasoline demand of over 5 mb/d from 2019 to 2045 in the industrialized regions is more than offset by demand gains in developing regions. This brings major implications for FCC and other gasoline unit utilzations, 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 1 mb/d of projects, FCC additions of 1.4 mb/d are seen as needed for the period 2025–2035, then a further 0.6 mb/d for 2035–2045. The decelerating pace of additions equates to a slowing rate of gasoline demand growth in the developing regions.

Driven by the disparity in demand trajectories, only around 6.5% of the FCC additions between 2025 and 2045 are in the industrialized and Russia & Caspian regions. The bulk of these additions are spread across Latin America, Africa, the Middle East, China and Other Asia-Pacific. Correspondingly, FCC utilizations are projected to decline steadily in the US & Canada, Europe and other industrialized regions, potentially in the order of 6–7% on average from 2025 to 2045. This implies that needed FCC closures of refineries in the industrialized regions could total at least 0.5 mb/d over the long term. These could comprise single unit closures, as has been seen in the US, and/or components of total refinery shutdowns. (See also 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 resid FCC (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'.

While hydrocracking units have inherent flexibility to alter yields to emphasize either gasoline or distillates, their use today is mainly associated with increasing production of the latter, i.e. jet/kerosene and gasoil/diesel. Global project additions of 1.3 mb/d from 2020 to 2025 are projected to be followed by a further 1.3 mb/d from 2025 to 2035, but then much reduced additions of 0.4 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. Jet/kerosene plus diesel/gasoil demand is projected to grow by 1 mb/d from 2019 to 2025, then 2.3 mb/d from 2025 to 2035, but less than 1 mb/d globally from 2035 to 2045.

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, industrial region demand for jet/kerosene plus gasoil/diesel drops by 4.4 mb/d from 2019 to 2045 while that for developing regions rises by 7.8 mb/d.

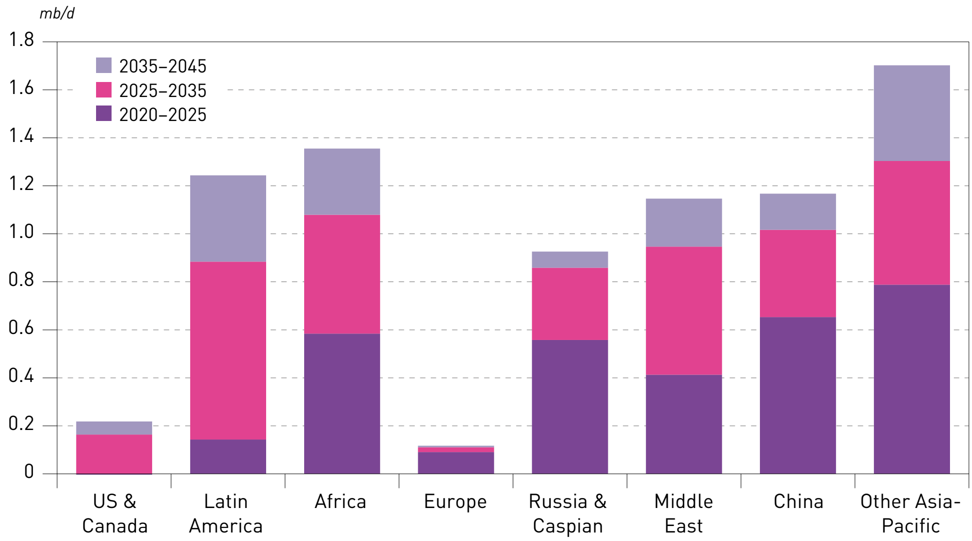
While the decline in industrialized regions' demand is projected to be steady at around 1.9 mb/d for each of 2025–2035 and 2035–2045, in the developing regions, 4 mb/d of demand growth for 2025-2035 is projected to be followed by only half that in 2035–2045. This explains both the slowing in global demand growth over the long-term and that in hydrocracking additions post-2035.

Consistent with the regional differences in demand growth, hydrocracking additions beyond projects are projected to be minor in the US & Canada and Europe (combined only around 2% of the global total). The Russia & Caspian region is expected to see around 7% of total additions while the remaining 90%-plus are again spread across Latin America, Africa, the Middle East and developing Asia. Unlike FCC units, hydrocrackers in industrialized region refineries are not expected to suffer the same risk of low utilization and closure. Worldwide, hydrocracker utilizations are expected to gradually rise over the long-term and to generally be in the 75% to 88% range.

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 36.5%, or 2.9 mb/d, of total additions to 2045; and the Middle East, with 14.5%, or 1.15 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 46.4% and 18% of global totals to 2045. This highlights how conversion additions, and more broadly those for all secondary capacity, can be expected to be more widely spread around the world, in part as existing refineries in nearly all regions raise their processing complexity.

Significant additions are projected for Latin America and Africa, at around 1.25 mb/d and 1.35 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

Figure 5.22
Conversion capacity requirements by region, 2020–2045



Source: OPEC.

0.9 mb/d, occurring predominantly in the period to 2035. Overall, it is the non-OECD regions that will sustain conversion capacity growth over the period to 2045. Only 4% of total conversion capacity growth to 2045 is expected in the US & Canada and Europe.

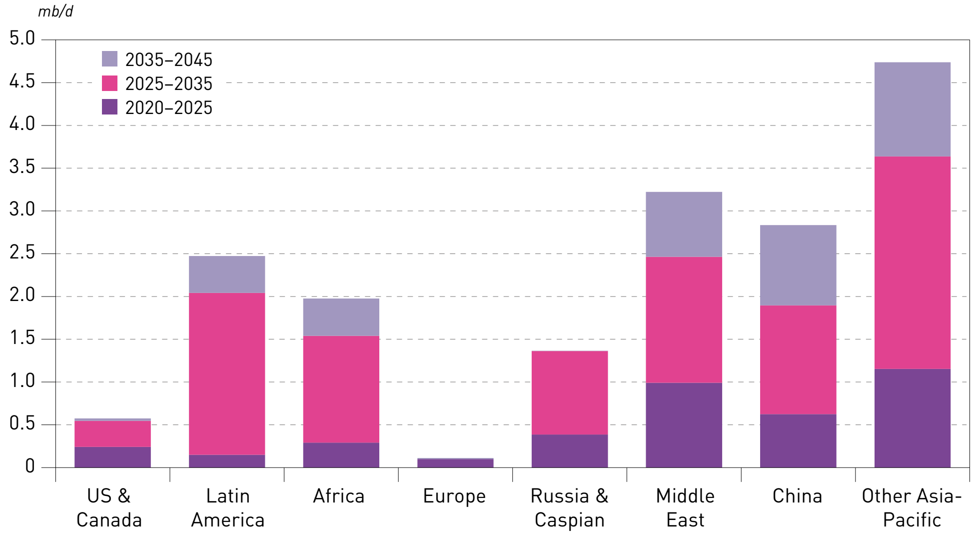
Desulphurization units

Desulphurization unit additions are projected to continue throughout the outlook period to 2045, but with the largest additions expected in the period 2025–2035. As illustrated in Table 5.7, and also re-expressed in Figures 5.23 and 5.24, 4 mb/d of worldwide projects for 2020–2025 are expected to be followed by some 9.6 mb/d of additions for 2025-2035, then by 3.7 mb/d for 2035–2045. (As per the table and charts, these figures cover gasoline, middle distillates and vacuum gasoil/residue desulphurization. In addition, 1.3 mb/d of naphtha desulphurization, which is mainly associated with a front-end step in catalytic reforming, is expected to be added by 2025 followed by a further 2-plus mb/d from 2025 to 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 17.7 mb/d of desulphurization additions by 2045 (which excludes close to 3.5 mb/d for naphtha desulphurization) exceeds the total of 15.6 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 as their processing complexity is raised in order to increase yields of predominantly light, clean products.

Specifically, the high level of desulphurization additions is driven by the continued move towards near-universal ULS gasoline and diesel standards, plus expected reductions in sulphur content for jet fuel and heating oils, as well as marine fuels with the impact of the 2020 IMO Sulphur Rule. The bulk of these changes is expected to have been completed by around 2030–2035, hence the pattern of extensive additions occurring for the 2025–2035 period followed by a slowing in the addition rate for 2035–2045. A steady increase in the global crude slate sulphur level, from around

Figure 5.23
Desulphurization capacity requirements by region*, 2020–2045



* *Projects and additions exclude naphtha desulphurization.*
Source: OPEC.

1.35% in the 2020–2025 period to around 1.5%, and rising, post-2035, becomes an important factor sustaining desulphurization additions in the longer-term.

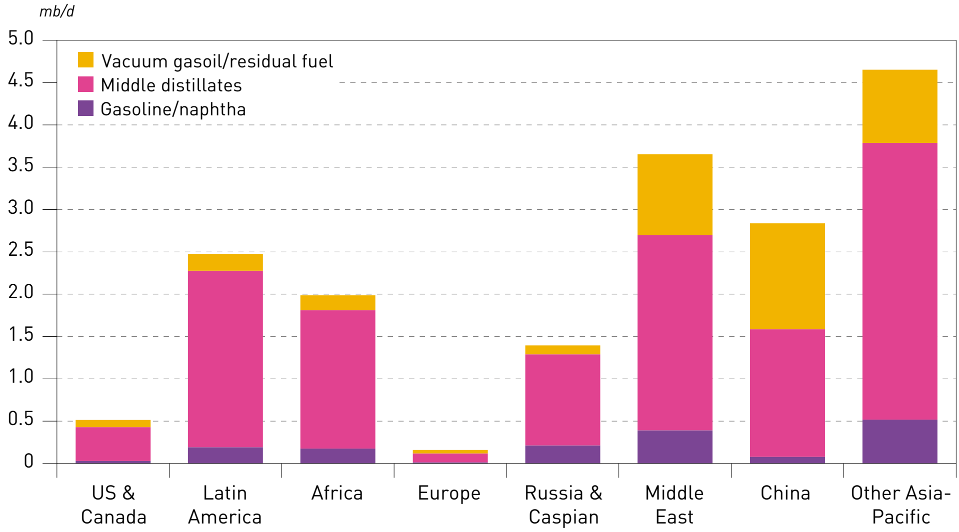
The industrialized regions are already largely at ULS standards for gasoline and diesel. In the period to 2025, project additions are thus focused mainly on those regions which are in the throes of completing the move to ULS gasoline and diesel, notably Russia & Caspian, China and Other Asia-Pacific (led by India), and/or which have heavy construction of new export refineries geared towards production of Euro 5/6 fuels, notably the Middle East (Figure 5.23).

Thereafter, to 2035, desulphurization additions are primarily in developing regions where, as discussed above, gasoline, jet 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. The slowing in gasoline and especially diesel demand growth after 2035 would lead to an even greater slowdown in desulphurization additions were it not for the projected increase in global crude slate sulphur during that period.

In line with conversion additions, the developing regions of Latin America, Africa, the Middle East and developing Asia account for some 88% of total desulphurization additions (excluding naphtha desulphurization) to 2045, with the US & Canada plus Europe only 4%. The remaining 8% are projected to occur in Russia & Caspian, driven by tax incentives to upgrade away from residual fuel and the intent to produce diesel and gasoline to ULS standards for both domestic use and export to Europe.

Gasoline desulphurization additions, at a total of 1.6 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 (70%) of total desulphurization additions (excluding naphtha) to 2045. They are anticipated across all regions but, again, with the primary concentrations in developing countries led by the Middle East and Asia at over 7 mb/d out of a global total 12.4 mb/d to 2045.

Figure 5.24
Desulphurization capacity requirements by product and region*, 2020–2045



* *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 2025 total 1.3 mb/d, in part associated with meeting increased demand for 0.5% VLSFO as a result of the 2020 IMO Sulphur Rule, 0.6 mb/d of additions are projected for the 2025–2035 period but then a tripling to 1.8 mb/d for 2035–2045. These are concentrated (84%) mainly in the Middle East and Asia and result from those regions processing large quantities of sour Middle Eastern and Latin American crudes in the long-term, consistent with the anticipated 'heaving up' of the global crude slate in that time period. By 2045, the Asia-Pacific region is projected to process some 20 mb/d of Middle East crudes plus over 2 mb/d from Latin America.

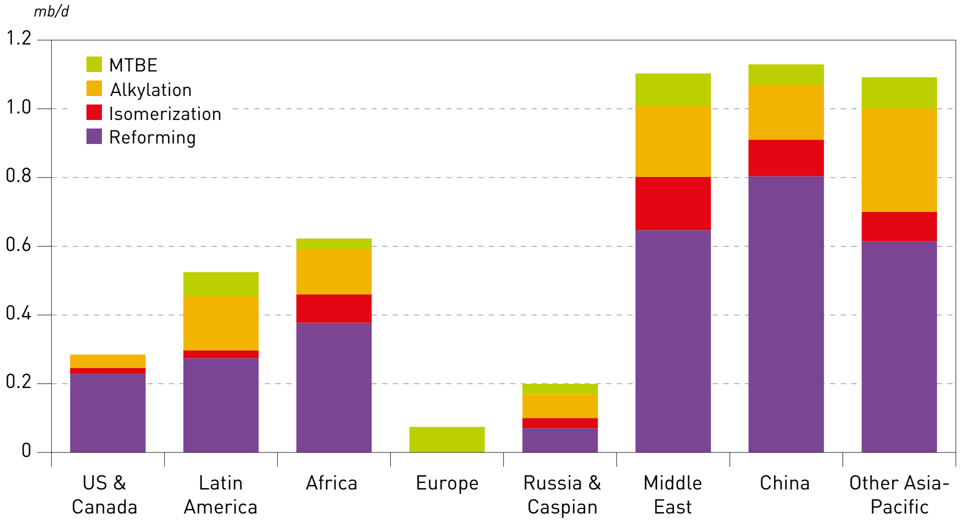
Octane units

As shown in Table 5.7, additions for octane units are expected throughout the period to 2045, with a sustained pace through 2035 but slowing thereafter. By 2025, 1.4 mb/d of project additions are expected to be followed by 2.3 mb/d for 2025–2035, dropping to 1.2 mb/d for 2035-2045. As discussed in relation to FCC unit additions, one primary driver of octane unit additions is the projected continued growth in developing-region gasoline demand 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, approaching those currently seen in industrialized countries, while levels in industrialized countries themselves are expected to keep rising in order to improve engine efficiency. This progressive increase in octane needs is projected to have largely played out though 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 the octane units are expected to be required in the form of catalytic reforming at 3 mb/d total to 2045, with alkylation at 1.1 mb/d, isomerization at 0.4 mb/d and MTBE/TAME/ETBE units at 0.5 mb/d. Reforming and isomerization raise naphtha's octane content and thus enable additional naphtha – including that from condensates – to be blended into gasoline. MTBE and associated ethers are used (outside the

Figure 5.25
Octane capacity requirements by process and region, 2020–2045



Source: OPEC.

US & Canada) either to meet oxygen content requirements in gasoline and/or to boost octane levels.

In line with other secondary processes, the vast majority (89%) of these additions are projected for the developing regions, led by the Asia-Pacific and the Middle East (at 66% combined), driven by large gasoline demand increases and expanding petrochemical industries. (The latter increase 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 respectively 10% and 12% of the total additions.

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 recognized that refiners have some limited flexibility to optimize their product slates based on market circumstances and seasonality. This can be done by changing feedstock composition 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 2020–2025. It also corresponds with the potential incremental output shown in the Section 5.2.3.

Table 5.8
Global cumulative potential for incremental product output*, 2020–2025 *mb/d*

	Gasoline/ Naphtha	Middle distillates	Fuel oil	Other products	Total
2020	0.5	0.8	–0.2	0.4	1.6
2021	0.8	1.4	–0.1	0.6	2.7
2022	1.1	1.9	0.0	1.0	3.9
2023	1.4	2.2	0.0	1.3	4.9
2024	1.5	2.5	0.0	1.5	5.4
2025	1.6	2.6	0.0	1.6	5.7
%	*28*	*46*	*–1*	*27*	*100*

* *Based on assumed 90% utilization rates for the new units.*
Source: OPEC.

As already highlighted, the potential refining capacity in the medium-term is projected at around 5.7 mb/d. This assumes that new refinery units are run at maximum 90% utilization rates. Furthermore, the estimates do not include refinery closures.

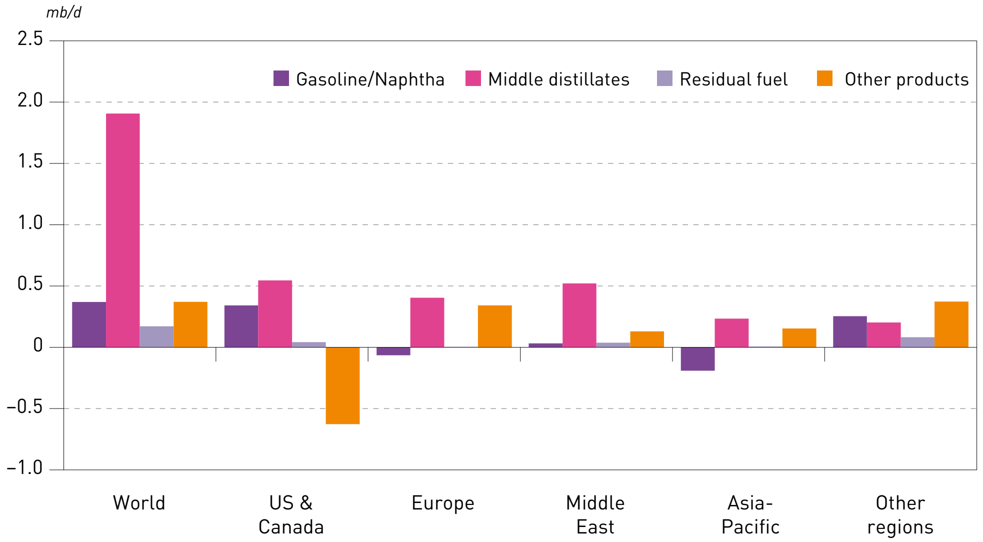
In line with the general trends in oil demand pointing to a rising share of high-quality products, the projections show the largest share of the incremental refining capacity accounted for by the middle distillates and light distillates, in line with significant additions of secondary capacity relative to distillation capacity.

By 2025, around 1.6 mb/d of potential refining capacity will be attributed to gasoline and naphtha. At the same time, around 2.6 mb/d (around 46%) of additional capacity will be attributed to middle distillates. A significant part of additional capacity will be related to other products, around 1.6 mb/d. The only product class that is not expected to see any increase is fuel oil, which remains at zero by 2025.

Figure 5.26 shows balances for the main product classes on the regional level. It is based on the incremental refining potential by product (Table 5.8) and the regional incremental demand by product (after deduction of non-refinery streams such as biofuels, CTLs, GTLs and partly NGLs). The trend towards a growing excess of refinery output potential compared to refined product requirements was previously described from the perspective of overall distillation capacity. This analysis shows the breakdown as net surpluses/deficits by major product group, both globally and regionally, based on the same underlying figures. As already discussed in Section 5.2.3, the overhang of the potential refining capacity in the period by 2025 is around 2.8 mb/d.

Figure 5.26 shows the overhang of all products on the global level, totalling 2.8 mb/d with significant differences between products. Middle distillates show the largest imbalance for the medium-term, reaching levels of 1.9 mb/d by 2025. While projected middle distillate demand growth between 2019 and 2025 remains lacklustre, there is additional related capacity of 2.6 mb/d, which explains this wide disparity. Regionally, the largest overhang is expected in the US & Canada, Europe and the Middle East.

Figure 5.26
Expected surplus/deficit* of incremental product output from existing refining projects, 2020–2025



* *Declining product demand in some regions contributes to the surplus.*
Source: OPEC.

Gasoline/naphtha, residual fuel and other products show a minor overhang on the global level (in the range of 0.2 mb/d to 0.4 mb/d). All regions, except for the US & Canada, are seen in relative balance with a small surplus for these product groups. In the US & Canada, a considerable deficit of other products of around 0.5 mb/d by 2025 is projected (including LPG).

The large surplus of middle distillate capacity shown in the Figure 5.26 indicates the need for refiners to possibly adjust the yield in order to reduce the output of middle distillates. This could help to address the issue of relatively slow demand growth for middle distillates in the medium-term.

Update on the IMO Sulphur Rule

The long-awaited implementation of the IMO Sulphur Rule occurred on 1 January 2020. Initially, the implementation of the rule was expected to have significant effects on the downstream market and refining sector through the sudden shift to low-sulphur fuels and away from HSFO. Some scenarios even projected a supply crunch with refiners not being able to handle sufficient volumes of low-sulphur bunker fuels due to expectations of high overall demand. Consequently, the price effect would have been a large one with implications for spreads between HSFO and low-sulphur fuels, which, in turn, would influence crude spreads as well. Furthermore, this would have given significant support to refinery margins, especially to deep conversion margins with low output of HSFO.

However, the effects of COVID-19 on the oil market eradicated many potential implications of the IMO Sulphur Rule implementation. Consequently, no supply crunch nor major fuel quality issues were recorded. The drop in refinery utilization rates was more than sufficient to provide enough capacity for producing low-sulphur bunker fuels. Some market participants (including traders) built VLSFO stocks ahead of the implementation date, which additionally helped to offset the significant increase in VLSFO demand. Finally, the COVID-19 crisis and the wave of lockdowns led to a decline in the overall marine bunker fuel demand in the first half of 2020, thus reducing the switch volume as well. Sufficient refining capacity, as well as stock builds of VLSFO in 2019 helped to replace HSFO mostly by VLSFO and much less by middle distillates.

In terms of economics, the VLSFO/HSFO spread indeed widened in the second half of 2019 and early 2020, reaching levels of around $50/b. However, the overall drop in demand and the DoC production adjustments (leading to a tighter market for HSFO-rich grades) resulted in narrowing the spread to levels below $10/b in some markets in mid-2020. This makes the utilization of scrubbing facilities much less economically attractive, which could lead to some cancellations or delays in installing additional scrubbers in the near future.

Looking forward, the situation related to the IMO Sulphur Rule should also normalize with the recovery of the global oil and bunkers demand. This means that low-sulphur fuels should see their spreads widening relative to HSFO. However, given that the global oil demand (and in particular middle distillate demand) is projected to recover only gradually, no supply crunch in the bunker fuel market can be expected in the near future.

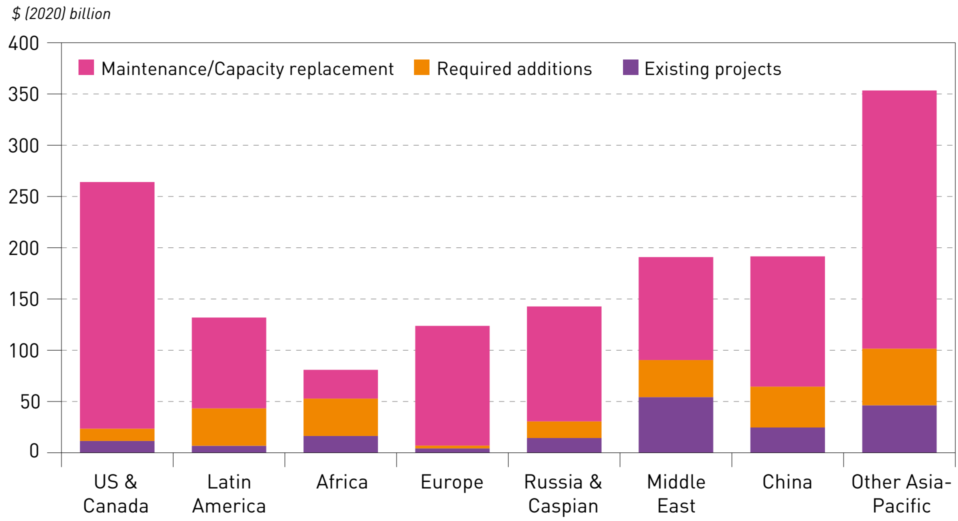
5.4 Investment requirements

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 be commissioned in the medium-term (2020–2025). The second category is related to investments beyond 2025 and generally represents still unknown 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 (2020–2045).

For the first category, the total investment requirement is estimated at around $180 billion, which is significantly lower compared to last year's Outlook. Capacity additions of 5.2 mb/d in the medium-term in the current Outlook are almost 3 mb/d lower compared to the five year medium-term period in the WOO 2019. The majority of the investments are located in the Middle East and Asia-Pacific (some $125 billion), with minor additions in other regions. Additions in the Middle East account for almost $55 billion and in Other Asia-Pacific around $45 billion. Investments in China are estimated at around $25 billion. Africa is projected to record investments of more than $16 billion. Investments in Latin America, however, are seen at only $6 billion with only minor expansions in the pipeline.

Long-term investments are calculated at around $235 billion. Besides the Middle East and Asia-Pacific, investments in Latin America and Africa also play an important role. Investments in the Middle East are expected to slow down in the long-term and are estimated at around $36 billion, while investments in China are likely to be somewhat higher compared to the medium-term. In Other Asia-Pacific, constant oil demand growth supports continuous investments in the refining capacity with an estimated volume of around $55 billion.

Figure 5.27
Refinery investments, 2020–2045



Source: OPEC.

Latin America and Africa are expected to see investments of around $35 billion each in the long-term, significantly higher than in the medium-term. Growing oil demand and the relatively inefficient refining system supports investments in these regions. However, the implementation of projects will largely depend on the willingness of market participants to invest in large downstream projects in the future. Long-term investments in other regions are only minor and are limited to expansions of existing plants. Altogether, capital investments in the global refining system in the medium- and long-term are seen at below $420 billion.

Finally, maintenance requirements and the 'capital replacement' of installed refining capacity are calculated at around $1.05 trillion for the period 2020–2045. This is somewhat higher compared to last year's Outlook, as the projection period has been extended by five years. The assessment of this investment category is based on the assumption that the annual capital needed for capacity maintenance and replacement is around 2% of the cost of the installed base. Based on this approach, around half of the of maintenance costs will occur in developed countries, while the other half will be accounted for by developing countries.

In summary, the total of the three downstream investment categories is estimated at $1.5 trillion in the period 2020–2045.

5.5 Refining industry implications

By all measures, 2020 has been an exceptional year, one that turned the refining sector upside down. In late 2019 and early 2020, the industry outlook was cautiously optimistic with expectations of higher demand growth for 2020 and wider light-heavy spreads due to the implementation of the IMO Sulphur Rule.

The demand destruction due to the COVID-19 pandemic led to historic declines in oil demand and consequently in refinery utilization rates across the globe. This Outlook assumes that global oil demand will return to 2019 levels only in 2022. At the same time, the expansion of the global refining capacity has continued and is expected to be maintained in the coming years. The resulting gap between the required refining capacity relative to available potential has widened tremendously this year and is expected to remain so at least until 2022. This disparity (based on a conservative outlook for medium-term refinery capacity additions) is likely to have an effect on refining capacity in several ways. We are already seeing a surge in firm closures during 2020 and are likely to see more with several companies putting this possibility on the table (including ENI, TOTAL, ExxonMobil, Gunvor and JXTG). In addition, some projects in the medium-term could be delayed or even cancelled, due to the uncertainty over demand developments or even financial difficulties caused by the current crisis. (Some Middle Eastern companies have already announced significant deferrals of projects and joint ventures.) And finally, some of the announced refining projects scheduled for the period beyond 2025 will certainly become subject to additional reviews and potentially rescaling, redesign and/or deferral before ever being considered for final investment decision.

The pace of demand recovery, the rate of refinery closures, as well as potential delays of new projects are all sides of the uncertainty triangle in the downstream sector for the medium-term.

In the long-term, there are a number of crucial challenges related to the demand development. Trends observed in recent years are expected to continue in the long-term, including the overall slowdown in refining capacity construction and the gradual migration of refining capacities from developed to developing countries.

As global demand growth decelerates, the slowdown of refining capacity construction seems unavoidable. This Outlook sees the annual average rate of global additions at around 350 tb/d in the period 2040–2045. Broken down on the regional level, this combines declines in several regions with meaningful additions in others. However, the overall moderate rate of additions points to expansions taking place at existing facilities. In other words, it seems that constructing new large refining projects will become more difficult to justify.

As the refining construction outlook suggests, the migration of refining capacity to developing regions will continue. However, some otherwise excess refining capacity in developed countries may increasingly be exported to international markets. This is especially true for the US, where refiners are still expected to benefit from ample domestic oil supply as well from a high degree of refinery complexity. The scale of any such product export expansion will depend, however, on the capability of developing countries to expand their refining capacities in line with rising demand.

As this Outlook points out, large capacity increases will be needed to mirror the increase in demand, including in the Asia-Pacific, Middle East and Africa. Any failures in these regions to add capacity commensurate with demand growth would provide a chance for refiners in developed countries to export more to these regions and increase their own utilization rates. Nevertheless, as this Outlook illustrates, such export growth will not be enough to offset falling demand in developed regions and declining refining utilization, which will lead to additional refinery closures – especially in Europe, the US & Canada and OECD Asia Oceania.

Bearing in mind the medium-term challenges that could keep refining margins under pressure for an extended period, the next consolidation phase seems unavoidable. The sector will certainly force refiners to put more effort into raising operational efficiency and excellence. This may include increasing the focus on vertical integration, including shifts to petrochemicals. In the long-term, challenges of declining demand in developed regions will most certainly lead to more consolidation. However, this consolidation may not necessarily mean closures. It may also lead to a reorientation to so-called biorefining (e.g. biodiesel), as well as to hydrogen production. What is clear is that governmental policies and support, as well as suitable technology availability, will be decisive for the refining sector in the long-term.

Oil movements

Key takeaways

- Global interregional oil flows (crude, condensate and products) are projected to increase from 56.5 mb/d in 2019 to 63.2 mb/d in 2045.

- Overall crude and condensate trade is expected to remain stable between 2019 and 2030 (except for the anticipated drop in the short-term due to the COVID-19 pandemic) at around 38.5 mb/d. Increases from the US & Canada are expected to be offset by declines from crude oil-exporting regions such as Africa.

- The effect of COVID-19 on oil demand and related oil production adjustments are likely to have a major impact on the global oil trade, possibly leading to a significant decline in 2020 followed by gradual recovery in the years after.

- In the long-term, global crude and condensate trade is forecast to reach levels of 41 mb/d by 2045, driven by Middle East exports, which offset declines in most other regions.

- Middle East crude and condensate exports are set to decline from 18.5 mb/d in 2019 to just below 17 mb/d in 2025, due to falling demand for OPEC liquids and rising local use, but then increase to 23.5 mb/d by 2045.

- Crude and condensate flows between the Middle East and Asia-Pacific will remain the most important trade link, with volumes increasing from around 15 mb/d in 2019 to nearly 20 mb/d in 2045.

- Exports of crude and condensates from Latin America are expected to increase by around 1.8 mb/d to 5.5 mb/d by 2025, driven by rising oil supply in this region, though exports are projected at 4 mb/d in 2045 due to rising domestic use. The US & Canada, as well as the Asia-Pacific region, will be the two most important buyers of Latin American crude.

- Trade flows from the Russia & Caspian region are expected to rise throughout the period, reaching 7.3 mb/d in 2045, in line with rising supply and lower domestic use.

- African crude and condensate exports (mostly to Europe and the Asia-Pacific) are projected to decline gradually from almost 6 mb/d in 2019 to 4.7 mb/d in 2045. Rising production will not be able to offset the increase in domestic use of more than 2 mb/d in the same period.

- Exports from the US & Canada are projected to increase initially from 2.6 mb/d in 2019 to just below 4 mb/d in 2025, but decline gradually towards 1.6 mb/d in 2045 as US production falls. The largest share of exports is seen heading to the Asia-Pacific.

- The US & Canada will remain a crude importer throughout the period (mostly heavy crude to the US Gulf Coast), purchasing barrels mostly from Latin America and the Middle East at levels around 2.5 mb/d from 2030 onwards.

- European crude and condensate imports are expected to decline continuously, from just over 10 mb/d in 2019 to 7.6 mb/d in 2045, due to decreasing demand. The Russia & Caspian region and the Middle East & Africa will be the most important suppliers to Europe.

- Imports to the Asia-Pacific are expected to increase from 23.7 mb/d in 2019 to almost 30 mb/d in 2045. The Middle East will remain the key supplier with almost 20 mb/d in 2045.

Trade movements of crude oil, intermediate and refined products are crucial elements of the global oil market and are responsible for the integration of different regions into the overall global system. This section describes projected crude and product flows based on the assumptions presented throughout this Outlook, including those related to logistics.

6.1 Logistics developments

The development of logistics infrastructure is crucial for maintaining oil trading and exporting capacity and the availability of products to markets. This is why significant interregional developments have major impacts on oil flows and are considered among the key inputs for 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 the development of infrastructure – 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 and US & Canada regions.

6.1.1 US & Canada

The COVID-19 pandemic has resulted in many changes since last year's Outlook. The key statement in this section last year was that the "substantial increases" in US and Canadian crude oil production "have run headlong into logistics constraints", followed by a review of whether and by when new (primarily pipeline) infrastructure developments could alleviate the bottlenecks (World Oil Outlook 2019, p. 190). By mid-2020, the demand collapse related to the COVID-19 pandemic resulted in an oversupply of crude oil and attendant low prices. Resulting financial difficulties and production declines for US shale producers, combined with new pipelines to the Gulf Coast, have dramatically altered the logistics capacity balance. Logistics constraints have changed into a logistics surplus, at least for the short-term. At the same time, the uncertainties and resistance (at the political level, as well as legal challenges) that have delayed major US and Canadian pipeline projects for the past several years have not diminished and, if anything, are on the increase. As a result, the logistics outlook remains uncertain, as it has for several years.

The growth of US tight oil and Canadian oil sands production has led to a substantial build-out and reorientation of the region's crude oil logistics system. In the US, this has primarily resulted in large new production volumes for export, instead of bringing imported crudes inland. There has been a parallel development of substantial crude-by-rail capacity, especially from the Bakken and other US producing regions to the coasts. In Canada, pipeline capacity from western Canada into the US, and to Ontario and Montreal in the east, has also been expanded. Similar to the US, rail capacity has been extended to carry western Canadian production to eastern Canadian and US destinations.

However, the production increases that have driven these developments have faltered. In the US, crude oil and condensate production that had risen from 5 mb/d in 2008 to 12.2 mb/d in 2019, but dropped temporarily by more than 2 mb/d during the first half of 2020. Overall, for 2020, it is projected to be down by more than 2 mb/d *versus* last year's Outlook. A recovery is expected in the medium-term, although a slow one, such that US crude and condensate production is still below last year's throughout the projection period. In Canada, crude and condensate output dropped temporarily by almost 1 mb/d in the first half of 2020 due to production shutdowns. These changes have implications for the logistics needs of both the US and Canada.

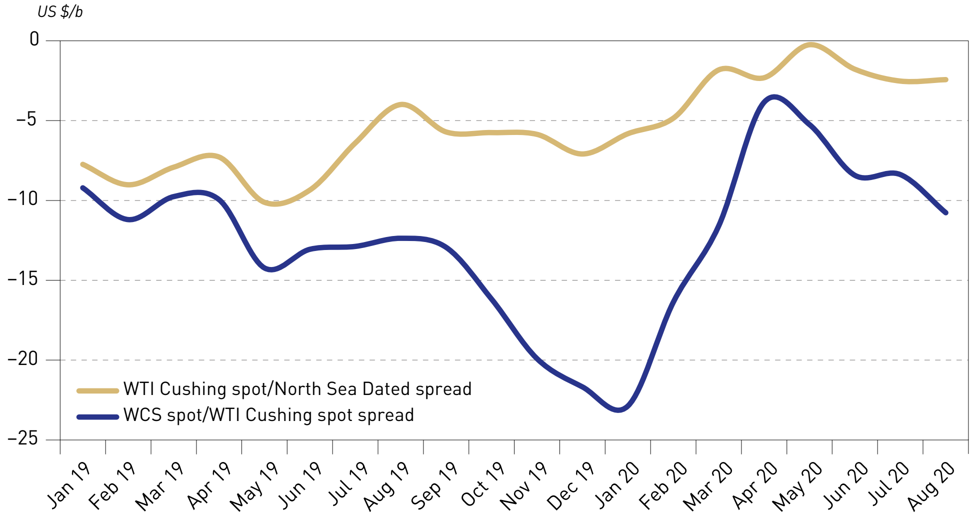
The drop in demand affects crude price differentials as well. Crude price spreads for North Sea Dated *versus* WTI Cushing and Western Canadian Select (WCS) *versus* WTI Cushing highlight what has happened over the past year. (Figure 6.1.) Recent wide discounts for WTI to North Sea Dated and for WCS to WTI have narrowed as logistics tightness has relaxed significantly.

The North Sea Dated-WTI Cushing spot differential averaged over $7/b in 2019 mainly because take-away capacity out of the Permian and Eagle Ford was not keeping pace with rapid production growth in those regions. The tightness also was exacerbated by growth in the supply from the Bakken and Niobrara plays where incremental production tended to need to reach the US Gulf Coast. After a temporary upheaval in April and May 2020 due to the Nymex contract expiry coincident with a lack of storage space, the North Sea Dated-WTI Cushing differential settled back to around $2 to $3/b by mid-2020. Key reasons for the recovery were the elimination of production growth in the Permian and Eagle Ford, and expansion of the pipeline capacity to the US Gulf Coast.

In late 2018, cross-border capacity from western Canada was so limited that price discounts to WTI Cushing for the heavy crude marker WCS reached extreme levels (at one time even above $50/b). To alleviate this situation, the Alberta government imposed mandatory production cuts. These, and the adverse economics for regional crude oils due to high costs and low prices, led to a number of announcements by the WCS Basin producers that they would delay oil sands expansion projects.

By the end of 2019, crude-by-rail export shipments had increased moderately and the first of a series of minor cross-border pipeline debottlenecking projects had come online. The WCS/WTI Cushing spread improved in early 2019 to around –$9/b to –$10/b, but widened to levels around –$22/b towards the end of 2019 (Figure 6.1). Severe Western Canadian Sedimentary Basin (WCSB) production cuts in the second quarter of 2020, driven by the COVID-19 pandemic, led to a sudden surplus in cross-border capacity, at least for the short-term with the WSC/WTI spread narrowing to around –$4/b in April 2020. Even with these improved economics, as of mid-2020, recovery in production by WCSB producers was very limited. As a result, cross-border pipeline capacity was not constrained, even with a collapse in crude-by-rail exports from WCSB to the US.

Figure 6.1
North Sea Dated, WTI Cushing and WCS crude price differentials



Source: Argus, OPEC.

US

Substantial new pipeline capacity to the US Gulf Coast from the Permian and Eagle Ford came on stream between mid-2019 and early 2020. Three major new pipelines (Cactus II, EPIC and Gray Oak) have added what will amount to nearly 2.2 mb/d of new capacity once fully operational. These three lines deliver primarily to Corpus Christi, in the western part of the Texas Gulf Coast, and led to crude oil movements out of the port reaching nearly 1.6–1.7 mb/d in early 2020, of which around 1.5 mb/d were for export. (The Port of Corpus Christi has embarked on a plan, through dredging and other actions, to raise export capacity to 3 mb/d.)

After averaging 3 mb/d in 2019, total US crude oil and condensate exports peaked at 3.7 mb/d in February 2020 of which 3.5 mb/d were from the Gulf Coast ('PADD3'). Thus, while the Gulf Coast clearly dominates US crude exports, and while Corpus Christi has started to occupy an important role in these, a further 2 mb/d were exported from other ports along the Gulf Coast.

In addition, two proposed 1 mb/d pipelines could come into service in late 2021 and into 2022. Both would start in the Permian region. The Wink-to-Webster line would run to near Houston while the Jupiter line would veer south to Brownsville, Texas, close to the border with Mexico and end at a 1 mb/d VLCC offshore loading terminal. Should all the Permian/Eagle Ford projects go ahead, total pipeline takeaway capacity from the two regions could exceed 9 mb/d. However, a round of delays and cancellations were announced in May through July, indicating the eventual total could be lower.

The export centres moving east along the coast comprise the greater Houston area, Beaumont/Port Arthur and St. James/LOOP (Louisiana Offshore Oil Port). Pipeline projects that are under consideration would deliver crude oil to these areas of the Gulf Coast, including from the Bakken and Niobrara regions and from Cushing, and move crude along the Gulf Coast, including from Texas east to Louisiana. Were they all to go ahead, the projects to move inland crudes to Louisiana and LOOP would add at least 1.5 mb/d of capacity to the middle and eastern Gulf Coast from inland regions. The projects include reversal of the Capline, which runs from St. James to Patoka, Illinois, and historically served to move imported crudes to the US Midwest. Upon reversal, the line would have an initial 300 tb/d capacity compared to its original inland capability of 1.2 mb/d.

One primary aim of the pipeline projects into Louisiana is to increase future VLCC export capability out of LOOP. Originally designed to take imports, and to work with Capline, the facility has been exporting local Gulf of Mexico medium sour crudes and light sweet grades since 2019. LOOP is significant in that it is the only Gulf Coast port currently able to routinely fully load VLCC's. Several new VLCC loading terminals are planned along the Gulf Coast, including at Corpus Christi, some onshore, some offshore. Again, if all were built, the total associated VLCC loading capacity would exceed 6 mb/d (in addition to that for loading SUEZMAX and AFRAMAX tankers). However, especially given the current upheaval, it is likely only one or two VLCC terminals will be completed.

While an array of major pipeline and export terminal projects is in principle under way, the 2020 demand crash led to a series of mid-year announcements putting several projects on hold. These include the Capline reversal, Dakota Access expansion and other similar projects bringing crude from the US interior to the Gulf Coast. The Wink-to-Webster project is still expected to be completed in 2021 but the Jupiter project is on hold. Each of the two leading offshore VLCC loading projects (the Enterprise SPOT terminal offshore Houston and the Phillips 66-Trafigura Bluewater project offshore Corpus Christi) has been delayed.

Amplifying the upheaval to projects resulting from dramatic supply and demand changes in 2020, resistance has grown to new pipeline developments and to existing pipeline infrastructure. Most projects today are the subject of lawsuits, including at the state level. In addition, state regulatory authorities are more frequently requiring lengthy reworking and extension of environmental reviews. Several recent rulings in federal courts regarding the inadequacy of environmental reviews have resulted in project delays and higher costs.

In early July 2020, a federal court ordered that the 570 tb/d Dakota Access pipeline out of the Bakken be shut down pending a further environmental review. This marked the first time an existing pipeline has been ordered shut. However, several days after, a federal appeals court annulled the earlier decision, effectively allowing operation of the pipeline. Only a day later, the US Supreme Court blocked the construction of Keystone XL pending a further environmental review. Late in July, a second operating pipeline, the 200 tb/d High Plains line out of the Bakken, was also ordered shut at least temporarily. As discussed further below, Enbridge's Line 3 and Line 5 renewal projects, and Keystone XL, continue to meet resistance. The bottom line is that it is becoming increasingly difficult for US operators to build major new pipelines.

While the current US administration has been supportive of pipeline developments, many states are enacting legislation geared towards reducing GHG emissions. In this context, new projects to move hydrocarbons are frequently seen as undesirable. Adding to what appears to be a growing groundswell of resistance, the November 2020 US general election has great potential to influence the outlook.

Canada

Cross-border pipelines and projects from Canada into the US impact both countries. It is important to note that the current outlook for Canadian crude and condensate production is expected to see only a limited increase in the long-term. On this basis, only limited additions to takeaway capacity are needed for the next several years. Against this, expected minor debottlenecking projects on both 'mainline' (Enbridge and TC Energy, formerly TransCanada) and secondary cross-border pipelines are projected to add 170 tb/d of capacity by late 2020 and up to 475 tb/d by 2022, more than enough to cover anticipated WCSB production increases. In addition, although more costly, the nominal 850 tb/d of WCSB crude-by-rail loading capacity allows an increase in rail shipments above their roughly 400 tb/d level at the end of 2019.

In terms of the future developments, western Canada continues to be beset by delays in long-planned pipeline projects and faces issues in terms of restoring and maintaining capacity on existing pipelines.

One of the critical projects for the WCSB is the expansion of the Trans Mountain pipeline from 300 tb/d to 890 tb/d. 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 the extreme move of purchasing the pipeline project from Kinder Morgan. A series of subsequent court actions culminated in the Supreme Court of Canada in early July 2020 dismissing 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. But construction has begun and the expansion could be in service by the end of 2022.

A significant cross-border project is the so-called 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. It too is the subject of resistance and an extended approval process such that it will not likely be completed before late 2021 or into 2022.

The largest cross-border pipeline project is Keystone XL, which would transport 830 tb/d of mainly heavy Canadian crude to the US Gulf Coast, supplying additional barrels to regional refiners. The line would also open up the possibility for WCSB crude oil exports via the Gulf Coast. A decade after the initial application was filed, the project was close to finally proceeding after receiving a second permit from the US President. In March 2020, and after the government of Alberta injected substantial funding, TC Energy made the final decision to go ahead. However, as described earlier, construction of the US section of the pipeline is currently blocked by a court order pending the completion of an additional environmental impact study. This effectively means a delay in the start of construction of US segments at least until 2021. The project has become highly politicized and is only likely to go ahead if President Trump is re-elected. This means that the project yet again faces further delays and may never be completed as initially planned.

Additionally, Enbridge is 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 the state Public Utility Commission is reviewing the operator's plan to build a new 5-mile (8-km) tunnel to replace the existing exposed section of the ageing underwater line. In late June, after an incident on the underwater section, Enbridge was ordered to shut part of the line until such time as a review of related safety issues shows that a restart is safe.

Should all of the three major expansion projects (Keystone XL, Trans Mountain Expansion and Line 3 Replacement) go ahead, they will add nearly 1.8 mb/d of new exit capacity from western Canada. However, other minor debottlenecking could add nearly 500 tb/d which itself is well above the latest projection for WCSB supply growth through 2030. In a major change from a year ago, infrastructure is no longer constraining WCSB supply from reaching markets in the period to 2030. Should the Line 5 project be blocked, a constrained situation would likely recur.

Assuming Line 5 continues to operate, the completion of just one major expansion should provide excess WCSB takeaway capacity for several years. In terms of the effects on 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 to Asia rather than to the US Gulf Coast.

What does appear certain is that the high-paced build-out of pipeline and related infrastructure in the US in recent years of is now over. The demand collapse this year has only reinforced the arguments against allowing new capacity and the difficulties and costs of getting projects built. A stunning turnaround within the space of a year is increasingly rendering pipelines into pipedreams. It seems that it will be some time before logistics capacity once again becomes a constraint to supplying US and Canadian crudes to market.

6.1.2 Other regions

There are several important developments in regions other than the US & Canada. In late 2019, the expansion of the ESPO pipeline from Russia to China and the Far East was officially inaugurated. The capacity of ESPO 1 (the leg from Taishet to Skovorodino) has risen to 1.6 mb/d. Furthermore, the capacity of ESPO 2 (the leg from Skovorodino to the Pacific Coast) has grown to 1 mb/d. This project was part of Russia's efforts to diversify supply routes and expand its presence in the Asia-Pacific, including China. At the moment, there are no concrete plans to further expand the export capacity from Russia to the east. However, further expansions are probable, bearing in mind the demand outlook in Asia. This Outlook assumes further expansions of the ESPO pipeline system to China and the Pacific Coast after 2020, with overall capacity increasing to 2 mb/d in 2030 and 2.4 mb/d in 2040.

During 2020, the Russian government proposed to reduce pipeline and railway tariffs for crude oil and products. The reduction would last during the DoC-related voluntary production adjustments and should help oil producers in Russia. The level of tariff reductions was still not published at the time of writing this Outlook; however, any reduction of tariffs would negatively affect Transneft's revenues, thus potentially impacting future pipeline projects.

The expansion of the Caspian Pipeline Consortium (CPC) pipeline in 2018, including construction of new pumping stations and storage facilities, raised the capacity from around 550 tb/d to 1.3 mb/d. Furthermore, based on the plans of the CPC consortium, additional expansions are possible in the coming years. This would involve additional investments (including usage of drag-reducing agents), potentially increasing the capacity up to 1.6 mb/d. This is in line with rising Kazakh crude output, of which a large share will be shipped through the CPC pipeline.

In terms of Kazakhstan's eastern pipeline towards China that carries Kazakh and Russian crude, the initial capacity was around 200 tb/d. Capacity was increased to 440 tb/d on the Atasu-Alashankou leg with the rest to be expanded in the coming years. Further expansions of the nameplate capacity of the pipeline are possible in the long-term through the application of drag-reducing additives or the installation of additional pump stations.

Finally, in China, the government decided to create a company that would manage domestic transmission and distribution of oil and gas pipelines. The so-called 'midstream reform' includes asset transfers from national oil companies, which currently manage the oil and gas pipeline infrastructure as a part of their portfolio. The result would be the creation of a single national pipeline operator, under the name China Oil and Gas Pipeline Network (PipeChina), which was to become operational in September 2020. This move also would enable independent oil and gas companies to access the pipeline grid under non-discriminatory terms.

6.2 Crude oil and product movements

The integrated global downstream sector relies on the ability to move crude oil, refined products and various intermediate streams between regions driven by economics. The infrastructure (pipelines and shipping capacities) enable market participants to move large amounts of oil liquids (crude or products) between almost any two regions of the world, whether over short or 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 to avoid short-term shortages of fuels 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, which 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; 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, it is never only one of the factors influencing the flow of petroleum, rather it is a combination.

The refining sector and its development is a key element in this regard. Based on the economics of oil movements and refining, there is a general preference for locating refining capacity in consuming regions due to the lower transport costs for crude oil compared to oil products. Strategic reasons are also a factor. As a result, crude and condensate account for the majority of trade, especially over long distances. However, refining hubs in developed countries (e.g. in the US) with highly complex plants are competing increasingly in the international product market, in line with slower domestic demand growth and available cheap feedstock.

Furthermore, for producing and consuming countries alike, there is an emphasis on securing refined product supply through domestic refining rather than imports, regardless of the 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 instead of just crude oil. As an extension of this strategy, in their efforts to secure future outlets for their 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, they continue to seek to participate in downstream projects in the Asia-Pacific.

Given the considerations described above, 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 all 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 where it is impossible to predict what the ownership interests and policies of individual companies and countries might be. The differences between short-term market realities (such as the constraints resulting from ownership interests and term contracts) and a modelling approach that looks at the longer-term (with few restrictions on movement and one that operates by minimizing global costs) mean it is necessary to recognize that model-projected oil movements do not fully reflect short-term factors. Therefore, they may predict trade patterns that are not direct extensions of those that apply 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 trends in crude oil movements, which necessarily function to resolve regional supply and demand imbalances for both crude and products. These projections are, of course, dependent on the assumptions used in this Outlook, which, if altered, could materially impact projected movements.

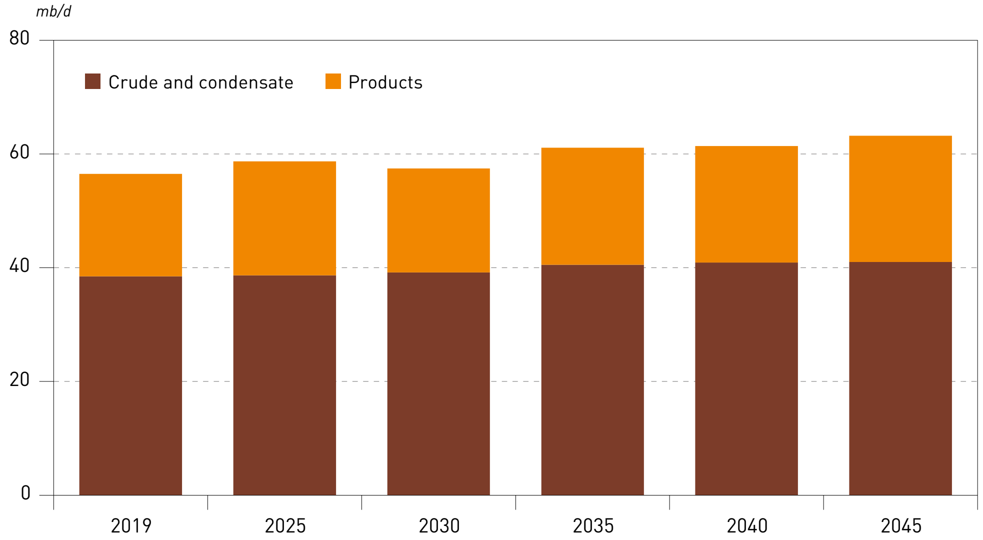
Key elements in model-based projections are the volumes and qualities of both crudes produced and the products consumed by region, and how these change over time. Another element is the location and capability of refining capacity. Over the longer-term, the relative economics of building new refinery 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 opportunities to those regions with spare refining capacity to export products.

In Figure 6.2, projected global oil trade between 2019 and 2045 is shown on a seven-region basis (excluding trade within these regions). Global oil trade is projected only for anchor years (2019, 2025, 2030, 2035, 2040 and 2045) with a focus on the long-term trends. These projections are in line with forecasts for regional demand (Chapter 3) and supply (Chapter 4), as well as refinery capacity, including expansions (Chapter 5).

In total, oil trade (including crude oil and condensates, as well as products) increases from around 56 mb/d in 2019 to 63 mb/d in 2045. Both crude and condensate, as well as product trade increase between 2019 and 2045, with the share of product trade expected to rise from around 31% to 35%.

The level of the total crude and condensate trade is expected to remain broadly stable at around 38.5 mb/d between 2019 and 2030, with several export regions increasing domestic use of crude, which limits growth in this period. After 2030, global crude trade increases towards 41 mb/d in 2040 and remains at that level to 2045, with trade increasingly shifting from the Atlantic basin to the Asia-Pacific. This is slightly lower compared to levels forecast last year, with projections of close to 42 mb/d in 2040. This is mostly due to lower demand levels in several major importing regions calling for fewer crude and condensate imports.

Figure 6.2
Interregional crude oil and products exports, 2019–2045



Source: OPEC.

Product trade increases from around 18 mb/d in 2019 to 20 mb/d in 2025, driven by rising demand and insufficient domestic refining capacity in this period. However, product trade is expected to drop back to around 18 mb/d in 2030 in line with refining capacity expansion in net importing regions such as Africa and Latin America. In the long-term, rising demand in developing countries leads to higher product trade, which gradually increases towards 22 mb/d in 2045. One of the major reasons for this increase is the falling demand in the US & Canada region, where refiners increasingly focus on product exports. Although under pressure, US refiners are estimated to be competitive in line with the availability of domestic feedstock supply and complex refining systems. The majority of additional product trade is linked to Asia-Pacific and its rising demand.

6.3 Crude oil and condensate movements

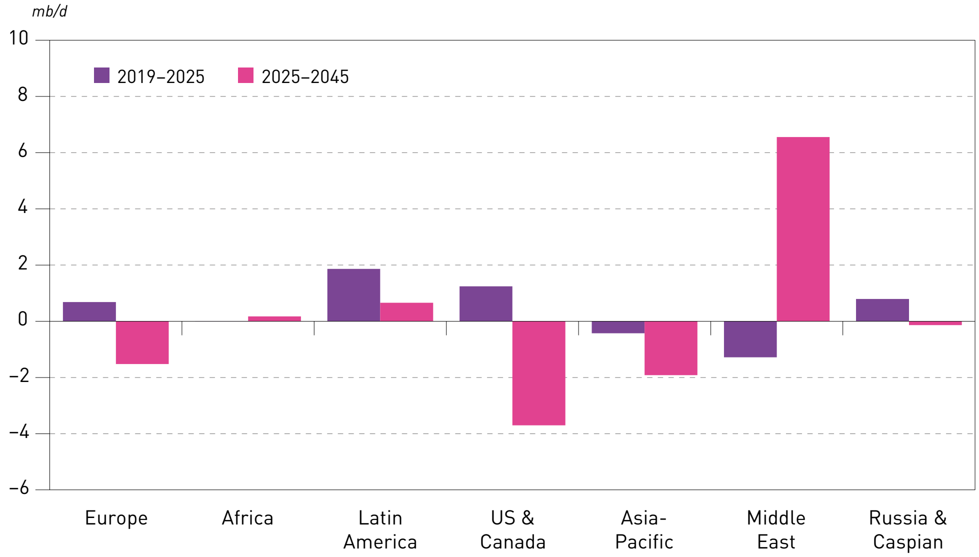
This section focuses on main crude oil and condensate movements on the regional level. It shows trade flows from the perspective of main exporting regions and main importing regions.

Crude oil supply and quality

Figure 6.3 shows changes in crude and condensate supply (excluding NGLs and non-crude liquids) by region in the periods 2019–2025 and 2025–2045. In the first period (2019–2025), crude and condensate supply is expected to increase by almost 3 mb/d. The largest contributor to this growth is Latin America (predominantly Brazil and Guyana) with close to 2 mb/d. The US & Canada region contributes around 1.2 mb/d in the same period, as the growth has been dampened in the medium-term by the COVID-19 pandemic and corresponding decline in demand. (In the case of the US & Canada, crude and condensate supply and trade include synthetic crude.)

The Russia & Caspian region increases by around 800 tb/d by 2025, while Europe also shows a significant increase of around 700 tb/d which can be attributed to new developments in the North Sea. At the same time, the Middle East is set to decline by 1.3 mb/d due to falling demand for OPEC crude, while the Asia-Pacific decreases by 400 tb/d due to natural depletion of existing fields.

Figure 6.3
Change in crude and condensate supply between 2019 and 2045*



* *Includes condensate crudes and synthetic crudes.*
Source: OPEC.

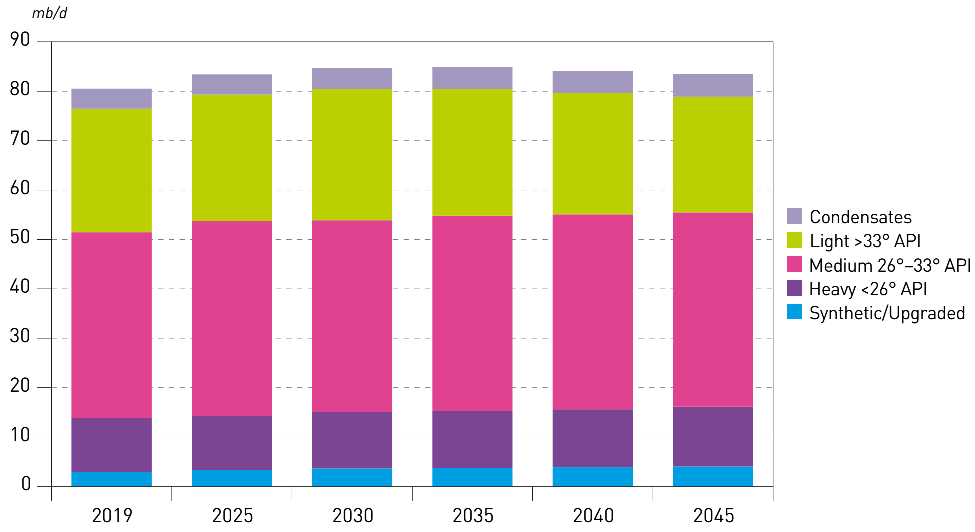
Between 2025 and 2045, the picture changes fundamentally. Although the overall crude and condensate production stays flat in this period, there are large shifts on the regional level. Middle East production is expected to increase by around 6.5 mb/d, driven by rising demand for OPEC crude. The growth in Latin America slows down and is expected at some 700 tb/d in the same period. Minor growth of only 200 tb/d is also expected in Africa. All other regions are likely to see declines in the long-term.

The most significant decline of around 3.7 mb/d is observed in the US & Canada as production in the US peaks and decreases. Gains in Canada are not enough to offset US declines. Crude and condensate production in the Asia-Pacific region is projected to fall by nearly 2 mb/d due to continuous declines at existing fields. Similar trends can be observed in Europe with projected declines of 1.5 mb/d in the period 2025–2045, mostly attributed to the UK and Norway. The Russia & Caspian region stays basically flat in the long-term with declines in Azerbaijan and Russia, which are offset by production gains in Kazakhstan.

Oil supply developments described above also have implications on the quality of the crude oil supply. As shown in Figure 6.4, the supply of all crude oil qualities is expected to increase between 2019 and 2030. In the post 2030-period, however, the supply of light crudes is expected to decline, while the supply of heavy grades (including synthetic), medium grades and condensates increases.

The light-sweet supply is set to increase by some 1.5 mb/d between 2019 and 2030, reaching 26.5 mb/d, mostly due to increases in the US, which more than offset declines in other regions (e.g. the Asia-Pacific). This modest increase is lower compared to projections from previous Outlooks. The growth in the light-sweet supply has been revised down significantly in this period due to the strong impact of the COVID-19 pandemic and the related demand shock on US production. In the long-term, as US production peaks and other non-US light production declines (Europe and Asia), global light-sweet production inches down to below 23.5 mb/d in 2045. Light supplies still increase in Kazakhstan, but this is insufficient to offset declines elsewhere.

Figure 6.4
Global crude and condensate supply by quality, 2019–2045



Source: OPEC.

Medium grades are projected to increase between 2019 and 2030 mostly based on the rising production in Norway and Latin America (Brazil), which are predominantly medium-sweet. Total medium production increases by around 1.3 mb/d, reaching 38.8 mb/d in 2030. In the long-term, the supply of medium-grades is projected to increase even further to almost 39.5 mb/d. This is the result of a significant increase in the Middle East, which is somewhat offset by declines of medium supply in other regions including the Asia-Pacific, Europe and Russia & Caspian.

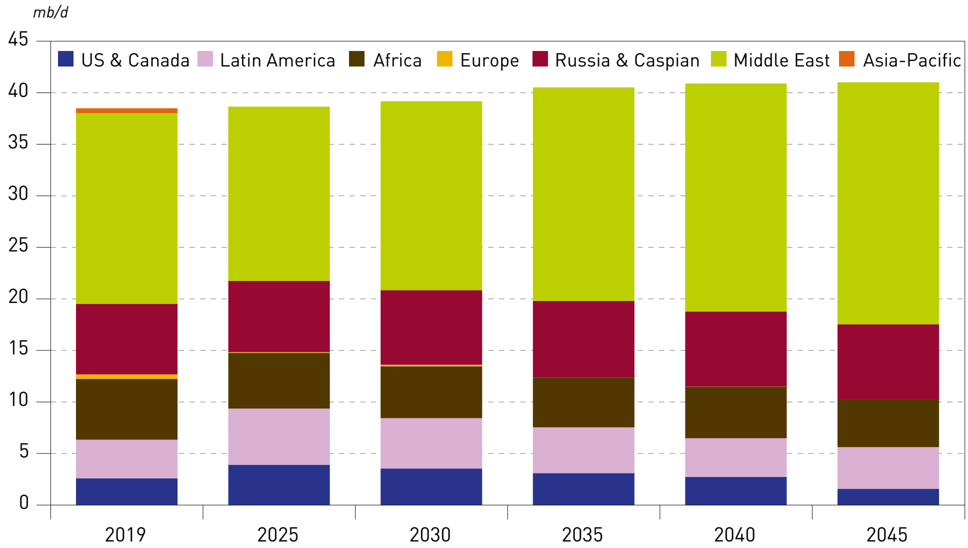
Heavy supply increases gradually from around 11 mb/d to over 12 mb/d in 2045, which is mostly due to the expansion in the Middle East, as well as Latin America (mostly Venezuela). In addition, heavy synthetic supply increases from 2.9 mb/d in 2019 to 4 mb/d in 2045, which is accounted for by gains in Canada and Latin America.

Compared to the previous Outlook, the current Reference Case projects a lower supply of light grades in the long-term, which may result in fewer difficulties for refining industry operations. Last year, concerns arose regarding the capability of the global refining system to process additional light-sweet barrels. Based on an analysis in the WOO 2019, global refining capacity, although with continuous challenges related to blending, logistics and trading, had sufficient capacity and flexibility to address the increase of light-sweet supply from the US. As this Outlook sees a lower supply of light-sweet grades from the US, especially in the medium-term (relative to the WOO 2019), the global refining system is not likely to be facing a light-sweet 'oversupply' in the years to come.

Crude and condensate oil movements

Figure 6.5 shows global crude oil and condensate trade by major region. Overall, the trade volume, which was estimated at around 38.5 mb/d in 2019, is likely to increase only slightly by 2030, reaching 39.2 mb/d. As this is the period of relatively strong refining capacity expansion in several crude-producing regions (Chapter 5), more crude is consumed domestically, thus reducing crude and condensate exports.

Figure 6.5
Global crude and condensate exports by origin*, 2019–2045



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

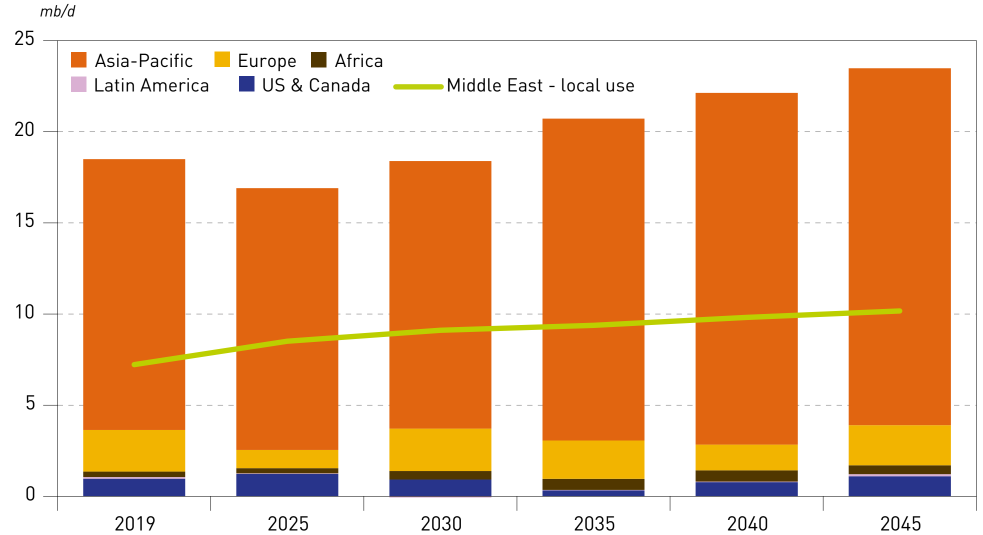
In more detail, exports from the US & Canada and Latin America increase in this period while exports from Africa and the Middle East decline. Crude and condensate exports from the US & Canada increase from around 2.5 mb/d in 2019 to almost 4 mb/d in 2025 and decline slightly to 3.5 mb/d by 2030. In Latin America, exports rise by more than 1.5 mb/d between 2019 and 2025 to 5.5 mb/d, but decline to just below 5 mb/d. Crude and condensate flows from Africa are expected to decline gradually from almost 6 mb/d in 2019 to 5.2 mb/d in 2030. Middle Eastern exports decrease from 18.5 mb/d in 2019 to 16.7 mb/d in 2025, as demand for OPEC barrels declines and in line with rising domestic use. Exports recover in line with rising supply and come back to 2019 levels of around 18.5 mb/d. Movements of crude and condensate from the Russia & Caspian region remain stable in the period by 2030.

In the period 2030–2045, total crude oil exports are expected to increase to around 41 mb/d in 2040 and remain stable to 2045, mainly due to the expansion of exports from the Middle East, offsetting declines in most other regions. Middle East exports increase to above 23 mb/d by 2045, a rise of around 5 mb/d relative to 2030. OPEC volumes (Chapter 4) are the major driver for the relatively high level of incremental exports in the increase. The only other region which shows growth is Russia & the Caspian, with only marginal increases. All other exporting regions see declines in the flows due to rising domestic use and lower supply. The largest decline is assumed for the US & Canada, where exports should fall by around 2 mb/d from 2030 until the end of the projection period. Latin America and Africa also decline, but at levels below 1 mb/d.

Figures 6.6 to 6.10 describe crude and condensate exports in the main exporting regions – such as the Middle East, Russia & Caspian, Latin America, Africa and the US & Canada.

Figure 6.6 shows crude and condensate exports from the Middle East, where exports are projected to decline significantly in 2025 relative to 2019, falling from 18.5 mb/d to 16.7 mb/d. Declining demand for OPEC barrels in this period is one of the reasons for the fall in exports. However, an even more significant reason is the increase in domestic crude runs, in line with the start-up of new refining projects in this region. As the total increase in refinery runs of around 1.2 mb/d is higher relative to the incremental domestic demand by 2025 in the Middle East, some of the

Figure 6.6
Crude and condensate exports from the Middle East by major destination, 2019–2045



Source: OPEC.

incremental product volumes will be exported. In other words, additional product exports will, to some extent, replace lost crude export volumes in the medium-term period.

In line with the gradual rise in Middle Eastern supply, export volumes of crude and condensates are projected to increase gradually from 2025 onwards, reaching levels of around 23.5 mb/d by 2045. Consequently, the Middle East's share of global crude and condensate exports increases from around 48% in 2019 to 57.5% in 2045.

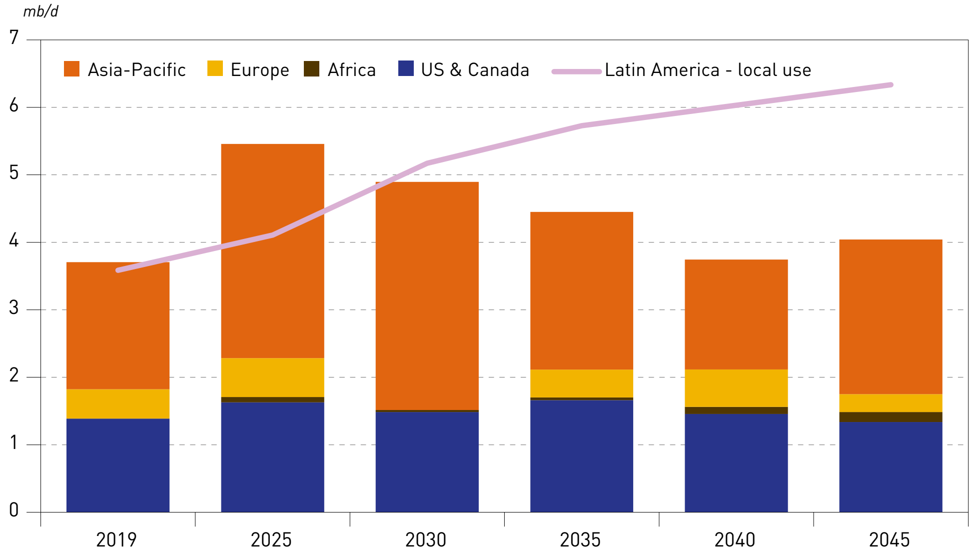
In terms of the regional distribution, the Asia-Pacific is by far the most important outlet for Middle Eastern barrels – growing from around 15 mb/d in 2019 to almost 20 mb/d in 2045. The share of east-bound barrels in the Middle East's total exports increases from around 80% in 2019 to 83% in 2045. Despite a dip to about 1 mb/d in 2025 (due to rising European domestic supply and exports from the US & Canada), crude and condensate exports to Europe remain important for the Middle East in the long-term. Exports are projected to increase again to 2.2 mb/d in 2045, a level similar to 2019. It is important to note that Middle Eastern exports to Europe compete against barrels from Africa and to some extent the US & Canada.

Finally, exports to the US & Canada are projected to remain stable by 2030 at around 1 mb/d, after which a drop is projected to below 500 tb/d in 2035, in line with declining crude runs in the US. However, Middle Eastern exports rise again towards 1 mb/d in 2045, partly due to declining flows of heavy-sour barrels from Latin America to the US.

Lastly, the local use of crude and condensate in the Middle East is projected to increase by almost 3 mb/d throughout the projection period, reaching 10.2 mb/d in 2045. Only one part of this increase will be used to satisfy incremental local refined product demand, while the rest will be exported to other regions.

Flows from Latin America are expected to increase by more than 1.5 mb/d to around 5.5 mb/d in 2025 (Figure 6.7) in line with growing supplies, which rise by more than 2 mb/d in the same period. However, exports decline gradually towards 4 mb/d in 2045 as new refining capacity is expected to come online, thus increasing local crude use.

Figure 6.7
Crude and condensate exports from Latin America by major destination, 2019–2045



Source: OPEC.

There are two major outlets for Latin American barrels – the US & Canada and Asia-Pacific. Exports to the US & Canada are mostly heavy-sour crudes, which are in strong demand from US refiners. These exports increase from around 1.4 mb/d in 2019 to 1.7 mb/d in 2035 on rising Latin American supply. However, these flows decline gradually towards 1.3 mb/d in 2045, in line with a significant decrease of refinery runs in the US & Canada and rising supplies of heavy barrels from Canada.

Crude and condensate exports from Latin America to the Asia-Pacific region are projected to increase from 2 mb/d in 2019 to almost 3.5 mb/d in 2030, thanks to the rise in supply. However, rising local crude use in Latin America limits the exports to the Asia-Pacific, which decrease after 2030, reaching 2.3 mb/d in 2045.

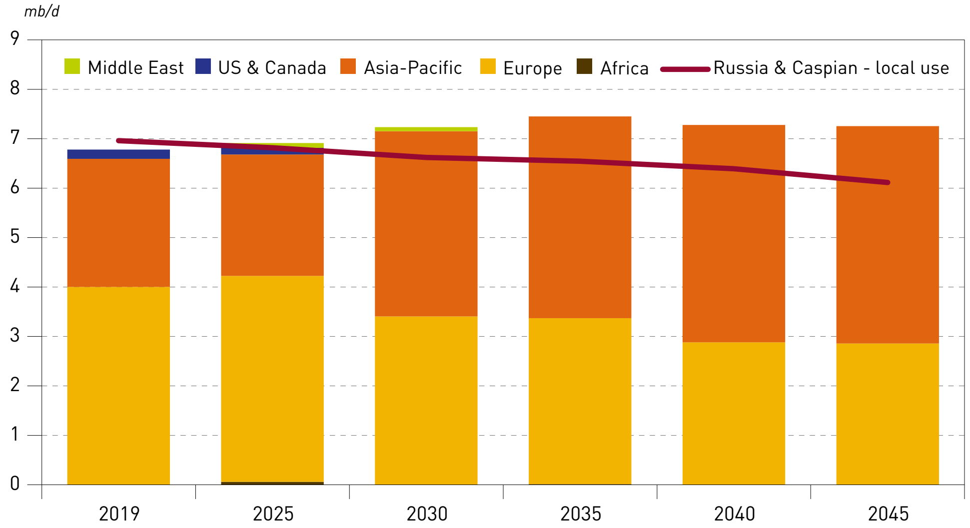
Latin American exports to Europe do not exceed levels of around 600 tb/d throughout the projection period. Latin American barrels in Europe compete against other supplies, mostly from Africa and the Middle East.

Finally, local crude use is expected to increase from 3.6 mb/d in 2019 to 6.3 mb/d in 2045, as the Latin American region is likely to consume more crude in its own refineries. This should help to reduce the need for product imports and satisfy rising demand.

Crude and condensate exports from the Russia & Caspian region (Figure 6.8) increase throughout the forecast period, from around 6.8 mb/d to 7.3 mb/d in 2045, the result of rising oil output (mostly in Russia and Kazakhstan) in combination with declining local use of crude. Crude and condensate exports go mostly to Europe and the Asia-Pacific region, with minor volumes directed elsewhere.

Exports to Europe remain at levels of around 4 mb/d in 2019 and 2025. However, flows decline from 2030 onwards due to waning oil demand in Europe and the increasing focus of Russia & Caspian exports to the east. Some competition for Russian barrels in Europe is expected from

Figure 6.8
Crude and condensate exports from Russia & Caspian by major destination, 2019–2045



Source: OPEC.

Africa and the Middle East throughout the period. Export volumes in 2030 and 2035 are estimated at around 3.5 mb/d and are expected to decline to just below 3 mb/d in 2040 and 2045.

Crude and condensate flows from the Russia & Caspian region to the Asia-Pacific are expected to increase gradually, from around 2.5 mb/d in 2019 and 2025 to levels above 4 mb/d from 2030. Expected oil demand growth in the Asia-Pacific region is the major driver for the increased movements and is supported by expansion of the export infrastructure. In late 2019, the expansion of the ESPO pipeline from Russia to the Pacific Ocean was finalized, increasing capacity to 1.6 mb/d for ESPO 1, ending in Skovorodino, and 1 mb/d for the leg to the port of Kozmino on the Pacific Coast. Further expansions of export infrastructure are probable in the long-term and are assumed in the Reference Case.

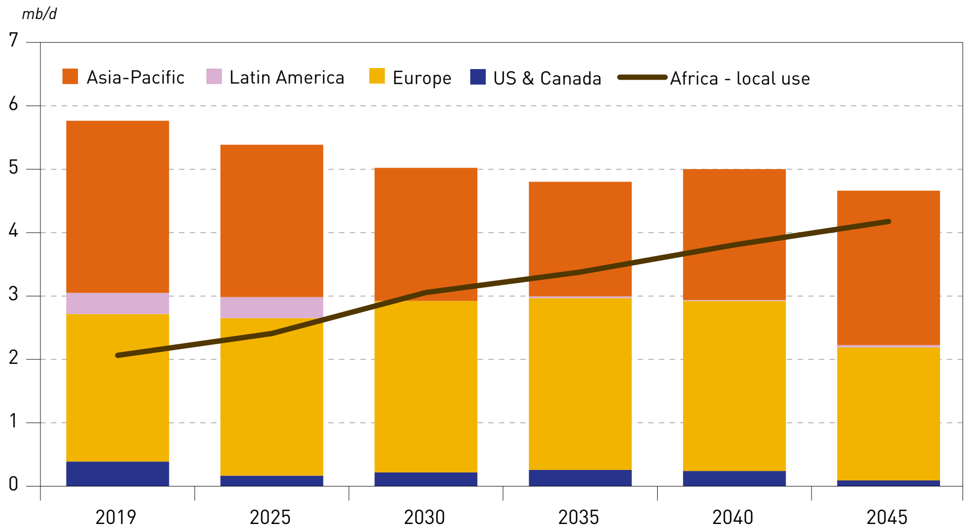
Finally, local crude use is projected to decline gradually, from 7 mb/d in 2019 to just above 6 mb/d in 2045. Refinery throughputs in Russia come increasingly under pressure in the long-term as export markets such as Europe decline significantly.

Crude and condensate exports from Africa (Figure 6.9) are projected to decline gradually throughout the period 2019–2045, from almost 6 mb/d to 4.7 mb/d. This is despite the fact that Africa's crude and condensate supply is expected to increase somewhat in this period. The major driver is the significant rise in domestic refinery throughputs in line with the expansion of the refining capacity (Chapter 5). Consequently, domestic crude and condensate use doubles between 2019 and 2045, reaching 4.2 mb/d by the end of the projection period.

Europe and the Asia-Pacific are the two major outlets for African crude and condensate. Flows to Europe increase from around 2.3 mb/d in 2019 to around 2.7 mb/d between 2030 and 2040 before dropping to around 2 mb/d in 2045. Rising flows to Europe in 2030 can be justified by declining European production. Remaining in the Atlantic basin, African crude and condensate exports to the US & Canada are projected to almost disappear by 2045. Some of these US-bound volumes will be redirected to Europe.

Exports to the Asia-Pacific are expected to decline in the 2019–2035 period, from around 2.7 mb/d in 2019 to just under 2 mb/d in 2035. This is due to declining volumes of African exports and competition from other regions, such as the US & Canada. Exports to the Asia-Pacific are expected to stage a slight rebound of almost 2.5 mb/d in 2045 as African flows to Europe decline.

Figure 6.9
Crude and condensate exports from Africa by major destination, 2019–2045



Source: OPEC.

Crude and condensate flows from the US & Canada (not including intra-trade flows between the US and Canada) are projected to increase from 2.6 mb/d in 2019 to almost 4 mb/d in 2025 (Figure 6.10). This is somewhat lower relative to last year's projections as the supply outlook was revised down (Chapter 4). From 2025 onwards, US & Canada exports to international markets decline gradually, reaching levels of just above 1.5 mb/d in 2045.

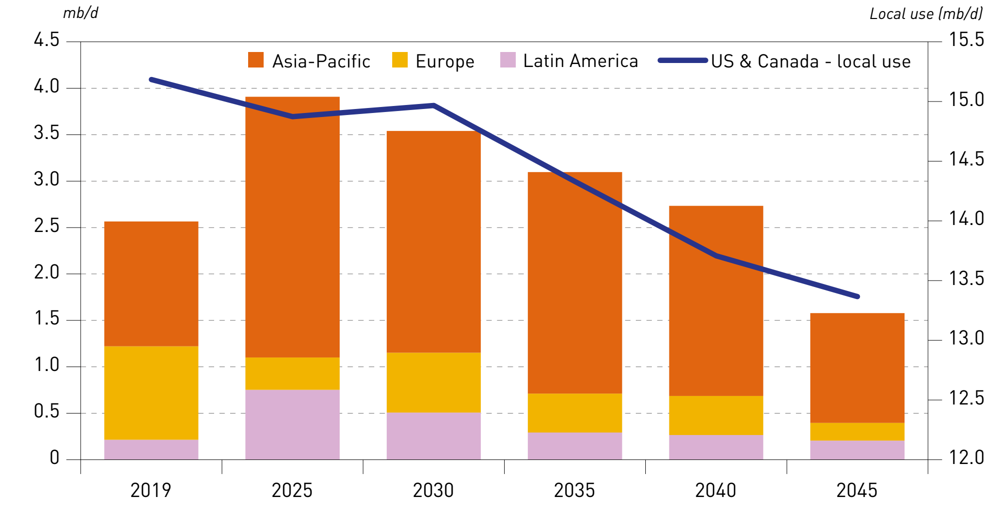
The majority of US & Canada exports are projected to head to the Asia-Pacific, peaking at 2.8 mb/d in 2025, declining to around 2.5 mb/d between 2030 and 2035, and decreasing towards 1.2 mb/d in 2045. The rising numbers of petrochemical projects in the Asia-Pacific represent a good fit, as the US light grades are rich in light distillates.

Exports to Europe are expected to drop in 2025 as the European (Norwegian) sweet supply is expected to increase in the medium-term and oil demand in Europe starts to decline. Exports recover again towards 2030, but remain at 600 tb/d followed by a gradual decline to only 200 tb/d in 2045. Declining demand and refinery throughputs in Europe are the major driver of the drop in crude and condensate flows from the US & Canada to Europe.

Latin America is also expected to receive some US & Canada volumes with the peak in 2025 at 800 tb/d. However, as overall export volumes from the US & Canada are declining, Latin America receives only 200 tb/d in 2045. Finally, local crude use in the US & Canada drops from above 15 mb/d in 2019 to around 13.5 mb/d in 2045, due to declining refinery throughputs in this region.

Figures 6.11 to 6.13 show the major crude and condensate importing regions: the US & Canada, Europe and the Asia-Pacific. These three regions combined represent more than 95% of the total crude and condensate imports throughout the outlook period.

Figure 6.10
Crude and condensate exports from US & Canada by major destination, 2019–2045



Source: OPEC.

Even with the current cutbacks in US crude and condensate production, crude quality is likely to remain a factor, which continues to support crude oil imports (Figure 6.11). With regard to imports, today these are predominantly medium to heavy, generally sour, grades. In the first four months of 2020, nearly 62% of US crude oil imports were of 25° API or heavier and 94% were at or below 35°. In contrast, incremental US production – notably in the Permian, Eagle Ford and other tight oil regions – is predominantly light to very light, in the 40–55° API range. Average US refinery crude slates are in the 32–34° range and heavier on the West Coast. Therefore, the current crude oil import quality is well matched to US refineries and likely to be sustained, whereas US light tight oil production is generally not a good fit and so is likely to continue to be exported, even if supply volumes dip.

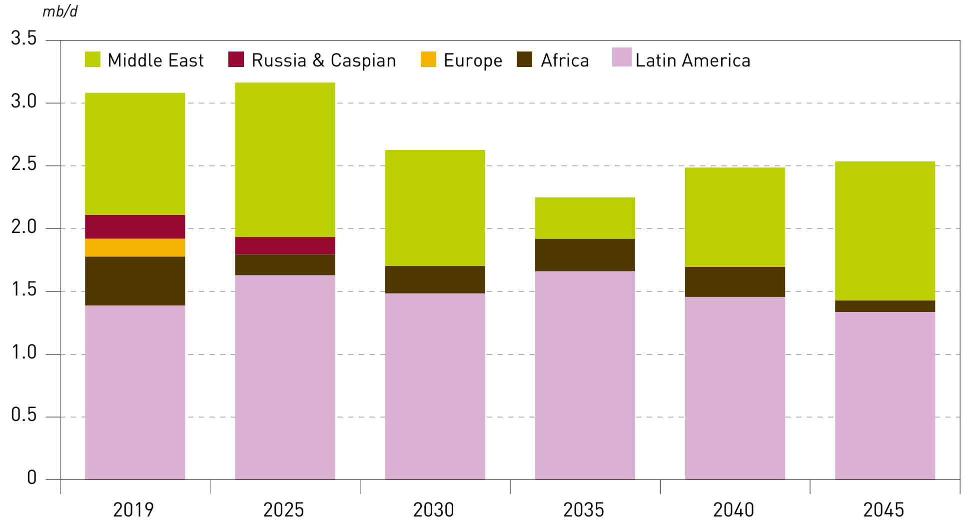
As shown in Figure 6.11, overall import volumes were around 3 mb/d in 2019 and at a similar level in 2025, but decline to around 2.5 mb/d in 2030 and remain at these levels until the end of the forecast period.

The predominant supplier throughout the projection period remains Latin America, with levels hovering round 1.5 mb/d (mostly heavy-sour crude). Imports from the Middle East remain at around 1 mb/d except for a temporary drop in 2035. Relative to last year's Outlook, volumes from the Middle East are somewhat higher which is partly due to the downward revision of local production of sour grades (mostly in Canada) and somewhat lower imports from Latin America. Finally, imports from Africa remain low and also diminish by the end of the period.

As shown in Figure 6.12, Europe's crude and condensate imports are projected to decline gradually from 10 mb/d in 2019. In the medium-term, crude and condensate imports drop to around 8.5 mb/d in 2025, partly due to increasing European domestic supply, followed by an increase to around 9 mb/d in 2030. However, as the European supply starts falling in combination with declining demand, European crude and condensate imports drop to around 7.5 mb/d in 2045.

The Russia & Caspian region, Middle East and Africa are major suppliers to Europe. Flows from Russia & Caspian are initially seen at around 4 mb/d in 2019 and 2025. However, they decrease

Figure 6.11
Crude and condensate imports to the US & Canada by origin, 2019–2045

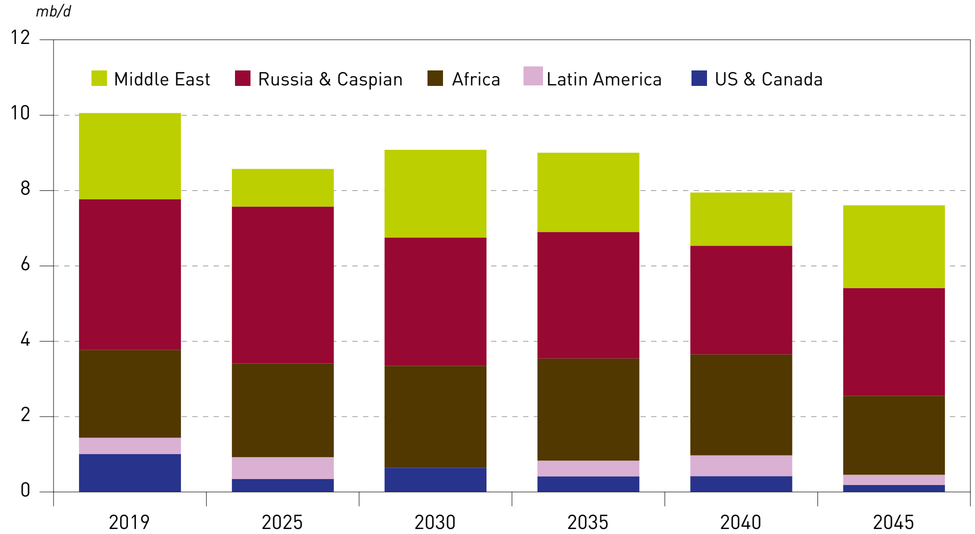


Source: OPEC.

towards 3 mb/d by the end of the projection period due to declining European demand and the increasing shift of Russia & Caspian exports to the Asia-Pacific.

Africa is the second most important supplier of crude and condensate to Europe. Volumes are forecast to increase from 2019 to 2025 and 2030 from around 2.3 mb/d to 2.7 mb/d. Volumes drop in the long-term to just above 2 mb/d, mostly due to declining European demand and rising domestic use in Africa.

Figure 6.12
Crude and condensate imports to Europe by origin, 2019–2045



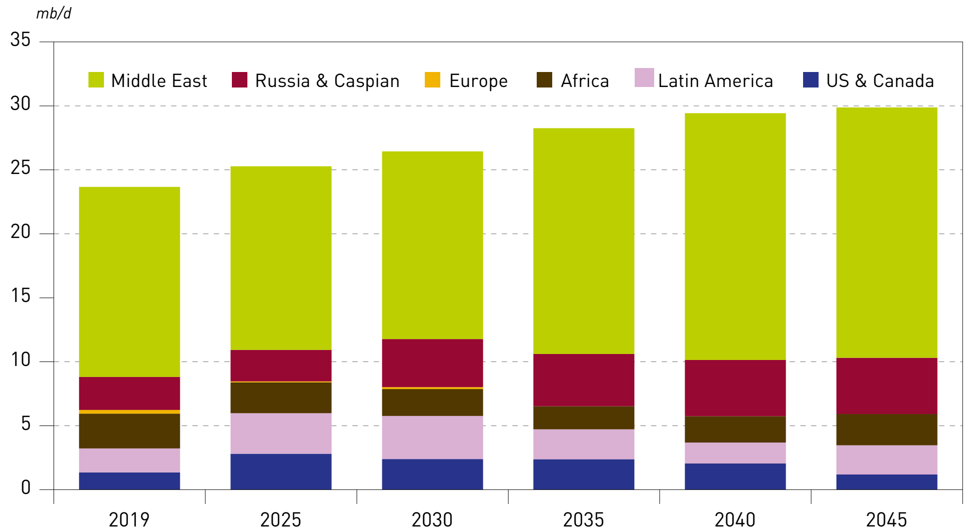
Source: OPEC.

The Middle East remains an important supplier throughout the period with import volumes above 2 mb/d, though with temporary drops in 2025 to 1 mb/d (due to the rising European domestic supply) and 2040 to 1.4 mb/d.

Imports from Latin America remain low, reaching maximum levels of 600 tb/d in the long-term. Europe is not a primary market for Latin American barrels, with limited volumes being shipped depending on competition from other regions.

Finally, the Asia-Pacific region remains the most important crude and condensate importing region (Figure 6.13). The overall volumes were at 23.7 mb/d in 2019 and are projected to increase to almost 30 mb/d by 2045, as demand in the Asia-Pacific continues to rise.

Figure 6.13
Crude and condensate imports to Asia-Pacific by origin, 2019–2045



Source: OPEC.

The Middle East is and will remain the largest supplier to the Asia-Pacific with exports at just below 15 mb/d and these are expected to increase to almost 20 mb/d in 2045. In the period to 2030, Middle Eastern volumes to the Asia-Pacific are projected to come under pressure, as demand for OPEC crude decreases in the medium-term and in line with additional competition from other regions. However, these volumes recover from 2035, with fast growth until 2040 as the supply from other regions declines or peaks (e.g. the US & Canada and Latin America).

The Russia & Caspian region is expected to become the second most important supplier to the Asia-Pacific after the Middle East. This trend is favoured by infrastructural projects, such as the ESPO pipeline, which are expected to expand in the future. Seaborne exports are also likely to increase. In total, exports from Russia & Caspian are set to increase from around 2.6 mb/d in 2019 to just above 4 mb/d in 2035 and further to almost 4.5 mb/d after 2040.

African flows to the Asia-Pacific decline from 2019 (2.7 mb/d) to 2035 (1.8 mb/d), in line with higher domestic use of crude in Africa, but also rising competition from the US & Canada and Russia & Caspian. However, African exports to the Asia-Pacific recover by the end of the forecast period and are estimated at close to 2.5 mb/d. Lower African exports to Europe make more volumes available for the Asia-Pacific.

Latin American exports to the Asia-Pacific were around 1.9 mb/d in 2019. Due to a strong increase in supply, Latin American flows to the Asia-Pacific increase to almost 3.5 mb/d in 2030. Exports decline to around 2.3 mb/d in 2045, mirroring rising domestic use of crude in Latin America.

Based on projected crude and condensate exports and imports, net imports for the seven aggregated regions are calculated in Figure 6.14. It summarizes the interregional flows already highlighted and puts regional net imports into perspective. This approach is especially helpful for regions that are both significant crude and condensate exporters and importers, like the US & Canada.

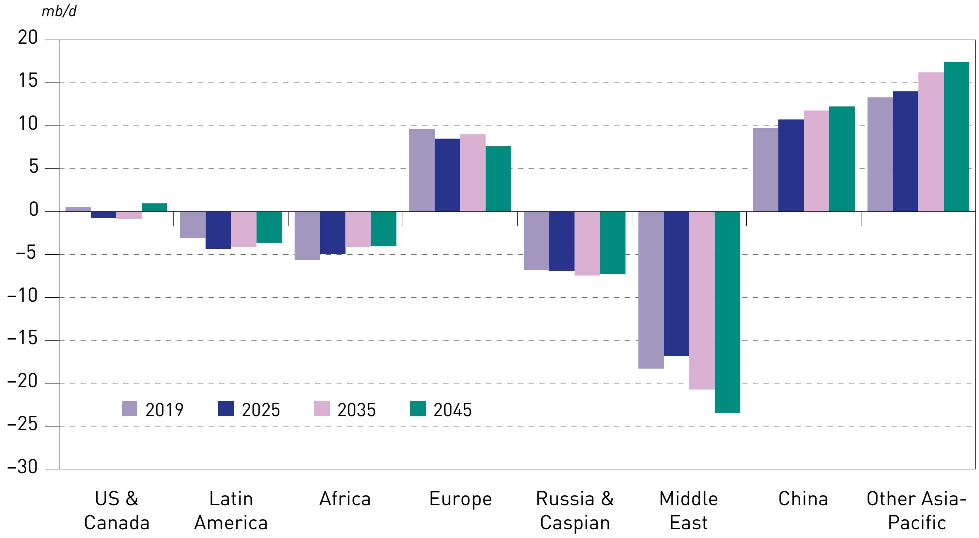
Figure 6.14 shows net crude and condensate imports (i.e. imports minus exports) for 2019, 2025, 2035 and 2045. The only region that is in close parity is the US & Canada, which starts with minor crude and condensate net imports of around 500 tb/d, flipping into negative net imports in 2025 and 2035 of around –700 tb/d. However, due to declining supply in the US, net crude and condensate imports flip back to positive territory and reach levels around 1 mb/d by 2045.

Latin America and Africa both remain important net crude and condensate exporters throughout the period. However, net crude and condensate exports decline in these regions as domestic crude use increases. Latin American net exports initially increase due to rising supply and reach 4.3 mb/d in 2025. As domestic use increases, net exports are seen at 3.7 mb/d by the end of the period. African net exports decrease from 5.6 mb/d in 2019 to 4 mb/d as domestic crude use in Africa rises by more than 2 mb/d.

Middle Eastern net exports show a dip in 2025, but increase in the long-term. Net exports are estimated at 23.5 mb/d, up from 18.3 mb/d in 2019. The increase of more than 5 mb/d illustrates the significance of the Middle East in the overall balance.

On the net import side, China and Other Asia-Pacific increase their net imports in the period 2019–2045. Chinese net crude and condensate imports are estimated at above 12 mb/d in 2045, up by 2.5

Figure 6.14
Regional net crude and condensate imports, 2019, 2025, 2035 and 2045



Source: OPEC.

mb/d from 2019. Net imports to Other Asia-Pacific increase by 4.2 mb/d from 2019, reaching 17.4 mb/d in 2045. At the same time, net crude and condensate imports to Europe decline by 2 mb/d in the same period, falling to 7.6 mb/d in 2045.

6.4 Product movements

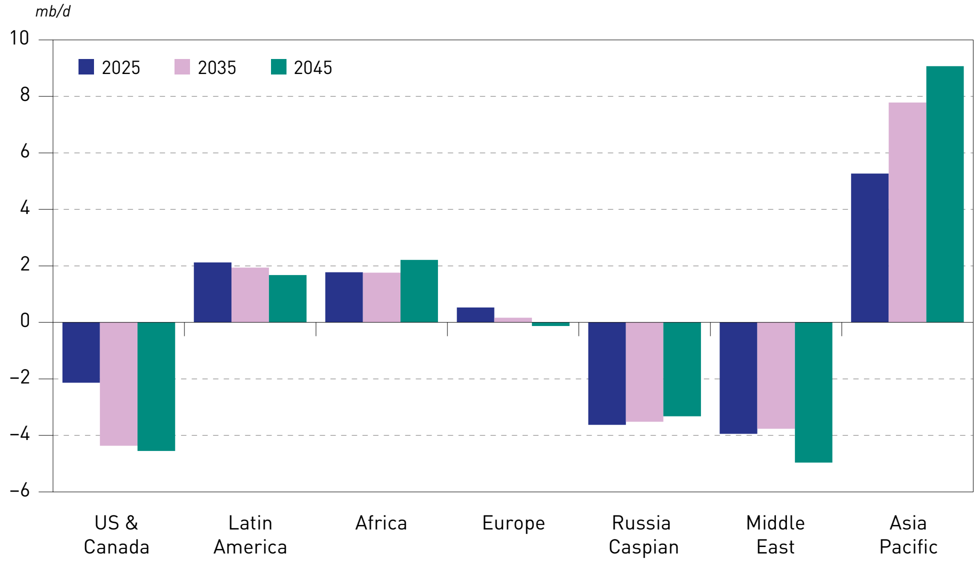
Refined product movements between the seven major regions are significantly lower relative to crude and condensate flows. The majority of refined products are produced and consumed within the respective regions. One of the reasons is the cost of transportation, namely for clean products, which are normally higher relative to crude and condensates.

There are several major trends that can be observed in the long-term (Figure 6.15). Two regions manage to increase their net product exports – the US & Canada and the Middle East. In the US & Canada, net product imports are expected to increase from 2.1 mb/d in 2025 to 4.5 mb/d in 2045. This is the result of declining demand in the US & Canada, which frees some of the refining capacity for international markets. Furthermore, the US refining system profits from high levels of complexity, as well as availability of discounted feedstock.

In the Middle East, net exports increase from just below 4 mb/d in 2025 to 5 mb/d in 2045. This is the result of expanding refining capacity in the region, some of which is aimed at international product markets.

The increase in net product exports in the US & Canada and Middle East mirror the increase in net product imports in the Asia-Pacific. Even though significant refining capacity expansion is projected in the Asia-Pacific region, product net imports increase from 5.3 mb/d in 2025 to just above 9 mb/d in 2045. In other words, exports from the US & Canada and the Middle East are estimated to be, to some extent, more competitive compared to constructing additional refining capacity in the Asia-Pacific. Even though refining capacity in the Asia-Pacific expands significantly in the long-term, rising demand still requires additional product imports from the US & Canada and the Middle East.

Figure 6.15
Regional net product imports, 2025, 2035 and 2045



Source: OPEC.

Net imports in Latin America are expected to decline from 2.1 mb/d in 2025 to 1.7 mb/d in 2045. Rising refining capacity and higher utilization of the existing capacity contribute to this trend. In Africa, product net imports remain stable between 2025 and 2035 at 1.8 mb/d. However, net imports inch up to 2.2 mb/d in 2045. Strong competition from US refineries is one of the reasons for the increase towards 2045.

In Europe, net imports of around 500 tb/d in 2025 are expected to decline to levels of around –100 tb/d, in line with falling demand in this region. In line with declining European oil demand, net product exports from Russia & Caspian are seen declining from 3.6 mb/d in 2025 to 3.3 mb/d in 2045.

Energy policy, climate change and sustainable development

Key takeaways

- Sustainable development provides a comprehensive framework for the pursuit of climate mitigation and human well-being by integrating socio-economic and environmental aspects.
- As the world has embarked on the 'Decade of Action', which entails delivery of the SDGs and implementation of the Paris Agreement, multilateral cooperation appears to be under pressure due to an unprecedented challenge, the COVID-19 pandemic.
- The 2030 Agenda for Sustainable Development pledges to leave no one behind, yet inequalities exacerbated by the pandemic could become even more pronounced in the long-term – not least for developing countries and vulnerable groups that feel the effects of the pandemic acutely.
- Achievement of the SDGs is necessary more than ever, particularly to reduce vulnerabilities to crises by optimizing the interactions between the goals – including those on ending poverty (SDG 1), good health and well-being (SDG 3), quality education (SDG 4), affordable and clean energy (SDG 7), decent work and economic growth (SDG 8), and climate action (SDG 13).
- The design of comprehensive and holistic strategies for the implementation of the 2030 Agenda and the Paris Agreement could be built on the narrative that climate change mitigation should not be an end in itself but a means to achieve the SDGs.
- The implementation of national energy policies under the Paris Agreement is gaining urgency with new targets set for 2030 and 2050.
- Novel approaches, such as the CCE, could support a transformational leap towards a sustainable society that enables us to tackle climate change and reduce GHG emissions.
- International cooperation could allow a more coherent, balanced and integrated approach for realizing the long-term goals of the Paris Agreement in the context of sustainable development.
- The EU is in the process of developing an ambitious plan for realizing a carbon-neutral continent by 2050. However, implementation of required steps by Member States will remain a challenge for future energy policy developments.
- Energy policy in the US has undergone significant change during the current administration. The outcome of the presidential election in November 2020 will likely have significant implications on future energy policies in the country.
- China's 14th Five-Year Plan, still under preparation at the time of finalizing this Outlook, will likely continue supporting actions for further control of GHG emissions aimed at meeting its nationally determined contribution (NDC) under the Paris Agreement.
- Energy policies in major consuming countries continue to support development of renewable energy sources, as well as electrification of the transport system.

Policies at both the national and international levels constitute one of the major drivers shaping the future energy demand level and the energy mix. In many cases, however, energy policies follow different – and often even contradictory – objectives. These include objectives of energy security, climate change mitigation, improved energy access, fiscal objectives and fuel standards. Often the result is a very complex set of measures and regulations, which are also subject to frequent adjustments or significant revisions. Therefore, it is important to keep track of these changes as they could potentially alter medium- and long- term projections for all energy sources. This chapter summarizes recent changes in policies and regulations related to energy demand and supply in major regions around the world.

This chapter also includes a dedicated section on the latest developments about UN processes on climate change and the implementation of the Paris Agreement in the context of sustainable development. This analysis demonstrates issues of importance related to the energy sector, briefly elaborating on past and present trends in global energy-related CO_2 emissions, with a particular focus on consumption-based CO_2 emissions, as well as emissions embedded in global trade. Insights into sustainable development issues associated with actions to address climate change and eradicate energy poverty are also provided.

7.1 Climate change and sustainable development

In the context of the 2030 Agenda for Sustainable Development, climate change action is considered a priority and a driver of multilateral cooperation to achieve the SDGs and leave no one behind. Climate change could be a risk multiplier of human well-being. SDG 13 on climate action is, therefore, perceived to have interlinkages with each of the other SDGs – from achieving food security to reducing inequalities and ensuring universal energy access, as well as building sustainable and resilient societies around the world.

The Paris Agreement also stipulates the relationship that climate change actions, responses and impacts could have with equitable access to sustainable development. Indeed, the agreement aims to strengthen the global response to the challenge of climate change, giving consideration to sustainable development and efforts to eradicate poverty. In pursuit of the objective of the United Nations Framework Convention on Climate Change (UNFCCC), the agreement is to be implemented recognizing the specific needs and special circumstances of developing countries.

Five years after the adoption of the 2030 Agenda and the Paris Agreement, and with only ten years left for the implementation of the 2030 Agenda and achievement of its SDGs, the United Nations (UN) has launched the 'Decade of Action' for the period from 2020 to 2030, calling for an ambitious global effort to address the world's most pressing challenges – such as those related to climate change and poverty eradication.

This year, the UN is also celebrating its 75th anniversary, with Member States commemorating under the theme 'The future we want, the UN we need: reaffirming our collective commitment to multilateralis'. This theme guides all activities and high-level meetings organized by the UN in 2020, including the 75th session of the General Assembly in September.

To mark its anniversary, the UN has initiated dialogues on critical issues, including on climate change, with the objective of identifying collective actions that could support a sustainable future. Recognizing climate change as an acute and global challenge, and sustainability as an important part of counteracting climate change, the UN Secretary-General has committed himself, and the UN system, to support collaboration and mobilize climate action impetus for improving people's well-being.

The Climate Action Summit in 2019 provided a platform to demonstrate leadership towards enhanced climate action and reinforced the global understanding of the need to implement the

Paris Agreement in the context of sustainable development. On this occasion, it was reiterated how climate action could have tangible impacts on people's lives – including on their health and jobs – and, therefore, the implementation of the Paris Agreement and achievement of the SDGs should be accelerated. The role of the energy sector to support climate resilient and sustainable pathways for all countries at different stages of development was highlighted.

Parties to the Paris Agreement were further encouraged to put forward their new or updated nationally determined contributions (NDCs) by the end of 2020 to reflect progressively ambitious climate action, with the aim to achieve emissions reduction in line with the agreement's long-term target of limiting average global warming to well below 2°C above pre-industrial levels. A prominent feature of the Parties' new or updated NDCs is expected to be their energy-related component, which could relate to various policies and actions aiming to reduce energy-related emissions.

Concurrently, the depth of knowledge and understanding of climate change, its causes and impacts, are growing due to increasing scientific evidence that could provide guidance for future action and raise public awareness. Scientific research indicates an increasing mean global temperature in the developed world since the time of the industrial revolution, and points to the need for taking action to reduce GHG emissions and enhance carbon sinks, while also adapting to the impacts of climate change. There are also concrete insights for great diversity in national trends, with developing countries being hit hardest by climate response measures, along with the manifestations of climate change itself.

In conceptualizing the relationship between climate change and sustainable development, the consideration of different national circumstances, capabilities and priorities is, therefore, vital. Sustainable development provides a comprehensive framework for the pursuit of climate action and human well-being, by integrating social, economic and environmental aspects, yet the wide range of approaches to respond to climate change calls for the need for adherence to core principles of the UNFCCC – including those of equity and common-but-differentiated responsibilities and respective capabilities.

The need to maintain the integrity of the Convention, including by enhancing global efforts to reduce GHG emissions, adapting to climate change and considering the broader challenges of sustainable development, is more urgent than ever amid the present disturbing times.

As the world has embarked on the 'Decade of Action', delivery of the SDGs and implementation of the Paris Agreement, multilateral cooperation appears to be under pressure. The world was confronted with an unprecedented challenge that brought widespread human and socio-economic ramifications – the COVID-19 pandemic. The challenge is especially onerous for developing countries in special circumstances and vulnerable groups which feel the effects acutely.

At the time of writing, UN high-level events for mandated processes have either been cancelled, postponed or scaled down due to the COVID-19 pandemic. Official missions have been suspended; in-person, formal meetings did not take place; a simple procedure applied for postponing meetings; and in some cases, work was shifted to a virtual format. The General Assembly has also decided to adopt any essential decisions via silence procedure.

As a result, negotiations and consultations on the ministerial declaration of the High-level Political Forum (HLPF) and the high-level segment of the Economic and Social Council (ECOSOC) that are held prior to the official sessions have not taken place in person. Regional sessions that comprise an important part of the preparations for the HLPF and the UN climate negotiation sessions were also postponed and preparatory meetings have been cancelled. Until late June 2020, the ECOSOC Bureau was examining different options for adjustments to the format and programme of the HLPF, whereas Member States were considering changes to the format of the UN General

Debate for the 75th session of the UN General Assembly and the surrounding high-level meetings. The Conference of the Parties (COP) Bureau also announced the postponement of the 2020 UNFCCC sessions.

In particular, the 52nd session of the UNFCCC Subsidiary Bodies (SB52), which was initially scheduled to take place from 1–11 June 2020, in Bonn, Germany, will eventually be held in 2021. The UN Climate Change Conference (COP26) that was expected to convene from 9-20 November 2020, in Glasgow, UK, has been adjourned until 1-12 November 2021.

Considering the evolving situation on COVID-19, discussions remain ongoing regarding all mandated and non-mandated events scheduled to take place in the course of the coming months. On UN climate process, more time has been given to Member States to advance discussions and exchange views on unresolved issues that would lead to the full operationalization of the Paris Agreement. At the same time, the UNFCCC Secretariat has made arrangements for continuing work through virtual meetings – such as the 'June Momentum for Climate Action', as 2020 was expected to be a pivotal year for making progress on climate change issues.

On the HLPF, the General Assembly will conduct its review after the UN has resumed normal operations. On this occasion, Member States reiterated the urgent need for countries to respond to the immediate health and financial crisis posed by the COVID-19 pandemic. They reaffirmed their commitment to international cooperation and multilateralism, stressing the need for a collective roadmap when implementing the 2030 Agenda, with the aim to achieve a sustainable, resilient and prosperous future for all.

Bearing in mind the emerging uncertainties on how climate change and sustainable development will be treated in the post-pandemic era, a brief analysis of recent developments associated with these critical issues is herewith provided, with a focus on energy-related matters.

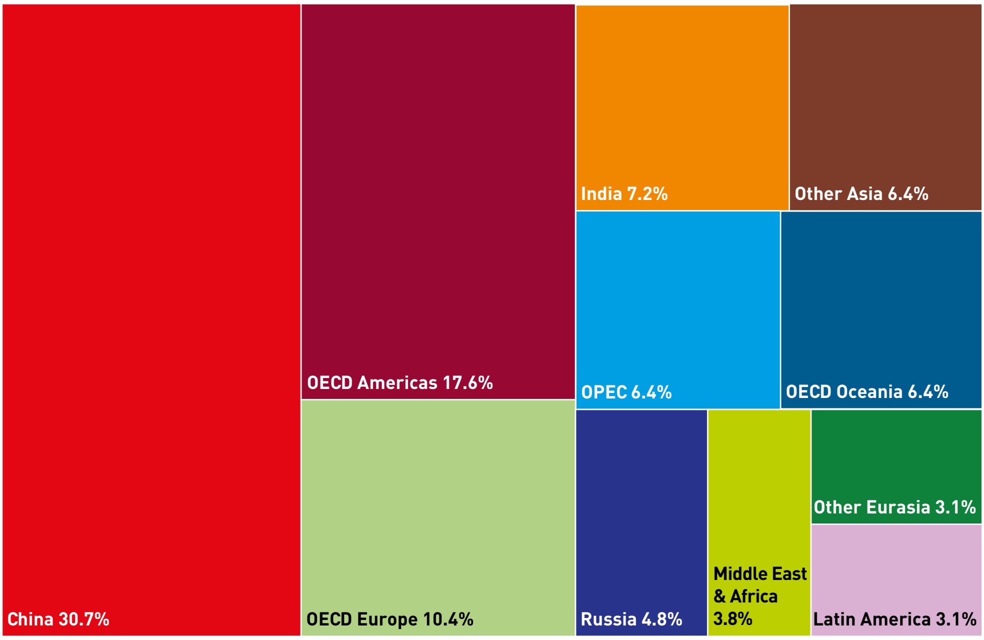
7.1.1 Trends in energy-related global emissions

Global energy-related CO_2 emissions are estimated at the level of about 36 gigatonnes (Gt) in 2018 (Figure 7.1 and 7.2). This corresponds to an approximate 12% and 66% increase compared to 2010 and 1990 levels, respectively. Note that estimates of total global energy-related CO_2 emissions are somewhat different from those reported in Chapter 2 of the Outlook owing the use of another database, which uses its own collection and reporting of energy statistics, conversion factors and assumptions on combustion efficiency. The rate of growth has declined since 2010, given that the average annual growth was about 2% for the period 1990–2010 and 1.4% from 2010–2018. CO_2 emissions of OECD countries are somewhat below 2010 levels, with their share of global emissions declining from 40% in 2010 to 34% in 2018. Non-OECD countries have increased their emissions over the same period, due to their development efforts.

In particular, CO_2 emissions attributed to China have increased by almost the same amount as for all other non-OECD countries from 2010 to 2018, and account for nearly 31% of the total global emissions in 2018. Moreover, the top-five emitters covered in 2018 about 65% of global CO_2 emissions (i.e. China, the US, EU, India and Russia).

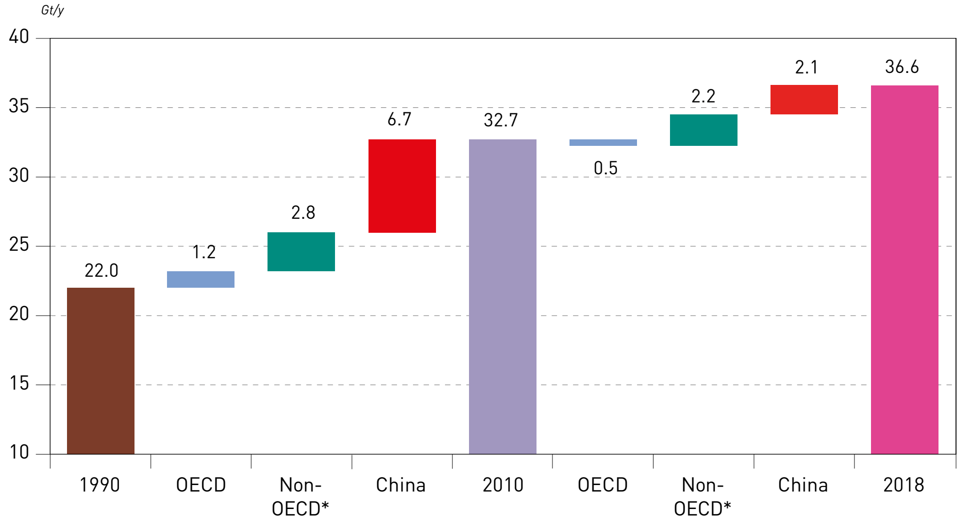
Countries also have a wide range of per capita emissions, reflecting their national circumstances. Some OECD countries have decoupled CO_2 emissions and GDP growth, but either only at very high levels of per capita income and per capita emissions or only temporarily. Energy efficiency improvements and deployment of low-emissions technology have contributed to these trends. Economic growth has been stronger in non-OECD countries, thus affecting CO_2 emissions growth rates. Yet per capita emissions in non-OECD countries remain much lower compared to OECD countries (Figure 7.3 and 7.4).

Figure 7.1
Share of energy-related global CO_2 emissions, 2018



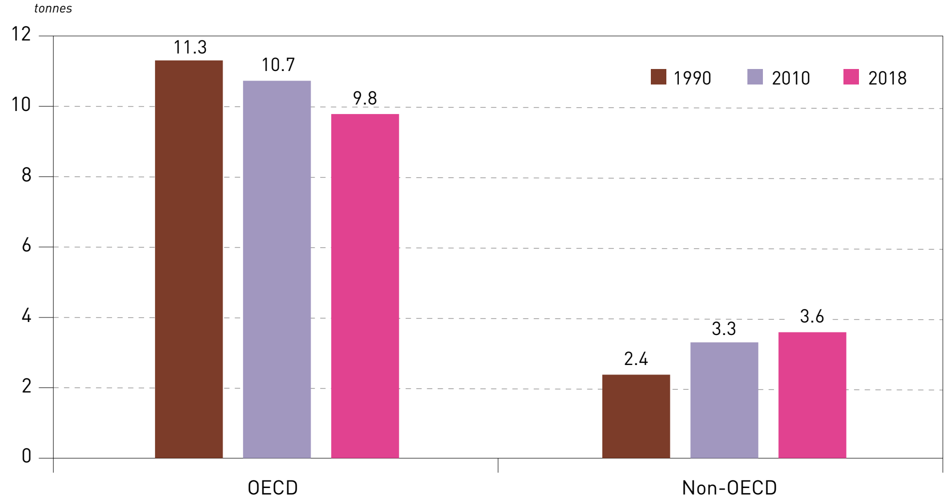
Source: Global Carbon Project, Data: CDIAC/GCP/UNFCCC.

Figure 7.2
Energy-related global CO_2 emissions growth



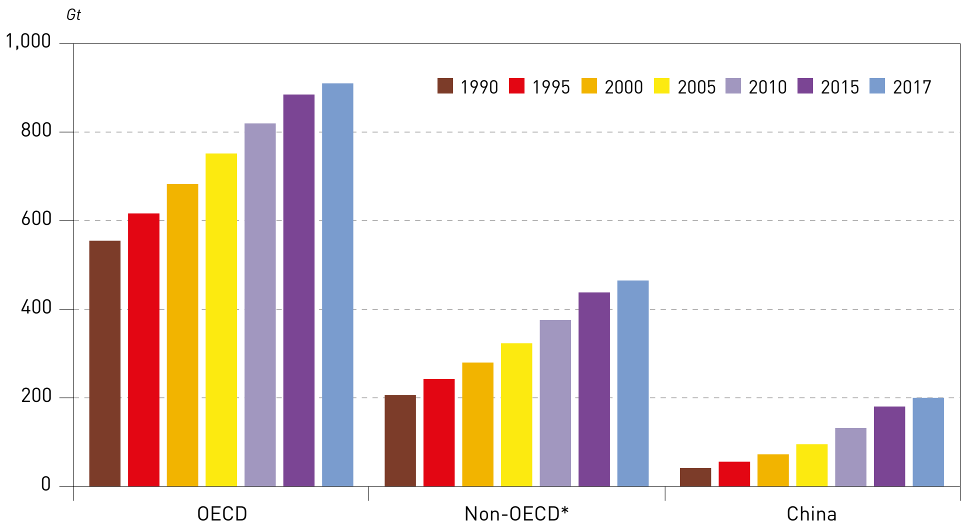
* *Non-OECD, excluding China.*
Source: Global Carbon Project, Data: CDIAC/GCP/UNFCCC.

Figure 7.3
Energy-related CO_2 emissions, per capita



Source: Global Carbon Project, Data: CDIAC/GCP/UNFCCC.

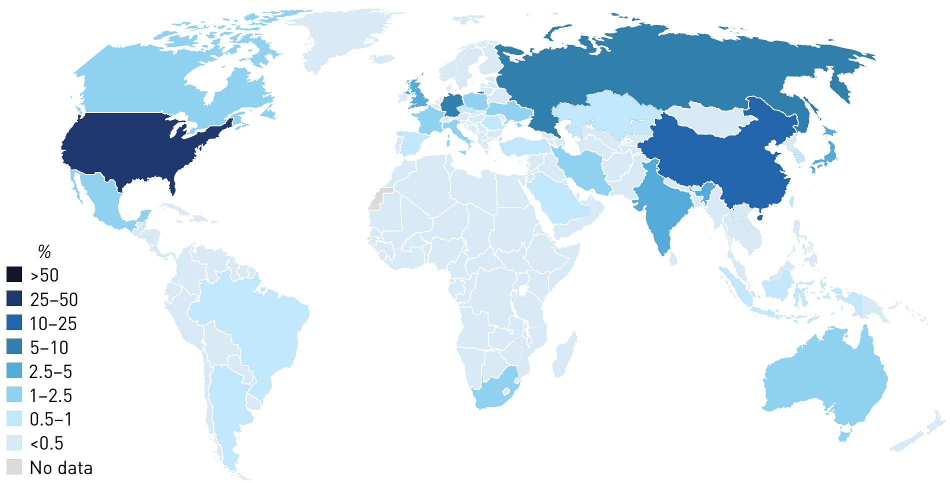
Figure 7.4
Energy-related CO_2 emissions, cumulative since 1751



* *Non-OECD, excluding China.*
Source: Global Carbon Project, Data: CDIAC/GCP/UNFCCC.

Figure 7.5 further illustrates the share of cumulative global CO_2 emissions per country in 2017. Cumulative CO_2 emissions are calculated as the sum of annual emissions since 1751, and are estimated at over 1.5 trillion tCO_2. The US appears to have contributed the most to global CO_2 emissions (25% of cumulative emissions). The EU Member States account for more than 22% of global cumulative emissions, followed by China (12.7%). The least developed countries have contributed less than 1% of CO_2 emissions.

Figure 7.5
Share of global cumulative CO_2 emissions, 2017



Source: Global Carbon Project, Data: CDIAC/GCP/UNFCCC.

In addition, CO_2 emissions are dominated by coal use (i.e. coal accounts for around 40% of global energy-related CO_2 emissions), whereas gas is currently contributing the most to global CO_2 emissions growth. Electricity and heat account for the vast majority of CO_2 emissions (about 45%), followed by industry (23%) and national transportation (19%).

In terms of total global GHG emissions – including CO_2, nitrous oxide (N_2O), methane (CH_4) and others – these continued growing over the last three decades and reached about 58 Gt CO_2eq in 2018. This is around 11% higher than GHG emission levels in 2010 and 52% higher than in 1990. Levels of GHG emissions in OECD countries remain rather stable, whereas most of the global GHG emissions growth occurred in Asia. The average annual GHG emissions growth across all regions decelerated over the years 2010 to 2018 compared to the previous decade, while China and India contributed more than 60% to the net increase in global emissions. Regardless, per capita GHG emissions in OECD countries remain higher than in non-OECD countries.

Owing to the accumulated levels of total GHG emissions, the global average temperature has increased by about 1.1°C since pre-industrial times. The global CO_2 concentration has increased from about 277 ppm in 1750 to 407 ppm in 2018. Being higher by almost 47% since 1750, it was already in 2016 that CO_2 concentration was above 400 ppm.

On the other hand, the emissions trajectory as prescribed in the NDCs suggest global GHG emissions of between 57 and 65 Gt CO_2 per year in 2030, and an expected warming in the range of 2.6 to 3.2°C. Therefore, the national contributions submitted so far under the Paris Agreement cannot be considered as sufficient to meet the long-term 2°C temperature target of the Paris Agreement. Moreover, 2019 concluded a decade of exceptionally high temperatures globally and 2020 started with record warmth. Economic growth remains a fundamental factor driving global emissions, as does population growth; changes in the level (and composition) of consumption and investment; changes in production; and reduction in the so-called carbon and energy intensity. Recent trends further indicate that total CO_2 emissions have temporarily fallen in many countries owing to the global lockdowns to prevent the transmission of COVID-19. Yet emissions growth resumed rather quickly as pandemic lockdowns were eased.

Overall, there is uncertainty on whether the COVID-19 pandemic will overshadow environmental concerns. The global outbreak could delay policies and actions related to climate change, as countries have been focusing on containing the virus. Significant changes in daily life have occurred, which have affected the level of emissions, yet any benefits are expected to be short-lived. Emissions have declined, although any long-term change in atmospheric CO_2 concentration is likely to be very small. It should be noted that in the aftermath of the 2008–2009 financial crisis, the stimulus measures that followed, such as in China, resulted in increased emissions. Therefore, similar trends may be observed in the post-pandemic era.

7.1.2 Consumption-based emissions

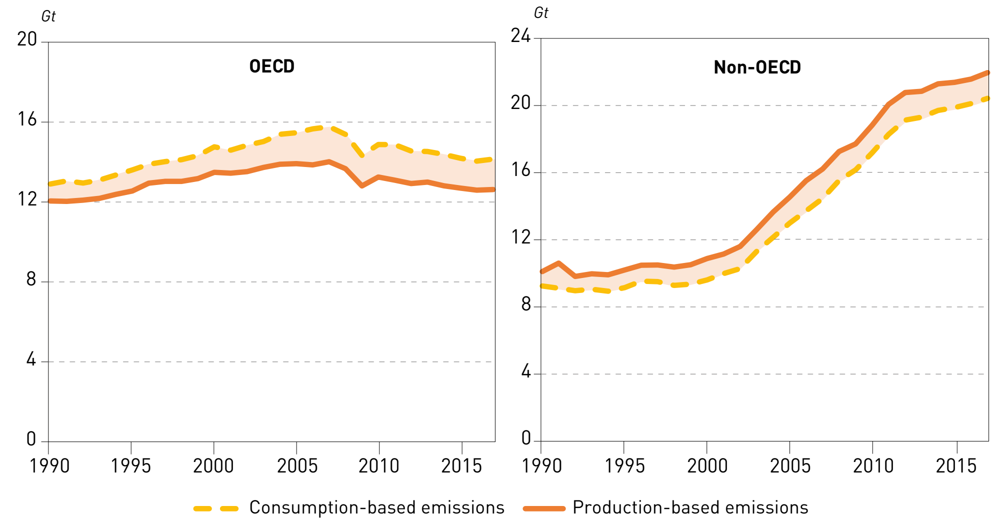
Global supply chains have increasingly gained importance over the last three decades, linking both OECD and non-OECD countries to international markets. At present, a considerable share of the production processes of global supply chains is taking place in non-OECD countries, offering opportunities as well as challenges. While facilitating access to international markets, non-OECD countries are often confronted with disadvantages related to trade and environmental policies. At the same time, continuously more domestic consumption in the developed world is met by global supply chains over long-distance trade routes and with increasing emissions in producing countries.

In this context, emissions related to goods and services consumed in one country but produced in (and traded from) another country should be considered. These are the consumption-based emissions (CBE) that refer to emissions of domestic consumption and imports.

The level of global consumption-based CO_2 emissions increased by almost 45% from 1990 to 2010 and by more than 7.5% between 2010 and 2017. The average annual growth of global CBE from 1990 to 2010 was of 1.8%, and after 2010 it fell to about 1%.

Figure 7.6 illustrates that consumption-based CO_2 emissions in OECD countries remain higher than their production-based CO_2 emissions (the latter being the emissions resulting from the production and consumption of goods and services domestically and for exports). CBE in OECD countries are estimated at 14 Gt in 2017 compared to almost 15 Gt in 2010 and 12.9 Gt in 1990. On the

Figure 7.6
Production *versus* consumption-based CO_2 emissions

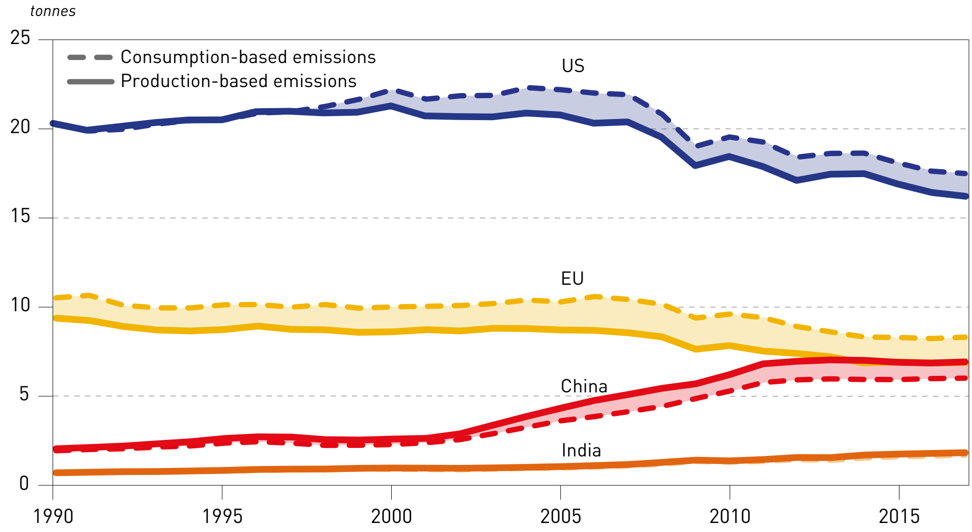


Source: Global Carbon Project, Data: CDIAC/GCP/UNFCCC.

other hand, non-OECD countries accounted for 59% of consumption-based CO_2 emissions in 2017, compared to 41% in 1990. Yet their consumption-based emissions remain lower than the production-based emissions throughout the examined period.

In addition, OECD countries, such as the US and those in the EU, had much higher consumption-based CO_2 emissions per capita compared to non-OECD countries (including China and India) over the years 1990 to 2017 (Figure 7.7). While countries in Europe and North America are experiencing a decoupling of their CO_2 emissions from economic growth, it is essential to consider not only factors such as improvements in production efficiency and the energy mix, but also a decoupling achieved by 'outsourcing' emissions.

Figure 7.7
Production *versus* consumption-based CO_2 emissions per capita



Source: Global Carbon Project, Data: CDIAC/GCP/UN/Peters et al 2011.

It should be further highlighted that countries use their production-based emissions for their national-level emissions accounting, their national policies and climate action, and for the development of their NDCs that reflect their contributions for the implementation of the Paris Agreement. Yet consumption activities significantly contribute to the total global emissions, and should, therefore, be taken into account for climate action in the context of sustainable development.

7.1.3 Emissions embedded in international trade

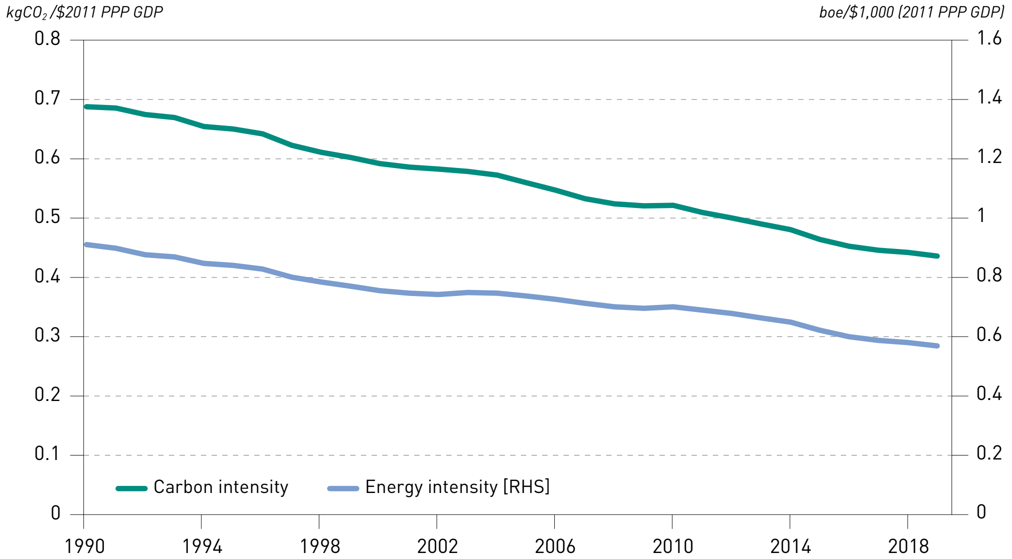
Connecting production and consumption activities through global supply chains have led to increased trade volumes. It is estimated that emissions embedded in international trade (EET) – that is the net difference between production- and consumption- based emissions – account for about one-quarter of global emissions.

The impact of trade on global emissions depends on the magnitude of the (i) scale effect – emissions change due to a higher level of economic activity; (ii) consumption effect – emissions change due to adjustments in the relative share of different goods in production; and (iii) technology effect – emissions change due to a different production method. Overall, trade could accelerate the diffusion of low-emission technologies, whereas trade disputes and policies, such as border tax adjustments (BTAs) and standards, could affect competitiveness, trade flows and future economic growth.

Improvements in carbon and energy intensity have resulted in lower trade-related CO_2 emissions. Until 2011, the scale effect was outweighing the consumption and technique effects. That is, an increase of trade-related CO_2 emissions was driven by higher trade volumes offsetting improvements in emissions intensity and changes in the composition of trade flows. Since 2011, these effects reversed, leading to a net reduction in trade-related CO_2 emissions.

At the same time, OECD countries appear to be net CO_2 importers, and non-OECD countries are net CO_2 exporters, considering that the developed world has transferred emission-intensive processes to developing countries where less stringent policies. Lower labour and material costs and increasing openness of trade are also observed in these countries. Figure 7.9 shows the share of CO_2 emissions embedded in trade, presented as the exported or imported emissions' share of domestic production emissions. Positive values represent net importers of CO_2, and negative values represent net exporters of CO_2. Thus, a share of almost 20% for the EU in 2016 would mean that this region (being a net consumer) imported emissions equivalent to 20% of its domestic emissions.

Figure 7.8
CO_2 and energy intensity



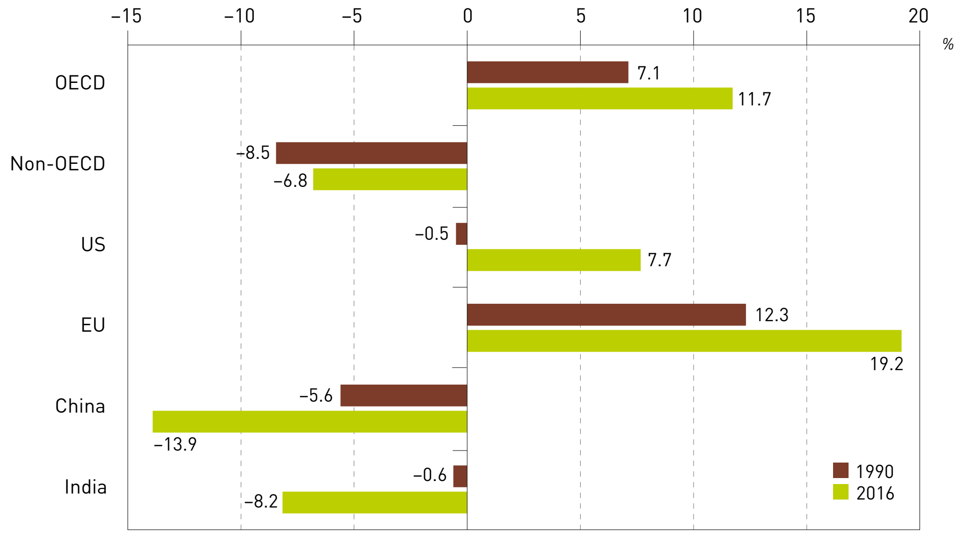
Source: OPEC.

It is evident that as goods and services are produced, traded and consumed across the world, the level of CO_2 emission transfers will be rising. Estimates of emissions associated with production and transport of internationally traded goods indicate that trade has led to emission reductions in advanced economies and emission increases in developing countries that have less advance production methods and technology. Thus, emissions 'outsourcing' (or carbon leakage) to developing countries, particularly in Asia, has led to an increase in their production-based emissions.

Figure 7.10 shows that OECD countries in North America and Europe are net importers of emissions, as they import more CO_2 emissions embedded in goods than they export. On the other hand, trade disputes could escalate or become more widespread, denting economic activity in the regions involved and elsewhere.

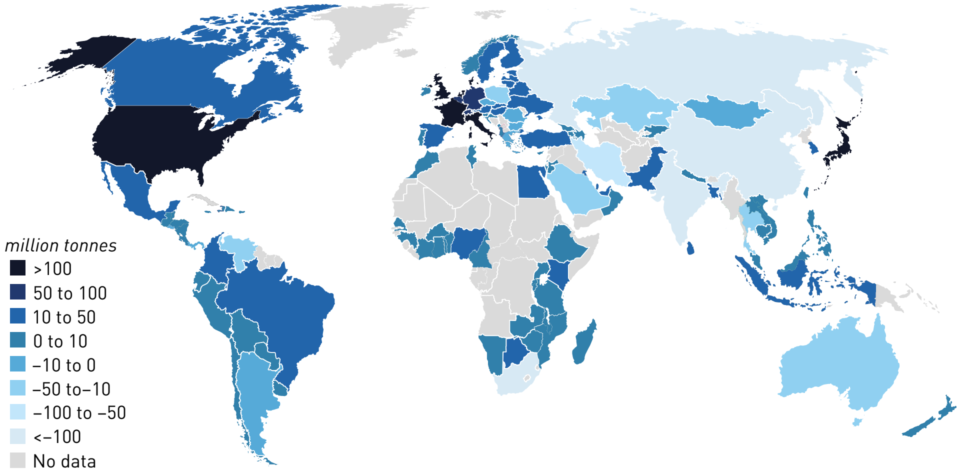
Investment and technology transfer could help to reduce emissions embedded in trade. The lack of consensus on the modalities, procedures and guidelines of international market mechanisms for the operationalization of the Paris Agreement (under its Article 6) could also affect trade-related matters of climate actions.

Figure 7.9
Share of CO_2 emissions embedded in trade



Source: Global Carbon Project, Data: CDIAC/GCP/Peters et al 2011.

Figure 7.10
CO_2 emissions embedded in global trade, 2016



Source: Global Carbon Project, Data: CDIAC/GCP/Peters et al 2011.

7.1.4 Climate change mitigation in the context of sustainable development

In light of the above, it is evident that developing countries have historically contributed fewer CO_2 emissions, and their citizens continue to have a small per capita environmental footprint. Yet they may suffer the earliest and the most from climate change, and face higher adverse impacts of response measures.

The Paris Agreement underlines the principles of the Convention, particularly those of equity and common-but-differentiated responsibilities and respective capabilities. An important dimension of equity is that the poor are least responsible for climate change and most vulnerable to its impacts. To implement the agreement, there is, therefore, an urgent need for multilateralism to enhance support provided to developing countries through access to finance and technology on a concessional basis.

Such enabling factors are essential for improving the capacity of developing countries and raising their standards of living, so that the challenge of climate change is addressed while leaving no one behind. Climate change abatement should thus entail a global effort, as well as development of comprehensive and effective policies that take into account national circumstances and priorities.

In this context, sustainable development provides a comprehensive framework for the pursuit of climate mitigation and human well-being integrating socio-economic and environmental aspects. Despite the appeal of the concept, countries are at different stages of development, affecting their capabilities, priorities and strategies to move towards a sustainable pathway. This indicates the need to consider equity and fairness among countries when conceptualizing the relationship between climate action and sustainable development.

The impact of the COVID-19 pandemic, one of the worst human and economic crises of modern times, must also be considered. The poorest and most vulnerable countries are affected disproportionally and stand to be hit hardest in the long-term. The pandemic will, therefore, have detrimental impacts on all SDGs. For the world to emerge from this crisis and become more sustainable, inclusive and resilient, a surge in international solidarity and cooperation is needed.

Based on the UN Secretary-General's report on progress towards the SDGs, which was made available for the 2020 session of the HLPF, the world is not on track to deliver on its commitments by 2030. Therefore, the pace and scale of implementation efforts should increase. Progress continues in some areas – for example more people have gained access to electricity – but progress has either stalled or reversed in other areas, considering for instance that climate change is occuring much faster than anticipated.

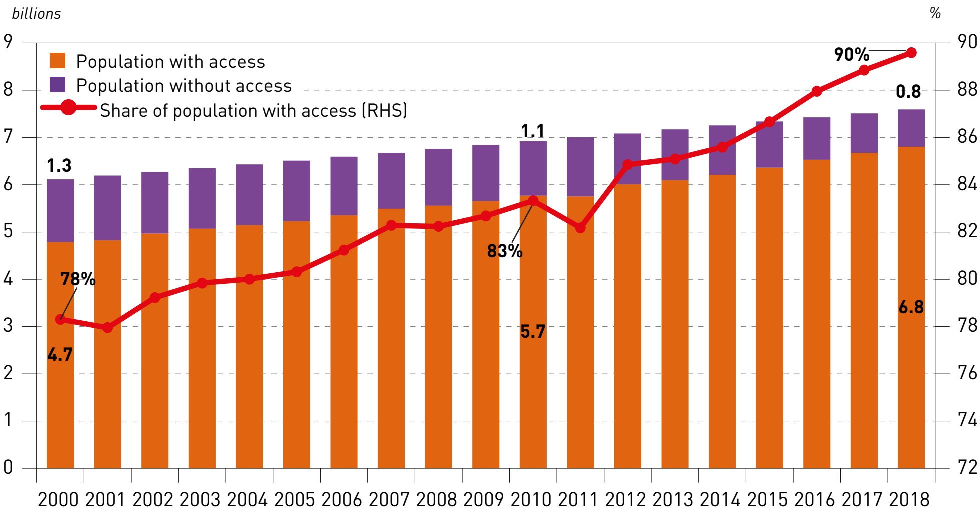
Energy access for all is an action area (or a systemic entry point) that could be leveraged to facilitate the coherent implementation of climate action and sustainable development objectives. SDG 7 is the first-ever universal goal on energy and seeks to ensure access to affordable, reliable, sustainable and modern energy for all. It should be noted that hundreds of millions of people around the world still lack access to electricity, and progress on access to clean cooking fuels and technologies is too slow (Figures 7.11 and 7.12).

Global electrification has increased from 83% in 2010 to 90% by 2018, but 789 million people still do not have access to electricity. The world's deficit is concentrated in Sub-Saharan Africa, where 47% of the population have no electricity. Access to clean cooking fuels and technologies increased from 56% in 2010 to 59% in 2016. Most recent estimates indicate that the level of access in 2018 was 63%, therefore, 2.8 billion people have no access to modern cooking systems.

In Sub-Saharan Africa, the number of people without access to clean fuels and technologies for cooking has further increased as a result of fast population growth. About 85% of people in this region lacked access to clean fuels and technologies for cooking in 2018 (Figures 7.13 and 7.14).

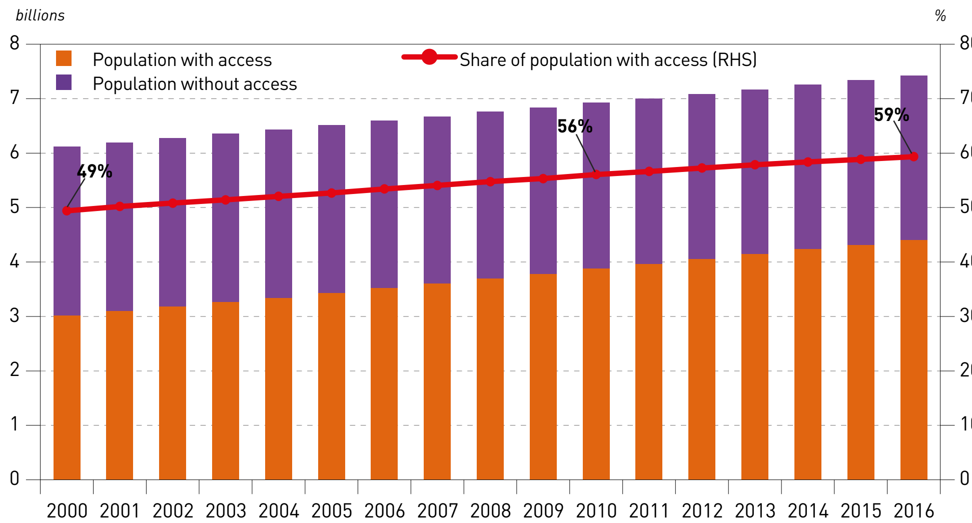
The lack of access to energy has the potential to magnify the socio-economic impacts of the COVID-19 pandemic. Health facilities in many developing countries are at a disadvantage due to insufficient electricity or unscheduled outages and this affects their capacity to deliver services. The lack of access to clean energy also means people in developing countries are more vulnerable to respiratory infections, such as COVID-19. Having no or limited access to electricity complicates efforts to practice social distancing because electricity is needed to power the technologies and devices that help people to stay in touch, receive information, engage in online education, and work from home.

Figure 7.11
Global electricity access



Source: World Bank, World Development Indicators, 2020.

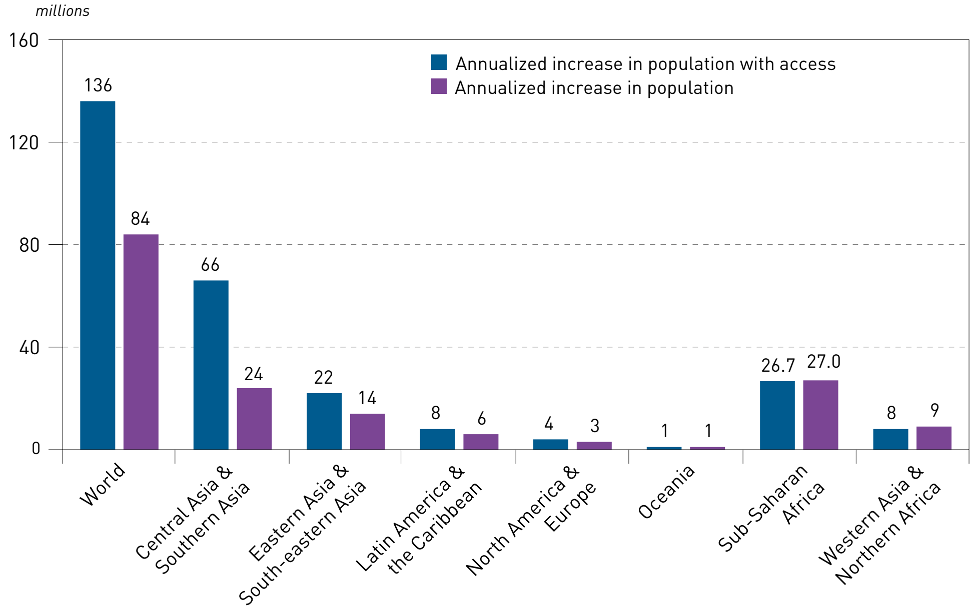
Figure 7.12
Global access to clean fuels and technologies for cooking



Source: World Bank, World Development Indicators, 2020.

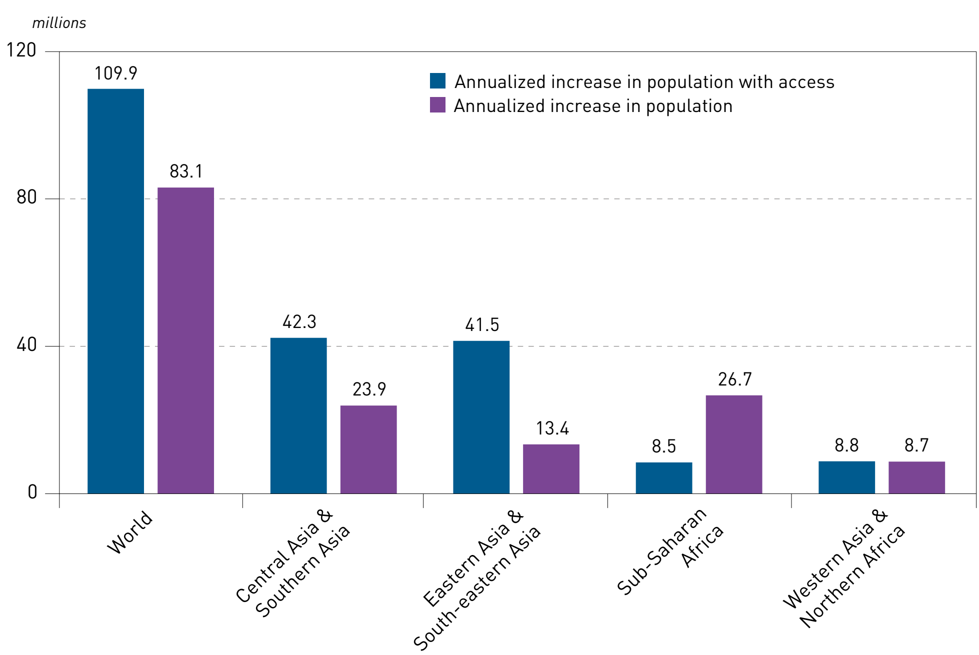
It appears then that the eradication of energy poverty in developing countries needs to be prioritized and deserves special attention. It is imperative to make clean cooking solutions a top priority in the policymaking agenda, while also enhancing efforts to close the electricity access gap. The eradication of energy poverty could have positive effects on other development aspirations, such as health, job creation and addressing inequality and environmental matters, and the provision of universal access to modern energy would have only a negligible impact on emissions. To this end, adequate finance and technology transfer need to be provided to enhance such efforts.

Figure 7.13
Annual incremental increases in electrification and population by region, 2016–2018



Source: World Bank, World Development Indicators, 2020.

Figure 7.14
Annual incremental increases in the number of people with access to clean cooking and population by region, 2014–2018



Source: World Health Organization, 2020.

Overall, the 2030 Agenda pledges to leave no one behind, but the impacts of the pandemic have not been felt evenly, and existing inequalities within and among countries have been exacerbated. As inequalities could become even more pronounced in the long-term, the implementation of the 2030 Agenda is a necessity more than ever, particularly to reduce vulnerabilities to crises by optimizing the interactions between the SDGs – including those on ending poverty (SDG 1), good health and well-being (SDG 3), quality education (SDG 4), clean water and sanitation (SDG 6), affordable and clean energy (SDG 7), decent work and economic growth (SDG 8), reduced inequality (SDG 10), and climate action (SDG 13).

On SDG 13, it should be noted that climate actions and long-term emission strategies rely mainly on reducing CO_2 emissions – the focus of this chapter. Yet the potential nature-based solutions (e.g. agro-forestry and land restoration) need to be considered as well. In addition to being an essential component of the response to climate change, many options are currently available for restoring balance to natural systems. For instance, enhancing soil carbon stores and protecting biodiversity could provide a range of co-benefits, such as for food production, water availability and wildlife. Nature-based solutions could, therefore, eliminate the chances of animal-borne diseases and support more resilient and sustainable societies in the long-term.

While only a few countries, representing about 3% of global emissions, have submitted a 2020 NDC, the design of comprehensive and holistic strategies for the implementation of the Paris Agreement and the 2030 Agenda should be built on the narrative that climate change mitigation should not be an end in itself, but a means to achieve the SDGs. Novel approaches, such as the CCE (Box 7.1), could support a transformational leap towards a sustainable society that enables us to tackle climate change. Finally, international cooperation could allow a more coherent, balanced and integrated approach for realizing the long-term goals of the Paris Agreement in the context of sustainable development.

Box 7.1

The circular carbon economy

The concept of a circular economy is an emerging megatrend that could support climate change mitigation. Different definitions are used by the international research community, yet it broadly conceives of an economic system with minimal losses of resources and energy through the principles of reduce, reuse and recycle (the 3Rs).

A departure from the traditional linear production and consumption system, as well as aspirations for waste avoidance and closed-loop recycling, have led to the approach of the circular economy and its potential wider environmental and socio-economic benefits.

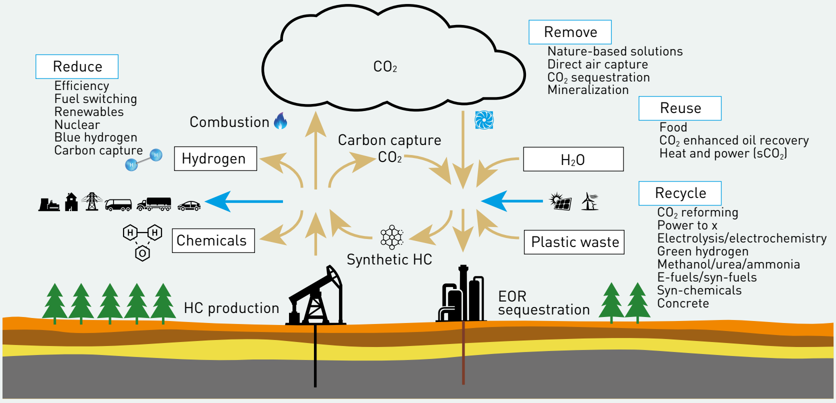
In this context, a circular economy has been identified as a novel approach, which considers the life cycle of any system or product in terms of its use of resources and energy, aiming to minimize environmental impacts and achieve socio-economic prosperity. As circular economy policies are evolving for various sectors in many countries, this approach has also been considered for more sustainable energy systems.

In particular, a shift to a CCE offers the potential to advance new energy systems based on innovation and technologies that utilize all energy sources, while increasing the achievement of SDG goals and addressing climate change.

Taking into account national circumstances, it is assumed that an economy is more circular based on a '4Rs strategy' by adding 'remove' to the 3Rs. The dimensions of the CCE are:

- *Reduce:* Reduce the level of emissions entering the system utilizing fuels with a lower environmental footprint and energy efficiency;
- *Reuse:* Convert emissions into useful industrial feedstock without chemically altering carbon (e.g. carbon capture and utilization or CCU);
- *Recycle:* Recycle emissions to create new value-add products by chemically altering carbon through decomposition, combustion and also natural processes (e.g. biofuels and blue hydrogen);
- *Remove:* Remove emissions from the system through natural sinks, carbon capture and storage (CCS) and direct air capture (DAC).

Figure 1
The CCE illustrated



Source: Saudi Aramco, 2020.

To this end, CO_2 from hydrocarbon combustion can be captured, reused and recycled in other forms of energy or value-add products or stored underground to close the carbon cycle efficiently.

Moreover, a CCE can support sustainable development through ensuring energy access for all (SDG 7), economic growth and decent work (SDG 8), fostering innovation (SDG 9), promoting responsible consumption and production (SDG 12) and enhancing action to combat climate change (SDG 13).

A holistic, integrated and inclusive approach is required to implement the CCE approach, adopting all four dimensions on a wide scale. Research and development, investment and sound policies are key enabling factors to advance development and deployment of a CCE and proceed with cost-effective mitigation options to achieve climate goals.

Acknowledging the need to reduce GHG emissions, the G20 Energy Ministers endorsed the CCE Platform and its 4Rs framework on 28 September 2020, proposed by the Kingdom of Saudi Arabia, which holds the G20 Presidency in 2020. Furthermore, the G20 Energy Ministers recognized the importance of accelerating the development and deployment of innovative, scalable and efficient technologies to advance energy for all. Thus, the voluntary CCE Accelerator is considered an inclusive vehicle to advance opportunities related to the 4Rs.

7.2 Energy policies in major regions

Recent changes in policies and regulations relating to energy demand and supply in major world regions are briefly presented here. In general, these are expected to become more stringent over the longer-term, driven by actions taken by a number of countries as part of the Paris Agreement. Increasing pressure from a large coalition of stakeholders, as well as an increased sense of urgency in public opinion, also will lead to some acceleration in the adoption rate of regional and international policies to mitigate climate change.

Nonetheless, it is assumed that the majority of policies relating to energy demand and supply will continue to be set and enforced at the national level, resulting in continued disparity in the scope of policy ambitions. One exception to this is the EU, where overarching policies provide a framework for the national laws enacted by Member States.

7.2.1 US

Energy policy in the US has seen significant change brought about by the current administration. The outcome of the presidential election in November 2020 will, therefore, have a major impact on the future direction of energy policy. The current US administration has increased its support for coal, cut environmental regulations, declared a strategy of 'Energy dominance', announced its intention to withdraw from the Paris Agreement and started a battle with individual states that have set their own emissions standards.

These trends will likely continue if President Trump is re-elected for a second term. However, the election of a new Democratic Party president would very likely see an undoing of these changes and, dependent on the Democrats winning a majority in Congress, policy changes with far-reaching implications could be expected. A new administration could focus more on investment in emerging clean energy technology, such as hydrogen and battery storage; expanding charging infrastructure and electrification of the transport sector; and creating a carbon-free power sector by 2035, which would require a huge shift to renewable sources at the expense of coal and gas power generation (unless CCUS can be utilized). Under a new administration, the oil and gas industry may also quickly face more forceful methane pollution limits that could even be applied to existing operations. Moreover, there is the added possibility of a ban on leasing of public lands and waterways.

The tight oil boom has enabled the US to become a net exporter in a short period of time and to shift its primary focus from energy security. It was only in 2015 that the ban on crude oil exports was lifted and similarly in 2014 for an amendment of the Natural Gas Act to set the stage for LNG exports. The concept of energy dominance, introduced in the 2017 National Security Strategy, seeks to further develop the US as an energy leader. Among the actions to 'embrace energy dominance' in the strategy are the reduction of barriers (highlighting regulatory burdens and approval processes), promoting exports (including increasing export capacity) and furthering the US's technological edge.

With regard to renewable energy policy, the Office of Energy Efficiency and Renewable Energy sets out goals in its own strategic plan for the period from 2016 to 2020. In the US, wind energy now accounts for 7.3% of electricity generation and projects have been able to benefit from either production tax credits for each kW produced (available for up to ten years) or investment tax credits at the time of installation. Due to end in 2019, these credits were extended for 2020. Similarly, a 30% tax credit that has long been available for solar installations is nearing its end. It was reduced to 26% in 2020 and will drop to 22% in 2021 before disappearing in 2022 for residential installations altogether and continuing at only 10% for commercial installations. Solar power provided a 1.8% share of US electricity generation in 2019.

In addition, policies implemented at the state level are fundamental to the energy demand of the US as a whole. As the most populous state and an economy the size of the UK, California's policies are particularly impactful. It has had its own 'cap-and-trade' scheme for GHG emissions since 2013 that applies to fuel distributors, electrical plants and industrial plants with yearly CO_2 emissions of over 25,000 tonnes. The 'cap' of the scheme, which has been decreasing at an annual rate of 3% over the last five years, is set for a faster reduction from 2021 to 2030 but exactly how fast is yet to be decided.

Furthermore, in March 2020 the California Public Utilities Commission voted for a new and tougher GHG emissions target for the electricity sector of 46 mt by 2030. With an ultimate objective of generating 100% of electricity from carbon-free sources by 2045, a huge increase in renewable electricity generation is required (25 GW is already expected to be needed for the 2030 target) along with a large amount of energy storage capacity.

Coal

On entering office, President Trump promised to end the "war on coal" and the government has made a number of efforts to change existing policies that cover a variety of areas from coal production, plant operations, emissions limits and waste management.

One such effort began in 2017 and sought to lift a ban from the previous year on new coal leases on federal land, where 40% of coal production in the US takes place. However, it took until this year for leasing to be re-opened.

In general, the amended and proposed policy changes lessen restrictions and are largely beneficial to the continued operation of coal plants, such as the Affordable Clean Energy (ACE) rule, proposed as a replacement for the Clean Power Plan of 2015, which has less strict requirements for power plant emissions and their monitoring. However, the end result of the changes will vary between the policies. For example, a plan announced in 2018 to raise the CO_2 emission limits for new coal generators in the New Source Performance Standards may not have much of an impact if new coal plants are otherwise uncompetitive with other fuel sources.

Road transportation

Fuel economy standards for cars and trucks is one area of policy that will be most affected by the outcome of the 2020 election. The longstanding Corporate Average Fuel Economy (CAFE) standard had previously set requirements for yearly increases in the average fuel economy of manufacturers' fleets and set a target of 54.5 miles per gallon (mpg) by 2025. Its replacement, the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule, ultimately reduces these fuel economy targets. Released on 31 March 2020, it sets a 40.4 mpg target for new vehicles in 2026 (a 1.5% improvement on an annual basis from 2021).

An initial and enabling part of the new SAFE rule was the 'One National Program Rule' issued in 2019. The rule essentially established that only the federal government can set fuel economy and GHG emission targets for vehicles. It is largely directed at California, removing the waiver it had previously been granted to set its own standards. The rule very quickly resulted in court action by California and several other states, challenges that could take a long time to resolve. Meanwhile, four major manufacturers have entered a voluntary agreement with California to aim for fuel economy standards higher than those of SAFE.

As part of the Renewable Fuel Standard policy, the EPA sets targets for the volume of renewable fuels used in transportation fuels. The scheme allows refiners and importers to accrue credits (RINs) by producing renewable fuels and can trade these credits on the market. The current policy sets an overall target of 36 billion gallons of renewable fuel by 2022. In May 2019, the US began to allow year-round sales of E15 gasoline (a mix of up to 15% ethanol). Prior to this, it was not possible to sell E15 gasoline in certain regions during summer months due to a conflict with the Clean

Air Act. The future of the standard after 2022 and balancing the differing demands of the refineries and ethanol producers will fall on the next administration.

With regard to commercial vehicles, the first policy to cover fuel economy and CO_2 emissions for heavy-duty vehicles began in 2014. Depending on the vehicle type, the policy required that new vehicles in 2018 achieve improvements in fuel economy and CO_2 emissions of between 6% and 23%. In 2021 Phase 2 of the programme will begin and run until 2027. With a baseline set at the end of Phase 1, Phase 2 will target additional improvements in new vehicles ranging from 16% for pickups to 25% for tractors by 2027.

Electric vehicles

At the federal level a tax credit of $7,500 has been available for battery electric and PHEV. The credit applies only to 200,000 vehicles per manufacturer and after that limit is reached it begins to phase out. A federal credit amounting to 30% of the cost, up to a maximum of $1,000, is also available for purchase and installation of charging stations. Some states provide a variety of additional tax credits and benefits beyond what is available federally. For example, Texas provides an incentive of up to $2,500 for EV purchases that it is limited to a mere 2,000 vehicles whereas Pennsylvania's maximum incentive is $750.

It is worth noting that California has targets for Zero Emission Vehicle (ZEV) production. Every year, manufacturers gain credits by producing ZEVs and more credits are given for vehicles with increased range. The credits are used to comply with a target that is based on a percentage of a manufacturer's vehicle production, which was 4.5% in 2018 and will incrementally increase to 22% in 2025. It is estimated that this will result in ZEVs (including PHEV) making up 8% of sales in 2025. The states of Connecticut, Maine, Maryland, Massachusetts, New York, New Jersey, Oregon, Rhode Island and Vermont have also adopted California's ZEV policy, highlighting the potential court challenges that could arise under under the new 'One National Program Rule' mentioned earlier in this section.

7.2.2 EU

Energy policies in the EU represent a mix of national level and EU-wide policies centred on contributions to the Paris Agreement. In order to achieve the objectives of the Paris Agreement, there has been a continuous strengthening of existing, and the introduction of new, legislation.
The EU's medium-term objectives set three targets for 2030:

- A 40% reduction in GHG emissions when compared to 1990;
- A 32.5% increase in energy efficiency when compared to projections made in 2007; and
- A 32% share of renewable energy in final energy consumption.

Member States were required to submit, by the end of 2019, their National Energy & Climate Plans (NECPs) for 2021 to 2030 to outline how they would achieve their 2030 targets.

The ETS is the EU's key tool for GHG reduction. The 'cap-and-trade' based system covers around 45% of the region's total GHG emissions for sectors including power generation, energy-intensive industries, raw material production and aviation. The scheme's participants are expected to achieve the greater share of the 2030 target. When compared to 2005 levels, they will need to achieve a 43% emissions reduction, whereas non-ETS sectors are only required to achieve a 30% reduction. Entering into Phase 4 in 2021, which will last until 2030, the emissions cap will be reduced by 2.2% p.a. (up from 1.79% in Phase 3) and there is an option to increase it further to 2.4%. The COVID-19 pandemic is likely, however, to put pressure on the EU to reform the system in terms of the surplus allowances that can be accumulated over time. With the drop in emissions seen in 2020, an even larger surplus could be created that needs to be absorbed for the system to have its desired effect of driving GHG emissions reduction.

The energy efficiency target of 32.5% was introduced through the amending Directive 2018/2002 and was required to be transposed into national law in 2020. The directive projects a 2030 limit of primary energy consumption in the EU of 1,273 mtoe compared to the 2017 total which was 1,675 mtoe (these numbers include the UK without which the 2030 limit is 1,128 mtoe). A review of the directive will also take place by 2024 and is expected to increase or maintain the target but not reduce it.

Similarly, the Renewable Energy Directive has a review mechanism that allows for an increase in the target by 2023. In addition to the headline target of a 32% share of renewable energy, a clause was added for the transportation sector that requires a minimum 14% share of renewable energy in road and rail energy consumption. The directive includes a target for advanced biofuel of 3.5% by 2030.

Regulation 2018/841 was adopted in May 2018 to include the impact of land use and forestry into the 2030 objectives. Covering the land use, land use change and forestry (LULUCF) sector, it requires the recording of emissions that are both released and absorbed from Member States' territory. The regulation works on the principle that the sector should not have any net emissions for the period of 2021 to 2030 and discourages the removal of carbon sinks such as forests or wetlands without offsetting the emissions elsewhere.

In 2019, the EU endorsed an ambitious objective to achieve net-zero GHG emissions by 2050, meaning that Europe would become the first climate-neutral region. This led to the European Parliament endorsing the European Green Deal in January 2020. The Green Deal itself is a collection of multiple policies, strategies and plans. The deal's biggest challenge may be the underlying goal of decoupling economic growth from GHG emissions.

A new industrial strategy was adopted in March 2020 that ties in the ambition of climate neutrality, and a proposal for a Circular Economy Action Plan was also introduced. The latter looks at the lifecycle of key products such as batteries, electronics and packaging in terms of their sustainability and circularity. The action plan is expected to increase the coverage of the Ecodesign Directive to address areas such as the repairability of electronics and premature obsolescence.

The European Commission estimates that additional investments of €260 billion are required each year to achieve the EU's 2030 climate targets. To boost investment, the Sustainable Europe Investment Plan aims to generate €1 trillion of over the upcoming decade, with the largest portion of the funds coming from the EU budget, followed by public and private financing through national banks and the European Investment Bank (EIB). The EIB aims to have 50% of its investments dedicated to climate-related investments. An additional €100 billion is also set aside for a new Just Transition Mechanism to support areas of the EU that will be negatively impacted by the climate-neutrality transition, e.g. to support retraining of workers in the fossil fuel industry.

Finally, a proposal made in March 2020 for a 'Climate Law' seeks to make the 2050 target of net-zero GHG emissions legally binding. Poland is the only EU country that did not initially commit to the 2050 carbon-neutral target, an issue that is expected to be revisited. The country's heavy reliance on coal was likely a key factor in the decision; by 2040 Poland still expects to generate 40-50% of its electricity from this energy source.

Alongside transportation and industry, buildings are the other major consumer of energy in the EU. Newly constructed buildings from 2021 must be 'nearly zero-energy buildings', while the Green Deal targets an increase in the renovation of existing public and private buildings, making use of the latest technology to improve their energy performance. Long-term renovation strategies are to be established by countries for the overarching goal of decarbonization by 2050. The Renewable Energy Directive of 2018 aims to boost the use of renewables for the heating and cooling of buildings by 1.3% annually between 2021 and 2030. To achieve this, there is an increasing use of technologies such as electric-powered heat pumps that make use of ambient heat. Hydrogen has the potential to help decarbonize heating and cooling in the longer term. Buildings can also benefit heavily from the use of smart technology and automated systems to reduce waste.

Coal

At the national level, one issue that continues to divide EU countries is the use of coal. This year, Austria and Sweden joined Belgium in phasing out coal from their energy mix. Twelve other EU countries have committed to joining them during this decade with Portugal likely to become the first of these after the operator EDP brought forward closure plans for its last remaining coal plant to 2021 from 2023. (The country's coal phase out date was originally set for 2030.)

Germany, the Czech Republic, Slovenia, Croatia, Romania, Bulgaria and Poland do not have plans for a phase out before 2030 and many are resisting the pressure to commit to a deadline. Germany, the largest coal consumer in the EU, approved legislation in July 2020 that would set a 2038 phase-out date with the possibility of it being brought forward to 2035.

Road transportation

In the transportation sector, two regulations came into force in August 2019 to tackle CO_2 emissions from new vehicles and directly contribute to the 2030 goals. The first, covering passenger cars and light commercial vehicles, set emission targets of 95 g CO_2/km and 147 g CO_2/km, respectively, from 1 January 2020. This figure is then to be reduced by 15% for both vehicle types from 2025 and by 37.5% for passenger cars and 31% for light commercial vehicles from 2030. The second regulation is the first of its kind in the EU to cover heavy-duty vehicles and sets ambitious CO_2 emission-reduction targets of 15% by 2025 and 30% by 2030, with a baseline period of July 2019 to June 2020.

In addition, the Clean Vehicles Directive, which was adopted in June 2019 and needs to be transposed into national law by August 2021, sets targets for local authorities to purchase low- or zero-emission vehicles. The revised Directive also tightened the definitions for clean vehicles, with cars and vans only considered clean if CO_2 emissions are lower than 50g/km and NO_x and particulate matter are up to 80% of applicable real driving emission limits. In 2026, this definition tightens further to apply only to zero-emission vehicles – although a separate definition has been set out for heavy-duty vehicles. Additionally, as part of the European Green Deal, the EU is investigating ways to increase multimodal transport to shift more freight onto rail and inland waterways. This could result in an update of the 1992 Combined Transport Directive to reflect this shift.

Electric vehicles

The EU's EV market, along with those of China and the US, is relatively well developed. However, the technology is still in the early stage of mass-market adoption, which tends to mean that EV market share increases are reliant on policy development. Direct incentives that helped with the initial penetration of EVs in the market by improving their cost in relation to ICE vehicles are gradually being replaced by tax reductions or exemptions.

Across the EU, there are a variety of measures used to promote the uptake of EVs and these vary in type, size and scope. Most countries offer some form of benefit or exemption from vehicle, registration and company taxes, while reductions in tolls, parking and congestion charge costs can be additional benefits. Some countries continue to provide direct incentives for the purchase of EVs, reducing the price the buyer pays. Incentives and tax benefits are typically greater for BEVs than PHEVs.

Although a member of the European Free Trade Association (EFTA) and not the EU, Norway follows and aligns itself closely with EU policies (for example, it participates in the EU ETS) and the country is noteworthy as the world leader in terms of EV market penetration. With generous tax exemptions that bring the cost of EVs to a level comparable to and even below that of ICE vehicles, BEVs in Norway accounted for 42.4% in new car sales during 2019 (an additional 13.6% were PHEVs). The current system will remain in place until the end of 2021 at which time it is due for review.

An important long-term factor for the EV market in Europe could be the impact of restrictions on ICE vehicles. Countries trying to meet environmental goals are considering targeting sales of ICE vehicles. Norway was the first, in 2016, to propose a ban on ICE vehicle sales starting in 2025. Several countries are now aiming for bans in 2030 or 2040. The UK had initially proposed 2040 in line with France and Italy, before announcing this year that its ban will take effect in 2035. In addition, cities wanting to combat air pollution are already implementing restrictions to keep polluting vehicles away. Low Emission Zones (LEZ) are now common in large European cities. One of the largest, in London, was scheduled to expand in 2020 to cover all of Greater London, while its more central Ultra Low Emission Zone (where diesel vehicles must meet Euro 6 standards) will expand next year. Other cities already restrict older diesel vehicles and Rome, Athens and Madrid are among the cities planning bans on diesel vehicles.

7.2.3 China

Energy policies in China revolve around the country's Five-Year Plans that set out strategies across the whole government, including areas of the economy and the environment. The 13th Five-Year Plan will end in 2020 and with it a number of other aligned policies. This means that 2021 will be an important year for China's energy policy and will usher in a new set of goals that will have far-reaching implications. It is expected that the 14th Five-Year Plan will seek to support a transition to becoming a developed country and will continue to support actions for further control of GHG emissions to meet China's NDC under the Paris Agreement.

The 13th Five-Year Plan has been consequential, leading to policies such as the Made in China 2025 initiative and reflected in others like the 'Blue Sky Defence', both of which are discussed later in this section. It set a major objective of improving the quality of the environment with associated targets for 2020 including a 15% share of non-fossil fuels in primary energy consumption and an 18% reduction in CO_2 emissions per unit of GDP.

Provisions were included in the current plan for a continued push to lower energy intensity with the addition of an energy consumption limit. China's industry sector accounts for the majority of energy consumption and initiatives like the Top 10,000 programme have required the largest energy consuming companies to implement measures to improve energy efficiency with supporting subsidies. Looking to the future, the Energy Supply and Consumption Revolution Strategy, which spans from 2016 to 2030, sets an ultimate goal of reaching the global average for energy efficiency.

Also important to the industry sector, Made in China 2025 is a 10-year strategic initiative which was launched in 2015, but has made headlines over the past few years as part of a trade dispute between China and the US. The initiative aims for China to transform to a high-end manufacturer and identifies ten sectors key to this transition, such as electrical equipment, aerospace equipment and new-energy vehicles. One major target is an increase of domestic content of certain core components and materials to 40% in 2020 and 70% in 2025. In addition, there are several other targets which include boosting research and development (R&D) levels in companies, increasing manufacturing quality and raising labour productivity.

The government has expanded its efforts to reduce air pollution to include more cities and released its action plan for 'winning the blue sky defence' to set out objectives and measures for 2018 to 2020. It targets an 18% reduction in PM 2.5 particulate pollutants and has increased the focus on ozone, which is becoming more of an issue than PM 2.5 in regions like the Pearl River Delta, with targets for a 10% reduction of volatile organic compounds (VOC) and a 15% reduction of NO_x. All these targets are baselined against the year 2015. Supporting measures identified in the action plan are wide-ranging, including plans to develop a low-emission transport system and increase railway cargo; efforts to control the use of coal in key regions; and the development of low-emission industries.

China seeks to cap CO_2 emissions by around 2030 as part of its Paris Agreement goals. For this purpose, the country has been implementing an ETS with the help of Germany and initial pilots in a handful of cities and regions began in 2013. The national ETS was announced in 2017 and is still taking shape with the development of the necessary legislation, data collection and supporting systems. The initial phases will only include the power sector, but this will expand greatly in later phases, ultimately becoming the world's largest. The ETS is expected to continue development and enter operation under the 14^{th} Five-Year Plan.

Road transportation

In recent years China has been transitioning to increasingly more stringent fuel standards and at the beginning of 2019 it implemented the current China VI standard, which can be compared to the Euro 6. The change from the V to the VI standard decreased limits of benzene, aromatics and olefins in addition to existing requirements for a sulphur content of less than 10 ppm. A second phase, VIb, is due to be implemented in 2023 which will lower the olefin limit, from 18% to 15%.

China's heavy-duty vehicles (those over 3,500 kg) are covered by a national standard for fuel consumption (GB 30510–2018). Stage 3 of the standard was implemented in July 2019 and further reduces the fuel consumption limits (litres per km) from Stages 1 and 2. These limits vary according to the vehicle weight and type, with trucks, tractors and buses included.

This year began with a significant development in relation to ethanol-blended fuels in road transportation. Since 2017 China had planned for the nationwide use of E10 blended gasoline (with 10% ethanol content). However, this was cancelled in January due to insufficient feedstock availability and fuel production levels. Targets will now only remain for provinces where the fuel has already been implemented.

Electric vehicles

As the country with the largest fleet of EVs, China's policies in this area are particularly impactful on the development of related EV technology and global market penetration. China's subsidy programme has in recent years seen several adjustments to reduce the value of the subsidy provided and increase the requirements to qualify for it. The 2019 programme update, for example, requires that BEVs now have a minimum range of 250 km to qualify. The subsidy value is calculated using factors such as range and energy density, increasing the value for higher performance EVs. However, the subsidy was reduced significantly for vehicles after 2019 compared to 2018, and for some vehicles (e.g. BEV passenger vehicles) the value was reduced by more than 50%.

The New Energy Vehicle (NEV) Credit System for manufacturers is arguably the most important mechanism in driving the growth of the EV fleet. Implemented in 2019, it is largely based on California's ZEV mandate. In 2019 the system required that 10% of sales of traditionally fuelled vehicles be covered by credits earned from the sale of NEVs where, for example, a BEV provides up to six credits (influenced by factors such as battery range) while a PHEV provides a maximum of two. The percentage requirement was increased to 12% for 2020.

The trading scheme of the NEV credit system also allows for the credits to be used with the separate Corporate Average Fuel Consumption (CAFC) regulation. CAFC establishes average fuel consumption targets for manufacturers of passenger cars and these targets are related to vehicle weight. Again, manufacturers can gain credits from exceeding their targets or must trade or purchase credits to meet credit deficits when targets are not met.

7.2.4 India

Energy policy in India has a foundation in its National Action Plan on Climate Change, launched in 2008. The plan includes eight underlying programmes for energy efficiency, renewable energy, natural resources and sustainability. The National Mission for Enhanced Energy Efficiency (NMEEE) includes the Perform Achieve and Trade initiative, a market-based system where industries with high energy consumption gain credits for achieving reductions below a target level. These credits can be sold to those who fail to meet the target. The third three-year cycle, which targets reductions in energy consumption of 1.06 mtoe, is due to end in 2020. A fourth cycle, ending in 2021, targets an additional 0.699 mtoe reduction.

India's NDC targets include achieving a 40% share of non-fossil fuel electric power capacity by 2030 and the government has set a target of 175 GW of renewable energy capacity by 2022 and 450 GW by 2030. Government-provided subsidies are key to driving this growth and continue to evolve. The tax system reform in 2017 that introduced a goods and services tax (GST) also had an impact, with lower rates for renewable energy-related manufacturing and for thermal generation.

For solar energy in particular, funding equivalent to $8.6 billion will be made available by 2022. One of the two schemes to benefit is the Rooftop Solar Programme, which moved to a second phase in 2019 in support of India's goal of 40 GW of rooftop solar capacity by 2022. The programme provides subsidies to residential solar installations up to 40% of the cost for capacities up to 3 kW (for capacities between 3 kW and 10 kW it is 20%). The second programme benefiting from the funds is targeted at deploying solar power for agricultural use and in rural areas.

The City Gas Distribution (CGD) project announced by the Indian government several years ago represents another part of the effort to improve energy access. This project grants licences to private domestic companies, as well as foreign players, to set up infrastructure for the distribution of cleaner cooking (piped natural gas) and transportation (CNG) fuels to the domestic market.

Road transportation

The transportation sector's rapidly increasing energy consumption ultimately conflicts with a goal to reduce India's dependence on imported fossil fuels and to prevent an increase in air pollution.

India has set separate fuel economy standards for passenger vehicles, light-duty commercial vehicles (those between 3 tonnes and 12 tonnes), and heavy-duty commercial vehicles (those above 12 tonnes). The latest is the standard for light-duty commercial vehicles, which was adopted in 2019 and came into force in April 2020. Similar to the other standards, it creates fuel consumption targets based on equations that involve the vehicle's weight. The passenger vehicle standard, originally set in 2015 and measured on a corporate average fleet-wide basis, enters a second phase in the fiscal year 2022–2023 when the fuel consumption targets increase.

The Bharat VI fuel standard, which limits the sulphur content of gasoline and diesel fuels to 10 ppm, was implemented in April 2020. The Bharat standards typically follow the EU regulations for new passenger cars and the country accelerated implementation by bypassing standard V to go straight to VI.

Electric vehicles

India's automotive market is one of the largest in the world, but differs from Europe and the US because of its large share of two- and three-wheeled vehicles, the electrification of which is more developed (57% of 3-wheeled vehicle sales in 2018 were EVs).

The Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles scheme (FAME) is the most prominent instrument driving the expansion and manufacture of EVs in the country. The $1.4 billion scheme is currently in the middle of its second three-year phase and makes available subsidies, given directly to original equipment manufacturers (OEMs) to reduce the purchase price, which are worth 10,000 rupees ($130) per kWh of battery capacity for two-, three- and four-wheeled vehicles and for buses the subsidy is twice as much. There is an upper limit on the vehicle price in the scheme of $2,000 for a two-wheeled vehicle and $20,000 for a four-wheeled vehicle. The FAME scheme also supports the establishment of public charging infrastructure.

In terms of the total value of subsidies, tax breaks (at around $220 million) account for approximately ten times the value of the FAME scheme ($22 million). This results from the lower GST levied on EVs, which was reduced from 12% to 5% in 2019, creating an even wider gap compared to the 28% tax on ICE vehicles.

7.2.5 Other regions

Japan

Japan's energy policies reflect the country's unique energy challenges. With the exception of Luxembourg, Japan has the lowest level of energy self-sufficiency in the OECD and in 2017 relied on overseas supplies of fossil fuels for approximately 87% of its primary energy supply. In 2019, Japan was the largest importer of LNG and the third largest importer of coal. This is partly a legacy of the 2011 Fukushima nuclear disaster which has sharply reduced the share of nuclear in the energy mix, leaving natural gas and coal to fill the void. Consumption of coal has, therefore, remained steady over the last decade and unlike other OECD countries, Japan plans to continue construction of new coal power plants. Coal use as a power source will, therefore, only drop from 33% in 2017 to 26% in 2030 and will constitute the largest source of GHG emissions. Japan was the first country in the G7 to submit its updated NDC as part of the Paris Agreement and the country targets a GHG emission reduction of 26% when compared to 2013, unchanged from its previous submission. Its long-term strategy targets an 80% reduction by 2050.

Renewable energy had a share of 16% in power generation in 2017 and the target for 2030 is for 22% to 24%. In a major change, the Feed-in Tariff (FiT) scheme for renewable energy, which has helped push the uptake of residential and small-scale renewable energy generation, looks set to be remodelled in the coming year, taking lessons learned from set-ups in other countries such as Germany. The FiT has existed since 2012, setting an initial price that year of 40 Yen/kWh for renewable energy generation which has been reduced in each subsequent year and stood at 14 Yen/kWh in 2019. The changes seek to lessen the burden on consumers who have been paying a surcharge on their bills to fund the scheme. This should increase competition.

Looking to longer-term solutions to Japan's energy challenges, hydrogen fuel provides the country with an option to both help diversify its energy supply and meet its GHG emission targets. Construction of the Fukushima Hydrogen Energy Research Field facility, one of the world's largest hydrogen-production operations, was completed in February 2020. The 10 MW electrolysis facility, which is powered by renewable energy, is one of a number of efforts being made in the country to realize a 'hydrogen economy'. Amongst the targets of the 2017 Basic Hydrogen Strategy was a hydrogen cost of 30 Yen/m^3 by 2030 and 20 Yen/m^3 in the long-term. The latest details of the approach and cost goals for hydrogen technologies were released in the revised New Strategic Roadmap for Hydrogen and Fuel Cells in March 2019. However, even for a leader in hydrogen technology like Japan, there is still a long way to go to realize low-cost hydrogen at a commercial scale. Bringing down the cost of hydrogen will be more difficult in Japan because of its relatively high cost of renewable energy generation.

Russia

The Russian Energy Strategy 2035 (ES-2035) was approved by the government in June 2020. It sets strategic goals for the energy sector intended to contribute to the socio-economic development of Russia and the strengthening and sustainability of the industry's positions in the global energy markets.

The ES-2035 focuses on developing the energy infrastructure in eastern Siberia and the Far East and forming a petrochemical complex there; expanding energy infrastructure and ensuring the resilience of the energy system; and diversifying energy exports towards markets in the Asia-Pacific region. Furthermore, there is emphasis on reducing the environmental footprint of the energy sector, a gradual growth of renewables, improving digital conversion and ensuring national energy security. The strategy also sets targets for the potential use of hydrogen.

The implementation of the ES-2035 is divided into two stages – up to 2024 and from 2024 to 2035. It also has two scenarios, representing lower and upper limits of variations of the parameters of the energy balance (Table 7.1).

Table 7.1
The ES-2035 main selected parameters

	Units	2018	2024		2035		2018–2035 *(%)*	
			lower	upper	lower	upper	lower	upper
Production								
Crude oil	*million tons*	555.7	556.0	560.0	490.0	555.0	–11.8	–0.1
Gas	*bcm*	727.6	795.1	820.6	859.7	1,001.0	18.2	37.5
Coal	*million tons*	439.3	448.0	530.0	485.0	668.0	10.4	52.1
Electric power	*billion kWh*	399.4	389.5	405.2	434.5	475.4	8.8	19.0
Total	***million toe****	**2,054.0**	**2,154.0**	**2,249.0**	**2,197.0**	**2,594.0**	**6.9**	**26.3**
Export								
Crude oil	*million tons*	260.6	267.0	269.0	244.0	252.0	–6.5	–3.3
Gasoline	*million tons*	4.2	8.0	9.0	18.0	20.0	326.2	373.8
Diesel	*million tons*	39.1	40.8	42.9	59.8	70.7	52.9	80.8
Fuel oil	*million tons*	30.7	26.0	25.0	12.0	15.0	–62.5	–50.2
Other refined products	*million tons*	58.6	62.0	61.0	37.0	50.0	–37.7	–15.5
Pipeline gas	*bcm*	220.6	243.9	250.4	255.4	300.6	15.8	36.3
LNG	*bcm*	26.9	60.0	65.0	108.0	189.0	301.5	602.6
Coal and products	*million tons*	210.3	219.0	272.0	257.0	392.0	22.2	86.4
Electric power	*billion kWh*	20.5	15.3	15.3	9.9	10.9	–51.7	–46.8
Total	***million toe***	**1,012.0**	**1,102.0**	**1,163.0**	**1,167.0**	**1,480.0**	**15.2**	**46.2**

* *million tons of oil equivalent.*
Source: ES–2035.

Brazil

The make-up of Brazil's energy sector paints a very different picture to those of the other countries explored in this chapter. Thanks to its wide use of biofuels and hydropower, renewable energy meets over 40% of primary energy demand and in terms of the installed capacity of renewables, the country is ranked third in the world (behind only the US and China). The Brazilian government, in its NDC, targets a reduction in GHG emissions of 37% by 2025 and 43% by 2030 with 2005 as the baseline.

Brazil is a major global producer of ethanol from sugar cane. In 2017 the Brazilian government signed and implemented the National Biofuel policy (RenovaBio) that encourages biofuel production and also aims to help meet the country's GHG emission-reduction targets. The policy established tradeable decarbonization credits (CBIOs) for biofuel producers and importers. Reduction targets are set annually over a period of ten years (from 2018 to 2028) during which CBIOs must be used to meet these targets or a fine is imposed.

Hydropower dominates the electricity generation mix, but efforts have been made to diversify and expand the use of other renewables. Wind and solar energy, although small in their share of the energy mix, are growing rapidly with financial support and defined prices from electric power auctions. In Brazil's latest energy plan (PDE), these renewables are expected to reach 28% of the energy mix by 2027 and solar in particular is to increase to 8.6 GW in 2027 from 2.5 GW in 2019.

At the start of 2020 the government proposed a bill which, if adopted, would ban the sale of petrol and diesel cars from 2030. This would mean that only EVs or cars using biofuels would be allowed. In line with the PDE, the share of diesel in the road transportation sector should decline while the plan expects that biofuels will take up an estimated share of 9% in 2026. Also important to the automobile industry is the Brazil Rota 2030 plan that sets the goal of increasing vehicle efficiency while boosting the industry. Incentives will be provided to achieve these goals. For example, there is a 3% tax reduction on products used in electric or hybrid engines.

7.2.6 International transportation

Air transportation

Policy matters in the aviation sector revolve largely around the ICAO and the Air Transport Action Group (ATAG). ICAO is a specialized agency of the UN and its membership is mainly comprised of the UN Member States. ATAG is an independent coalition of companies and organizations across the entire aviation sector.

Both have set the target of carbon-neutral growth from 2020. In addition, in the long-term, ATAG wants to halve net emissions by 2050 and ICAO aims to improve fuel efficiency by 2% p.a. until the same year. For the latter, the goals led to a 'basket of measures' being identified, one of which is particularly impactful: the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), adopted in 2016. It enters its three-year pilot phase in 2021 and despite being voluntary, will include states representing more than three-quarters of aviation traffic by the time it begins. CORSIA itself aims to offset aviation emissions, with the market-based system generating carbon credits when emissions are cut compared to the baseline. Credits can be bought by other members of the scheme who require additional credits to meet their own commitments.

The COVID-19 pandemic has challenged the design of the scheme because calculating the offsetting requirements involves the use of two factors: an 'aviation sector growth factor', which will now be influenced by the recovery of the sector; and a baseline year of 2020, a year which is expected to experience a sharp drop in emissions. An initial effort to address this issue means that 2019 CO_2 emissions figures will be used in place of 2020 figures for the pilot phase. A periodic review due in 2022 will scrutinize the impact of the pandemic and review the baseline for future phases.

Looking to the long-term, with only some exemptions for the least developed countries or small island nations, the mandatory phase of CORSIA will begin in 2027. It is envisaged that these emission cuts will emerge through such efforts as the development of more efficient technology and the use of SAF. For the former, ICAO sets technology standards to be observed for aircraft and engine designs, while also setting goals for the development of new technology, which in turn could replace the previous standard. With regard to SAFs, these can include fuels made from renewable feedstocks or those produced from waste. However, to be eligible they must produce 10% fewer lifecycle GHG emissions when compared to aviation fuel. The first flight using SAF took place in 2008, and at this early stage of development there are seven different pathways for producing SAF that have been approved, while six airports provide the option of SAFs to airlines. Nonetheless, ICAO expects production capacity to increase rapidly and this can help SAFs reach price parity with traditional aviation fuel.

Marine transportation

The year 2020 has been an important one for the shipping industry with the introduction of new limits on fuel sulphur content. Since 2005 the IMO has established limits on sulphur oxide (SO_x) emissions for international shipping under the MARPOL Convention. Furthermore, the areas that have been designated Emission Control Areas already have strict requirements. These include areas in the Baltic Sea, the North Sea, North America and the US Caribbean Emission Control Area and have a fuel sulphur content limit of 0.1%.

From 1 January 2020, the limits on the sulphur content of fuel for all ships operating outside the above regions was reduced from 3.5% to 0.5%. The IMO expects, as a result of the new limits, a 77% reduction in SO_x emissions, which are harmful to health and the environment, especially for populations living in coastal areas and around ports.

Adapting to the new regulations has meant switching to a blend of fuel oils to reduce the sulphur content, or the installation of emission 'scrubbers' onboard ships to reduce the exhaust gas pollutants to below the required limit.

Another important policy target of the IMO is to achieve at least 50% emissions reduction by 2050, compared to 2008, while at the same time pursuing efforts to phase them out entirely. Major components of the strategy to achieve this target include improvements of the energy efficiency framework; technical and operational energy efficiency measures for both new and existing ships; speed optimization and speed reduction; measures to address methane emissions; and incentives for the development of new technologies. An interim target in these efforts is to achieve 30% efficiency improvements by 2025 for all new ships compared to 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.

Oil demand and supply uncertainties

Key takeaways

- The COVID-19 pandemic, the resulting economic crisis and expected pathways for recovery have magnified uncertainties for the future energy mix. Extending the time horizon of this Outlook to 2045 further adds to the challenge of long-term energy and oil forecasting.

- These uncertainties are explored by developing alternative scenarios for the future energy mix and sensitivity cases to the Reference Case projections for oil demand and supply.

- Given the uncertainty in climate change mitigation, two alternative scenarios (Scenarios A and B) are used to explore possible future mitigation options. The results show that there is no one-size-fits-all approach and they raise awareness about potential adverse impacts of climate response measures on different economies. Therefore, a coherent approach is needed to set the world on a sustainable, more resilient and fair pathway.

- To account for uncertainty related to economic growth, two alternative cases – a Higher GDP Case and a Lower GDP Case – were developed, each complementing the Reference Case and depicting different developments.

- The gap between the GDP level in the Higher and Lower GDP Cases is projected at almost $8 trillion (2011 PPP) in 2025 and opens up to almost $22 trillion (2011 PPP) in 2045. The range of oil demand uncertainty related to economic growth is estimated at around 5 mb/d in 2025 and grows to almost 8 mb/d at the end of the forecast period.

- An Accelerated Policy and Technology Case (APT Case) has also been developed to assess potential implications for future oil demand, assuming that additional policy measures across all major oil consumption sectors were adopted, thus supporting the faster penetration of more efficient technology. Oil demand in the APT Case is projected to reach 102.8 mb/d in 2045, hence widening the uncertainty range for oil demand to 10 mb/d.

- On the supply side, the range and magnitude of uncertainties is at least as high if not higher than for oil demand. Modelling suggests that there is a range of some 9 mb/d for total non-OPEC supply in the long-term, of which 6.2 mb/d is to the downside and 2.7 mb/d to the upside.

- Due to its short-cycle nature and unique responsiveness to market conditions, the impact on US tight oil is much greater in the short- and medium-term, with a downside risk of nearly 5 mb/d by 2025. In contrast, the expected impact on other non-OPEC supply, largely as a result of underinvestment, takes longer to materialize.

- Compared to the Reference Case, in which non-OPEC supply hits a peak of 71.8 mb/d in the late 2020s, modelling suggests in a Lower Supply Case, non-OPEC supply stagnates earlier, at 65.6 mb/d, only marginally topping pre-pandemic levels, before eventually sliding substantially lower in the long-term. In a Higher Supply Case, it could reach 74.4 mb/d at peak.

Projecting future oil demand and the energy mix is never an easy task given the inherent uncertainties that surround the oil industry. However, preparing a long-term outlook in the midst of a global pandemic is more than challenging. COVID-19 brought with it a new set of uncertainties, many of them unthinkable only a few months ago, and these uncertainties influence key issues discussed throughout the first seven chapters of this Outlook.

In addition, the time horizon of this Outlook was extended to 2045. This by itself widens options for policymakers, provides more time for technology development and makes the qualified assessment of consumer preferences more challenging.

This chapter explores these uncertainties by developing alternative scenarios for the future energy mix, primarily driven by required emission reductions consistent with the Paris Agreement, and sensitivity cases to the Reference Case projections for oil demand and supply used throughout this Outlook. Sensitivity cases cover three fundamental areas: the economy, policy and technology, and non-OPEC oil supply.

When considering environmental issues and sustainable development, despite a number of negative implications of the COVID-19 pandemic, many argue that the resulting energy demand and emissions reduction in 2020 could serve as an example for an accelerated energy transition. At the same time, there is an ongoing discussion among policymakers in many countries about the optimal use of huge stimulus packages. The primary aim of these stimulus measures is to help to revive economic activity. The surrounding debate, however, includes potential investments into more advanced solutions and faster implementation of climate-related policy measures that could lead to a global energy system that is significantly different to the one of today. For these reasons, two alternative scenarios were developed in order to facilitate the exploration of possible mitigation approaches for the future with the focus on likely implications on oil demand.

The economic outlook is another driver, but also a fundamental source of uncertainty for future oil demand. In this respect, the range of uncertainty widened significantly with the COVID-19 pandemic. To account for this uncertainty, two alternative cases were developed, each complementing the Reference Case and depicting different, but possible economic developments. The main focus in developing these cases is on the economic recovery from the COVID-19-induced crisis over the medium-term while, at the same time, assessing long-term implications on future oil demand.

This chapter also explores options for faster penetration of available energy-efficient technology in various oil-consumption sectors, without assuming any new technological breakthroughs. Clearly the rate of penetration of such technology, including options for fuel substitution supported by policy measures, is another source of uncertainty for future oil demand. These options are presented in the Accelerated Policy and Technology Case (APT Case).

On the supply side, two alternative cases for non-OPEC supply developments were also considered. These alternative cases are not exhaustive, but serve to indicate the range of uncertainty for the oil industry in the years and decades to come.

8.1 Climate change-related uncertainties

Climate change is one of the world's most pressing challenges. The extreme weather effects manifested worldwide from accelerated glacier melt, heatwaves, drought, floods and catastrophic fires have resulted in economic disruption with unexpected and often devastating impacts on human societies and natural systems.

At present, countries across the world are tackling the health and socio-economic impacts of the COVID-19 pandemic. At the same time, they are being encouraged to keep up the momentum and address the challenge of climate change in the context of sustainable development and building resilient societies in the post-pandemic era.

While countries face the above challenges, policymakers are assessing and implementing different mitigation measures and strategies with inherent uncertainties. Science often provides input and guidance to policymakers for mitigation planning, yet knowledge providers have to deal with uncertainty as well. The nature and extent of these uncertainties should, therefore, be appropriately integrated when deciding how to use data and information in mitigation action.

In general, it is expected that the magnitude of climate change and the severity of its impacts will be larger if mitigation actions are not taken to reduce GHG emissions. However, uncertainty in climate change mitigation is a complex concept, which can relate to knowledge gaps and low confidence or probability for a possible outcome. Some of the main sources of uncertainty related to climate change mitigation include:

- The uncertain relationship between GHG emissions and temperature responses (including, for example, the estimated total and remaining carbon budget);
- The limitations and uncertainties resulting from the metrics used to estimate aggregate GHG emissions (such as the 100-year Global Warming Potential);
- Measurement errors due to imperfect observational instruments and/or data availability and processing (particularly for GHG emissions in developing countries);
- The uncertain linkages between human-induced changes in climate and natural climate variability, especially at the regional level;
- The ambiguity on how parties under the Paris Agreement will reflect in their consecutive nationally determined contributions (NDCs) the long-term goals of the agreement, and how they will implement their commitments and actions; and
- Different model limitations on future development and interactions of non-climatic factors that could determine climate change mitigation – including demographic and socio-economic trends, technological development, behavioural and institutional norms, and international cooperation.

One approach used to deal with uncertainty in mitigation action is to consider multiple plausible outcomes through scenario analysis. Climate change mitigation scenarios are used as plausible representations of possible future developments to assess the potential impacts of various alternative fundamental factors on emissions reduction. These factors may relate to different technological advancements, policies and socio-economic drivers. Models used to analyze such scenarios are, however, abstractions of key relationships. Thus, scenarios are not absolute forecasts of the future and are conditional on the assumptions introduced in their narratives. They only provide insights to allow better-informed decision-making that may not be possible without them.

In addition, mitigation action often aims to achieve emissions reduction in the energy sector, and various climate change scenarios present a different set of conditions for the future of energy systems. Some of these include mitigation options that could lead to 'win-win' solutions with environmental and socio-economic benefits, or 'flexible' options that enable amendments to be made in the future assuming the provision or availability of means that allow capacity-building.

It is worth highlighting that energy systems are also characterized by high levels of complexity, risk and uncertainty. For instance, technological change that enhances energy efficiency is a critical driver to reducing emissions, yet the pace of technological change is inherently uncertain. Uncertainties about synergies and trade-offs between policies and measures aiming to reduce emissions in the energy sector further complicate the evaluation of different mitigation strategies. To this end, the socio-economic costs of climate response measures could vary depending on how they are implemented, their timing and the speed of implementation.

Alternative mitigation pathways

In light of the above, two alternative climate change-related scenarios are presented in this chapter. These scenarios facilitate the exploration of possible mitigation approaches and assess their impact on future energy demand and the energy mix, as well as on the interaction between socio-economic development and emissions reduction.

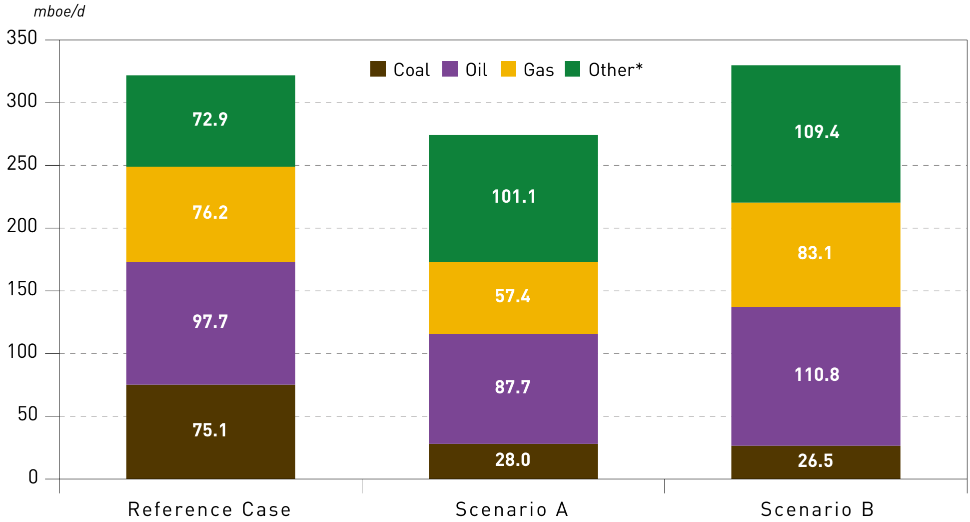
The portfolio of mitigation policies and regulations introduced in the two scenarios relates mainly to carbon pricing; technological changes and mitigation options, including improvement of energy efficiency; electrification and fuel switching with an enhanced role for renewable energy sources; material efficiency; lifestyle and behavioural changes; and use of fossil fuels with carbon capture and storage (CCS) technology. The respective scenario narratives are as follows:

Scenario A assumes emission reductions are achieved by implementing mitigation actions across all sectors of the economy. Besides the development and deployment of renewable energy technologies, a global carbon price is assumed that covers all industrial sectors and power generation. In the transport sector, the current stock of vehicles is assumed to be replaced by advanced-efficiency combustion engines, hybrids and battery electric vehicles. In the industry sector, regulations lead to substantial investments in energy efficiency.

Scenario B assumes a relatively high use of hydrocarbons in the first half of the century, with the exception of coal as demand falls significantly. Nuclear power plays a more significant role compared to Scenario A and regulatory policies are assumed to phase out coal use in the industry sector. Advancement of carbon CCUS technologies is also assumed, with large-scale deployment of bioenergy with CCS in the second half of the century.

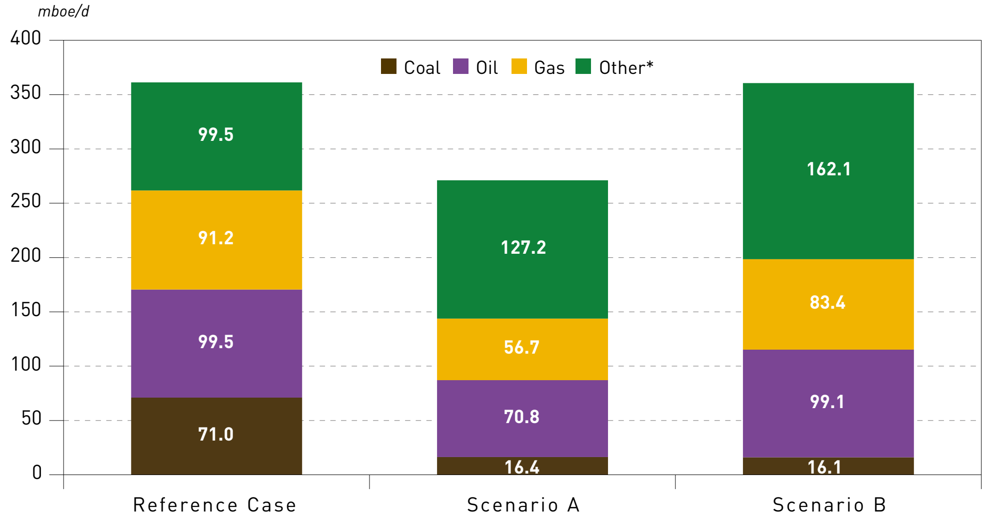
Both Scenario A and B are aligned with the Paris Agreement's long-term target of limiting global mean surface temperature change to well below 2°C, but have different amounts of negative emissions post-2050. Both scenarios are analyzed against the Reference Case presented in Chapter 2 of the Outlook.

Figure 8.1
Global primary energy demand and the energy mix in 2030



* *Including nuclear, hydro, biomass and other renewables (e.g. wind, solar and geothermal).*
Source: OPEC.

Figure 8.2
Global primary energy demand and the energy mix in 2045



* *Including nuclear, hydro, biomass and other renewables (e.g. wind, solar and geothermal).*
Source: OPEC.

Mitigation actions such as those assumed in Scenarios A and B would have a differentiated impact on global primary energy demand, as illustrated in Figures 8.1 and 8.2.

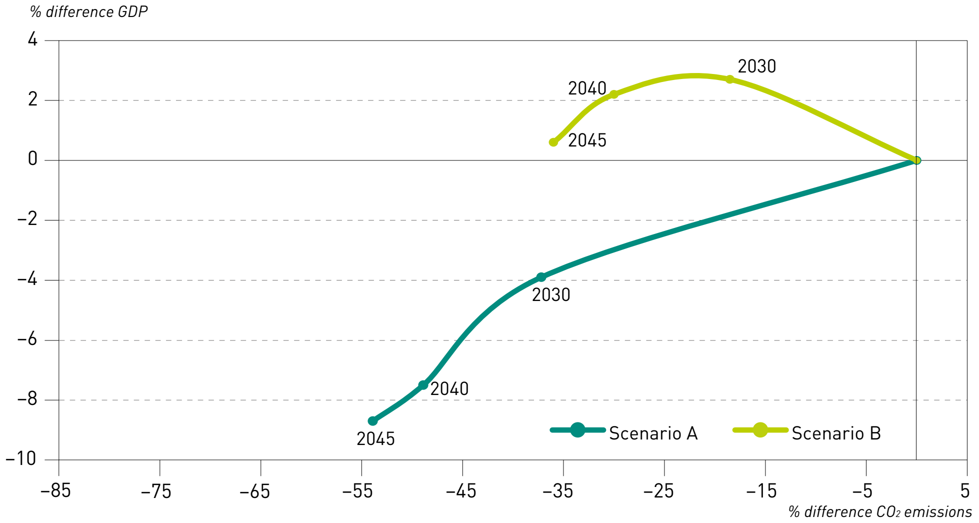
Under Scenario A, around a 15% reduction of global primary energy demand is estimated in 2030 compared to the Reference Case, with demand falling from 322 mboe/d to about 274 mboe/d. The respective figures in 2045 are at the level of a reduction of almost 25%, with global energy demand being reduced from 361 mboe/d to 271 mboe/d. On the other hand, global energy demand is expected to be higher under Scenario B by 2030, and almost at the same level as for the Reference Case by 2045.

Under Scenario B, significant changes in the energy mix are expected compared to the possible trends in the Reference Case. In 2030, the share of oil and gas in the total energy demand is almost 5% higher compared to the Reference Case. An increase of around 20 mboe/d is expected for oil over the period 2019–2030, with demand for gas being higher by about 16 mboe/d and demand for coal being reduced by 65%. The trends for oil and gas remain rather similar up to 2045, and demand for coal becomes minor.

Under Scenario A, oil demand reductions are higher, falling to 71 mboe/d by 2045 (29% lower than in the Reference Case). Consumption of gas is also affected, reaching a level of about 57 mboe/d by 2045. The level of demand for coal is estimated to drop by about 77% by the end of the projection period, while demand for renewable energy (including nuclear) is expected to be 28% higher compared to the levels under the Reference Case.

Given the above estimated impacts on future oil demand, the associated impacts on global energy-related CO_2 emissions and the GDP of selected energy-exporting developing countries is presented in Figure 8.3.

Figure 8.3
Impacts on global CO_2 and GDP of selected energy-exporting developing countries, % deviation from the Reference Case



Source: OPEC.

It appears that under Scenario A, global energy-related CO_2 emissions are reduced by about 54% in 2045 compared to the Reference Case. Emissions reduction under Scenario B is at 19% in 2030 and 36% in 2045. At the same time, energy-exporting developing countries could face negative impacts on their economies, owing to lower oil demand and, therefore, lower export revenues. The reduction of their GDP is observed under Scenario A, whereas a higher share of fossil fuel sources in the energy mix under Scenario B could help alleviate these potential adverse economic impacts.

As already stated, climate change policies inherently involve risk and uncertainty related *inter alia* to nature, the economy and society. Uncertainties also relate to the potential of technology advancement and the economic outlook that have been tempered by the COVID-19 pandemic. The elements of both scenarios have an associated uncertainty that surrounds them, but they could be used as consistent tools for probing possible futures.

Analysis shows that there is no one-size-fits-all approach to mitigate climate change. Energy-exporting developing countries are likely to experience significant socio-economic consequences due to climate change and mitigation responses, particularly in countries whose access to financing and technology is limited. In view of such vulnerabilities, it is essential to establish or restore the very foundations of resilience and stability in their societies.

The Paris Agreement is highly relevant for the establishment of partnerships, and for providing potential cooperation modalities based on the specific needs and capabilities of every country – including countries endowed with natural resources. The SDGs of the 2030 Agenda for Sustainable Development also set out a desired state of societies so that no one is left behind. Scenario analysis serves as a guide for enhancing climate action, seizing the awareness of the inequalities in terms of potential adverse impacts of climate response measures and vulnerability within societies and among countries.

A global challenge such as climate change requires a global response, while a coherent approach is needed to set the world on a sustainable, more resilient and fair pathway. Determined leadership, adequate finance and collaboration among countries will be needed to reduce emissions while also eliminating any adverse impacts of mitigation measures on livelihoods and societies.

8.2 Economic uncertainties

Even though the global economy is increasingly becoming less energy and oil intensive, economic activity is a fundamental driver of future energy and oil demand. The link between economic growth and oil demand was further weakened by the outbreak of COVID-19 in 2020, as discussed in detail in Chapter 3 of this Outlook. Driven by lockdowns and various restrictions, oil demand is expected to decline by 9% this year compared to 2019 while the global economy is anticipated to shrink by around 4%. Nevertheless, one of the key assumptions of this Outlook is that COVID-19 will be broadly contained during the next few years and a gradual recovery will take place.

In addition, it is important to note that there is a wide range of estimates on how deep the current recession actually is and how fast the recovery will be. For example, mid-2020 estimates of global GDP decline in 2020 provided by reputable institutions range between –3% to –6% compared to 2019. A somewhat smaller though still very wide range of 4% to 6% relates to expected global GDP growth in 2021. This is a clear sign that the outlook for the global economy and related oil demand is clouded by many uncertainties not only in the short-term, but also in the medium- and long-term.

To account for this uncertainty, it is vital to explore the possible implications that alternative GDP growth paths could have on oil demand. For this reason, two alternative cases were developed, each complementing the Reference Case and depicting different, but possible economic developments. The main focus in developing these cases is on economic recovery processes from the COVID-19-induced crisis over the medium-term while, at the same time, also assessing long-term implications on future oil demand.

In the **Higher GDP Case**, the biggest challenge facing the global economy, the COVID-19 pandemic, is broadly contained. An effective vaccine is assumed to become available soon and at an affordable price. Infection numbers dwindle in 2021 and the world adapts to a low-infection environment with consumer spending increasing and businesses reopening.

As the world emerges from the effects of the pandemic, the global economy rebounds and oil demand increases sharply. The stimulus measures of major economies to aid the economic recovery are effective both in their scale and scope. They are assumed to include targeted support for industries such as IT, telecoms and healthcare, and drive innovation in new and developing areas of technology. While tourism, hospitality and the leisure sectors may not recover to their full extent, the stimulus measures help develop industries of the future that increase investment, generate economic growth, raise productivity and create new jobs.

It is further assumed that governments show flexibility and react in a timely manner with a new legislative framework that not only helps to soften the impact of the COVID-19 pandemic, but also supports the economy and society, providing an overall managed transition to a post-COVID-19 world. Geopolitical issues in this potential future will not disappear, but level heads prevail in major disputes, such as the trade war between the US and China, while global trade relations improve in general.

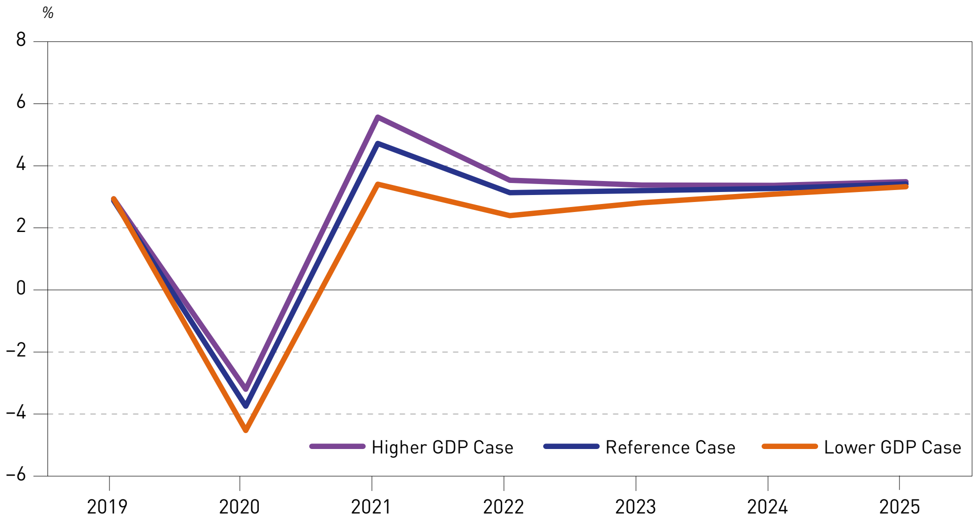
In contrast, the **Lower GDP Case** depicts a world still plagued by COVID-19 throughout most of the medium-term. The year 2020 ends with global infection numbers still on the rise and even those countries that navigated the pandemic somewhat successfully at the beginning of 2020 will face stronger and prolonged second waves. While testing for COVID-19 is widespread and the treatment of patients improves, an effective vaccine remains out of reach for most of 2021 and countries with ill-equipped healthcare systems are overwhelmed. Governments – reluctant to face the economic consequences of nationwide lockdowns – continually employ local lockdowns covering cities and regions, which stifle economic activity. Industries reliant on the global movement of people and goods will suffer the most with a growing number of bankruptcies, even among some major international corporations.

Stimulus measures in this alternative future are found to be less effective in reviving economic growth. They help, but to a large extent they act to compensate for shortfalls from nationwide or local lockdowns, for example, in supporting the hospitality industry or propping up large companies hit by the downturn. When the stimulus packages have drained and the impact from continued numbers of COVID-19 cases remains, smaller businesses especially are assumed to experience a growing number of defaults and bankruptcies, keeping unemployment rates at higher levels.

In this case, even after the pandemic is controlled in later years, the effects are felt for longer because of a more disorderly transition. Defaults on sovereign debt could be seen in countries that were already heavily indebted in the pre-pandemic period. The difficulties that countries face are expected to be compounded by issues on the international front, where current trade disputes may continue and an increase in protectionist policies will reduce or limit global trade. In addition, internal unrest in economies hurt by the pandemic could increase as discontent grows with governments that have been seen to be ineffectual. In this case, lingering social issues that were suppressed by lockdowns could become prominent once again and slow the recovery process in these countries.

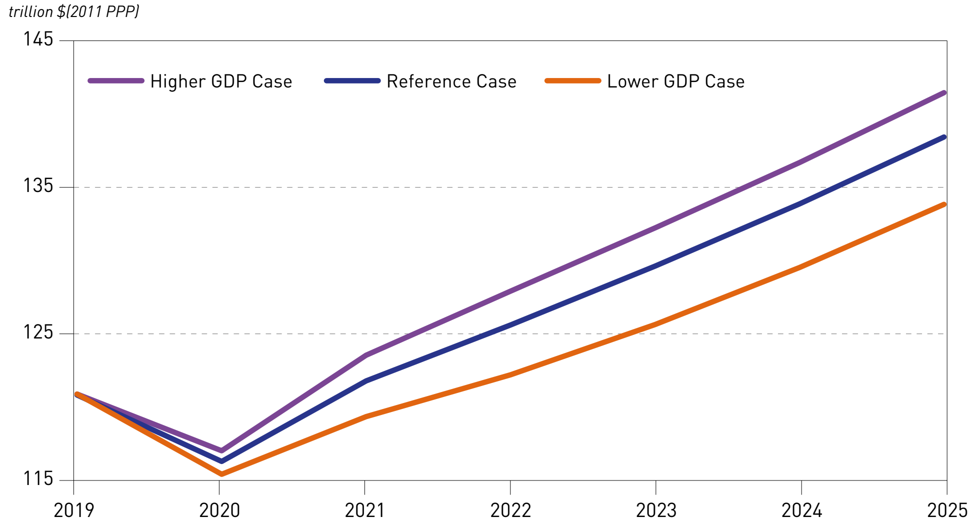
Figures 8.4 and 8.5 translate the narrative of these two cases into specific global GDP growth rates and absolute levels (in trillion $2011 PPP) during the medium-term period. In both cases, global GDP recovers during the medium-term from the very low levels reached in 2020. However, the speed of recovery differs quite significantly. While in the Higher GDP Case global growth is forecast as high as 5.6% in 2021, the same figure for the Lower GDP Case is just 3.4%. The corresponding growth rates for 2022 are forecast at 3.5% and 2.4%, respectively.

Figure 8.4
Global GDP growth rates in the medium-term, 2019–2025



Source: OPEC.

Figure 8.5
Global GDP levels in the medium-term, 2019–2025



Source: OPEC.

Adding to this the effect of varying growth rates in 2020 leads to a quickly widening gap between the Higher and Lower GDP cases if measured in absolute terms. Indeed, the difference between the two cases rises to almost $6 trillion (2011 PPP) in 2022, which represents almost 5% of global economic activity by then. The wide difference in the GDP growth rates in the alternative cases will gradually narrow during the remaining years of the medium-term. This is especially true for the Higher GDP Case, where growth rates will relatively quickly converge with those assumed in the Reference Case. In contrast, the effect of a sluggish recovery in the Lower GDP Case will likely delay convergence with the growth rate projected in the Reference Case by a year or two. Nevertheless, the gap between the two alternative cases will widen to almost $8 trillion (2011 PPP) in 2025.

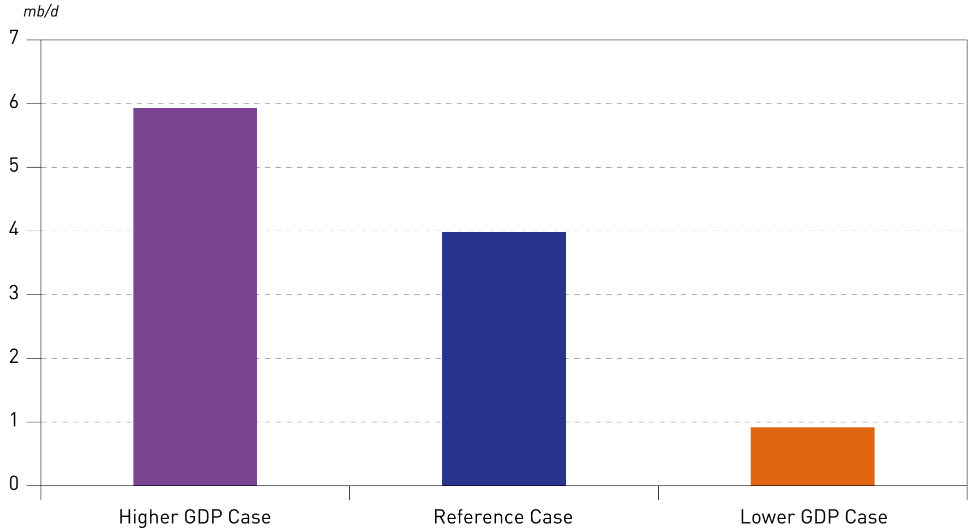
Beyond the medium-term, regional GDP growth rates in both alternative cases will evolve broadly in line with those in the Reference Case. However, because of the different bases reached in 2025, the gap in the level of economic activity opens up to almost $22 trillion (2011 PPP) in 2045. In 2045, global GDP is projected to reach a level of $267 trillion (2011 PPP) in the Higher GDP Case and $245 trillion (2011 PPP) in the Lower GDP Case. This compares to $257 trillion (2011 PPP) in the Reference Case. It is worth noting that the risk is skewed more to the downside rather than to the more optimistic Higher GDP Case.

Implications for oil demand

The alternative paths of economic development as portrayed in the Higher and Lower GDP Cases will have a significant impact on oil demand prospects. The summary of results, together with the Reference Case projections, are provided in Figures 8.6 and 8.7. Assuming most other factors that determine the medium- and long-term trajectory of oil demand remain broadly unchanged, as outlined in the Reference Case, the range of demand uncertainty will be around 5 mb/d in 2025 and grow to almost 8 mb/d at the end of the forecast period.

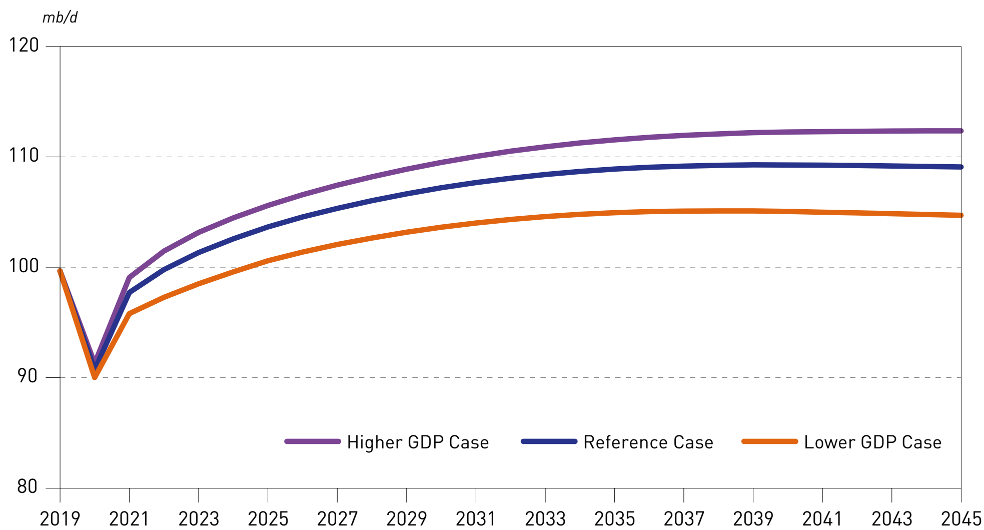
In the Higher GDP Case, a gap in the Reference Case emerges in 2021 as a quick economic recovery and the removal of major obstacles to mobility lead to a stronger recovery in oil demand,

Figure 8.6
Incremental oil demand over the medium-term in alternative cases, 2019–2025



Source: OPEC.

Figure 8.7
Global oil demand in alternative cases, 2019–2045



Source: OPEC.

though still below the 2019 levels. Demand will fully recover in all sectors of consumption, except in aviation and road transport in some regions such as Europe and Latin America. Strong demand growth will also continue in 2022 and 2023 at 2.4 mb/d and 1.7 mb/d, respectively.

By then, all sectors will have fully recovered from the COVID-19 crisis and growth will be driven by a 'standard' set of factors such as GDP, population, efficiency improvements and fuel substitution.

The net effect is that global oil demand will increase by almost 6 mb/d between 2019 and 2025 to reach a level of 105.6 mb/d. This is almost 2 mb/d higher than in the Reference Case during the same period.

This difference widens further to more than 3 mb/d in 2045 (Figure 8.7). It should be noted, however, that the projected demand level of 112.4 mb/d for the Higher GDP Case in 2045 is somewhat lower than the one corresponding to assumed GDP growth in this case, *ceteris paribus*. This is due to the second-order effects that will gradually arise as a result of higher GDP growth and would limit oil demand growth to some extent.

For example, under the Higher GDP Case, the disposable income of households would be greater. This could incentivize the move to more efficient means of oil consumption such as more economical household appliances and cars (including hybrids and EVs), better insulation solutions and more energy-efficient heating and cooling systems. Moreover, governments would have more funds to subsidize cleaner energy initiatives and companies would be in a better position to invest in advanced technological equipment and processes.

Turning to the Lower GDP Case, there are some similarities but also some differences. Similarities start with the major gap in the Reference Case already present in 2021 and widening as time progresses. In fact, a small part of this gap expands during the remainder of 2020 as demand in the aviation, road transport and industry sectors continues to suffer from the sluggish economic recovery and extended travel restrictions. The demand difference will reach almost 2 mb/d during 2021 and will further expand to 3 mb/d in 2025.

As a result, oil demand in the Lower GDP Case will likely remain below 2019 levels until 2024 and will be only around 1 mb/d higher in 2025. Starting from this lower base demand in 2025, the gap compared to the Reference Case will further expand during the period to 2045 even though economic growth during this period will broadly follow the pattern assumed in the Reference Case. The Lower GDP Case will reach a level of 104.7 mb/d in 2045.

It is to be noted, however, that the demand reduction in the Lower GDP Case is sensitive to how the required supply adjustment will be accommodated and, therefore, what will constitute the marginal barrel in this case. Estimates presented in Figure 8.7 assume only a moderate shift in the structure of marginal barrels leading to a moderate reduction of oil prices and a related demand rebound effect.

Table 8.1 presents oil demand levels in these alternative cases from the perspective of OECD and non-OECD countries. In the Higher GDP Case, oil demand in OECD countries increases by

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	47.9	43.4	47.5	45.3	42.0	38.5	35.1
Reference Case	47.9	43.0	46.8	44.6	41.5	38.0	34.8
Lower GDP Case	47.9	42.5	45.5	43.3	40.3	36.9	33.7
Non-OECD							
Higher GDP Case	51.8	47.9	58.1	64.2	69.5	73.8	77.3
Reference Case	51.8	47.8	56.9	62.6	67.4	71.2	74.3
Lower GDP Case	51.8	47.5	55.1	60.3	64.7	68.2	71.0

Source: OPEC.

between 0.7 mb/d and 0.8 mb/d above the Reference Case during the medium-term. This difference, however, is gradually reduced to around 0.3 mb/d during the long-term period, mainly due to faster penetration of technology with better energy efficiency. For non-OECD countries, the potential for faster growth is higher. Moreover, significantly higher GDP growth rates for non-OECD countries (compared to OECD countries) result in a much higher cumulative effect over the long-term. Therefore, oil demand for this group of countries in the Higher GDP Case departs quickly from the levels projected in the Reference Case, with the gap reaching 3 mb/d in 2045.

In the Lower GDP Case, the distinct pattern between the OECD and non-OECD is less pronounced. Differences to the Reference Case projection for these regions evolve almost in parity during the initial years of the medium-term period and expand slightly in the second part to stand at –1.2 mb/d for OECD and –1.8 mb/d for non-OECD in 2025. This gap to the Reference Case is broadly maintained for OECD countries during the long-term as the effect of relatively low GDP growth rates in this region and the oil demand rebound broadly counterbalance each other. This, however, is not the case for non-OECD countries, for which the gap widens quite significantly to –3.3 mb/d in 2045.

8.3 Policy and technology uncertainties

Improvements in energy efficiency have long been recognized as a key element of policies aimed at reducing emissions. This is clearly reflected in a number of policies in countries across the globe that target the efficient use of energy in a variety of sectors and in terms of energy consumption. Typically, these policy measures include financial and fiscal instruments (energy audits, subsidies, loans and tax/tax credits); direct regulations in the form of minimum energy efficiency standards; building codes, labels and certificates; and other measures such as voluntary agreements.

At the same time, energy efficiency is not just a matter of regulation. It is also closely linked to technology developments. In fact, it is technology that provides the ways and means for a more efficient use of energy. Policies, on the other hand, can support both technological progress and implementation, especially in sectors with high energy consumption.

Focusing on oil demand specifically, an **Accelerated Policy and Technology Case** (APT Case) has been developed to assess potential implications on future oil demand if additional policy measures across all major consumption sectors were adopted, allowing (and supporting) the faster penetration of more efficient technologies. It is important to note that this case does not assume any major technological breakthroughs. It simply explores the potential for a reasonably faster penetration of existing technology that could be achieved at reasonable cost if adequate incentives were put in place.

As the main source of demand, the road transportation sector provides the largest opportunity for fuel substitution and efficiency improvements. As discussed in detail in Chapter 3, the Reference Case projections incorporate an assumption that out of the total of 2.6 billion vehicles on the road by 2045, around 430 million will be EVs. In relative terms, the share of EVs is projected to reach around 5% in 2030, 13% in 2040 and more than 16% in 2045. As stated in Chapter 3, the incremental number of EVs is estimated to accelerate in the second part of the forecast period. Hence, their share will also grow significantly.

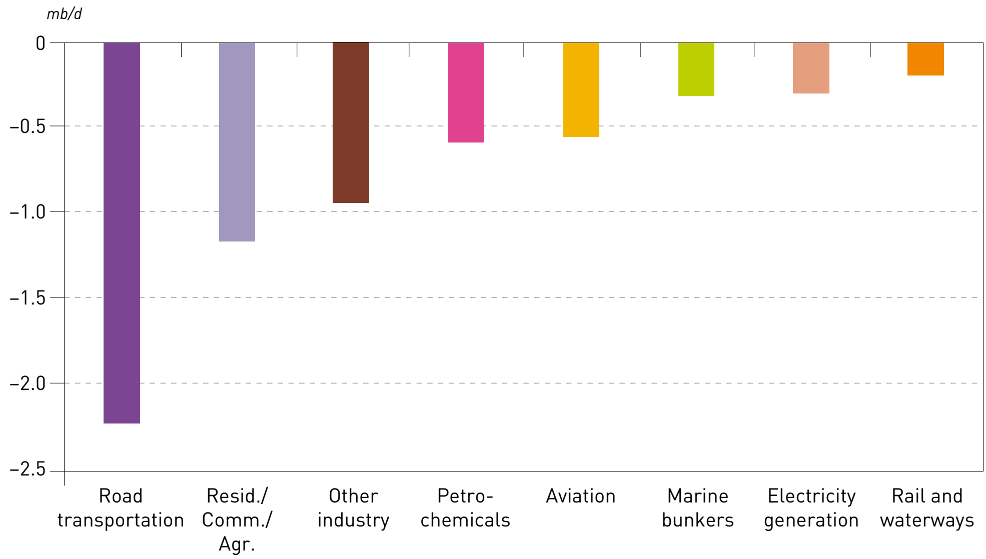
Admittedly, there is a high degree of uncertainty related to these estimates. For example, the cumulative effect of underestimating/overestimating the share of EVs in global annual new sales by just 1 pp results in a decrease/increase of around 30 million EVs in 2045. Bearing in mind that the share of EVs in global new sales of passenger vehicles in 2045 is likely to be in the range of 30% (for more details, Figure 3.20), it is not unrealistic that a faster reduction in battery cost, policy-driven incentives to develop necessary infrastructure and further shifts in consumer preferences (all compared to the Reference Case) could push up the sales of EVs by several pp, especially in the second part of the forecast period.

Moreover, as presented in Figures 3.23 and 3.24, efficiency improvements of ICEs will also play an important role in limiting future oil demand in road transportation. Although the Reference Case assumes rather ambitious fuel economy improvements, further potential still exists in several areas such as reducing vehicle weight by employing lightweight, though expensive, materials; reducing engine wall heat losses; and recovering waste heat. Moreover, the shift towards shared mobility or higher use of public transport could also contribute to improved overall efficiency.

As presented in Figure 8.8, the combined effect of these factors could result in lowering oil demand in the road transportation sector by more than 2 mb/d (and potentially even more) in 2045 compared to the Reference Case.

Figure 8.8 also shows that significant potential for future demand reduction – in the range of 1 mb/d – exists in the residential/commercial/agricultural and in the industry sectors. The larger part of the reduction would likely result from the increased use of electricity and natural gas in these sectors. For example, the Reference Case projections for India assume the continuation of the City Gas Distribution programme aimed at improved access to natural gas, especially in larger cities, leading to the increased use of natural gas instead of LPG and kerosene. Faster implementation of this programme and widening of the area coverage could further reduce oil demand in India compared to the Reference Case. Needless to say, similar programmes could be viably implemented or expedited in other countries. The same applies to other areas such as improved access to electricity, electrification of households, extending the restrictions on using oil in residential heating and tightening emissions quotas in the industry sector.

Figure 8.8
Potential efficiency improvements and fuel substitution in the APT case by 2045



Source: OPEC.

Another part of oil demand reduction could result from the increased use of better technology. For example, the replacement of old heating equipment with modern low-temperature condensing boilers may substantially increase energy efficiency in the residential sector. In a similar vein, the commercial sector may take advantage of synergy effects by combining traditionally separated services such as using the waste heat of the chiller to produce hot water.

From the technology perspective, the petrochemical sector is among the most efficient sectors and there is limited potential for further improvement. Some improvements could result from the use of more efficient catalysts, waste heat recovery and optimized heat exchangers and process control, albeit with limited impact on oil demand. However, the much larger potential exists with respect to improved plastics recycling and the reduced use of some petrochemical products. It is important to note that improvements in recycling rates were already assumed in the Reference Case. In this regard, even a relatively minor increase in these rates combined with a marginally reduced link between economic growth and the use of petrochemical products (again, all compared to the Reference Case) could result in an oil demand reduction of around 0.5 mb/d in 2045.

In the aviation and marine sectors, the IATA and IMO have ambitious plans to improve energy efficiency and reduce emissions in their respective sectors.

According to the IATA's Technology Roadmap for Environmental Improvement, further progress can be expected from the evolutionary development of jet engines with a high and ultra-high bypass ratio and, starting from the mid-2030s, from revolutionary developments in propulsion systems such as open rotor and hybrid or electric propulsion. Additional savings in fuel consumption and a reduction of GHG emissions can be achieved through the deployment of new designs and technology for airframes and equipment.

However, with each additional improvement in fuel efficiency, the potential for further gains becomes smaller and more expensive. In the future, it will become more challenging to achieve incremental improvements with existing aircraft configurations (tube and wing), and these minor improvements will also be less economically viable. That is why more revolutionary concepts and sustainable aviation fuels (SAFs) are being considered as potential pathways to reducing emissions. For example, hybrid-electric aircraft based on a new airframe body, the blended wing body, could lower emissions and improve fuel efficiency by up to 50%.

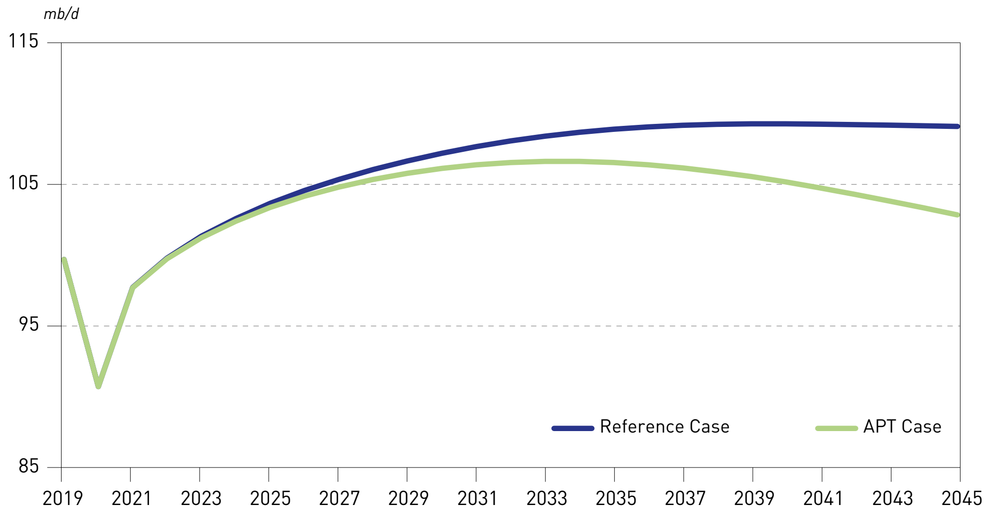
Besides improved efficiency, fuel substitution could also potentially reduce future oil demand in the aviation sector. It is expected that small electric aircraft, with up to 10 seats, could start entering the market in the current decade and gradually increase in size up to 150 seats thereafter. However, 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.

In addition to technology, it remains to be seen how the COVID-19 pandemic will affect business and leisure travel in the future. In this respect, the Reference Case assumes some but not a major change in consumer behaviour. However, assuming a further shift in this direction, supported by faster developments on the technology front, the result could be a downward adjustment of oil demand in this sector in the range of 0.5 mb/d by 2045.

In the marine sector, besides evolutionary improvements in fuel efficiency, the highest uncertainty relates to the rate of penetration of LNG-based vessels. Even a minor adjustment of this rate could potentially lower oil demand in this sector by 0.3 mb/d at the end of the forecast period.

The potential for demand reduction is lower in the remaining two consumption sectors, electricity generation and rail and domestic waterways. This is partly because the demand base, especially in rail and domestic waterways, is relatively low. Moreover, oil in the electricity generation sector is typically used in medium or large reciprocating engines, with the potential for future improvements mainly limited to the recovery of waste heat. This, however, requires significant investment. Some improvements could also be achieved via increased injection pressures, more efficient super-chargers and by faster replacement of older generators. The key area for railways relates to faster electrification.

Figure 8.9
Oil demand in the Reference Case and APT Case, 2019–2045



Source: OPEC.

The combined effect of tighter policy measures and the faster penetration of more efficient technology considered in the APT Case is presented in Figure 8.9. At the global level, oil demand in the APT Case is projected to reach 103.4 mb/d in 2025, 106.4 mb/d in 2035 and 102.8 mb/d in 2045. Oil demand in this case broadly follows the Reference Case projections during the current decade. The difference between the two cases is just 1 mb/d in 2030 as it takes time from the adoption of new policies to their implementation before they have a measurable impact.

The effect, however, is much larger in the second part of the forecast period when the difference widens to 4 mb/d in 2040 and further to more than 6 mb/d by 2045. It should be noted, however, that this does not represent the full potential demand reduction that is theoretically possible. In all major regions and sectors there is ample scope for far larger implementation of energy efficiency measures, which could potentially depress future oil demand to much lower levels.

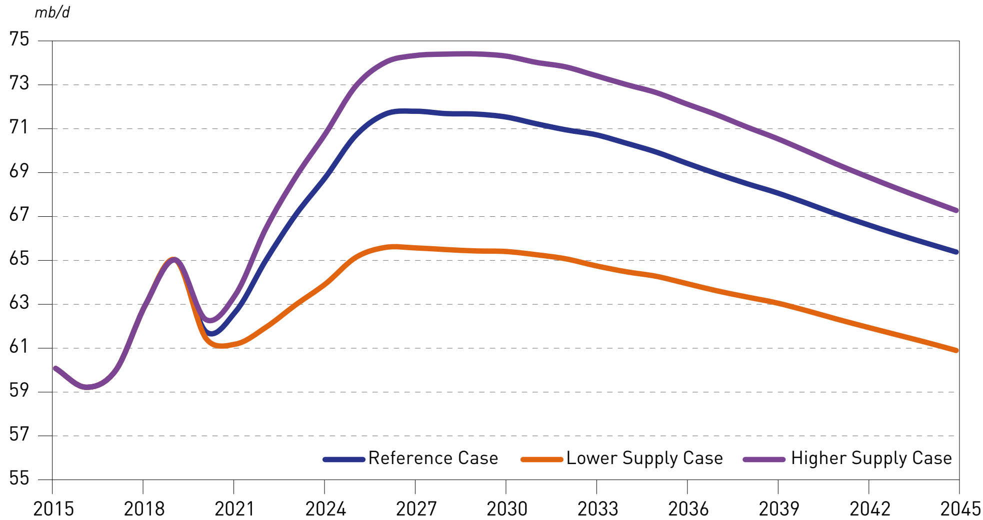
8.4 Supply uncertainties

On the supply side, the range and magnitude of uncertainties is at least as high, if not higher, than for oil demand. While oil demand is expected to gradually recover as the world emerges from the pandemic, the outlook for oil production is also dependent upon expectations of price stability, recovered oil demand levels and resulting investment decisions.

The pandemic-induced massive shock to global economic activity, and, as a result, to oil demand, incentivized the historic decision of OPEC and non-OPEC countries participating in the DoC to adjust production down by an unprecedented level of nearly 10 mb/d in April 2020. In addition, other producers, most notably in the US and Canada, felt compelled to shut in huge volumes due to barrels becoming uneconomic.

Compared to the pre-pandemic outlook, the range of uncertainty for supply is now arguably greater, as reflected in a wider upside/downside range of non-OPEC production sensitivity exercises, and portrayed here in a Lower Supply Case and Higher Supply Case, respectively. Modelling suggests that there is a range of uncertainty of some 9 mb/d for total non-OPEC supply in the long-term, of

Figure 8.10
Long-term non-OPEC supply sensitivities



Source: OPEC.

which 6.2 mb/d is in the Lower Supply Case and 2.7 mb/d is in the Higher Supply Case (all compared to the Reference Case). This implies a significant skew to the downside and a diametrically opposite picture to what most observers, including this Outlook, had expected prior to COVID-19.

Compared to the Reference Case, in which non-OPEC supply at its peak hits 71.8 mb/d in the late 2020s, modelling suggests that in a Higher Supply Case, it could reach as much as 74.4 mb/d at around the same time. In a Lower Supply Case, non-OPEC supply peaks earlier, at 65.6 mb/d, only marginally topping pre-pandemic levels of 65 mb/d in 2019, before eventually sliding substantially lower in the long-term.

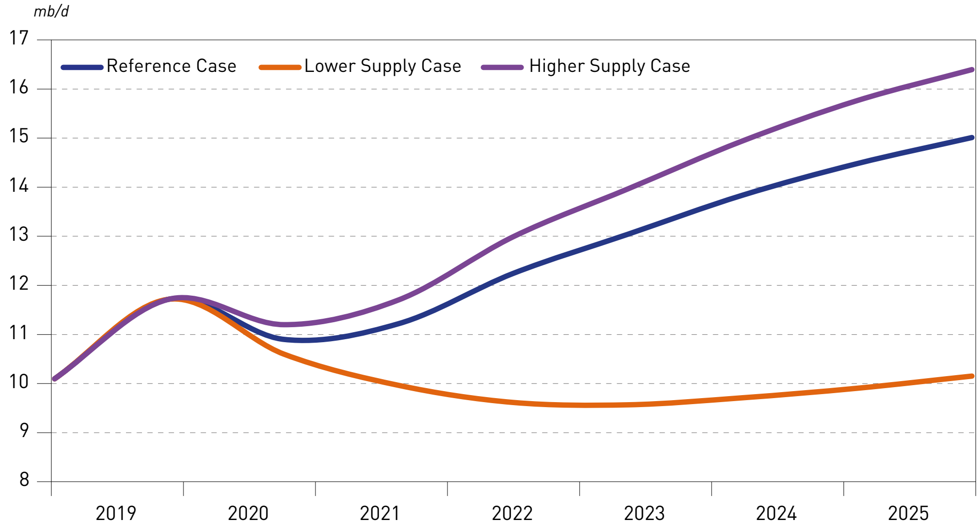
In the **Lower Supply Case**, it is US tight oil which is primarily affected, especially in the short-term. Not only has it been the most affected by the pandemic-induced price downturn, with around 2–3 mb/d of crude supply shut-in, it also remains one of the most price-sensitive components of non-OPEC supply due to its unique short-cycle nature, requiring far higher, industrial-style drilling and completion activity and, therefore, continuous investment.

Thus, in this Case, it is assumed that US tight oil does not recover in 2021, unlike in the Reference Case. In fact, it sees two more years of decline before stabilizing in 2023 and only growing modestly thereafter (Figure 8.11).

Implicitly, a prolonged impact of the COVID-19 pandemic, perhaps with multiple further waves, keeps the global economy depressed, resulting in lower oil demand and a less supportive price environment. Assuming other factors remain unchanged, this is assumed to result in lower drilling and completion activity, as companies remain hesitant or unable to hike investment, as production in many cases is uneconomic. This is reinforced by an ongoing focus on capital discipline and a resulting, more conservative, approach to risk-taking and investment.

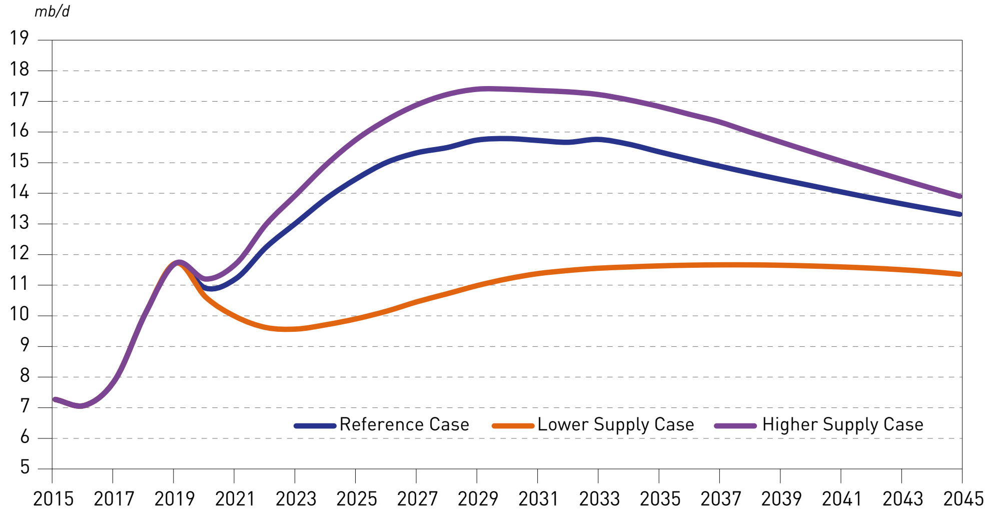
As a result, drilling and completion activity is sufficient to keep production steady, but not to grow. In other words, US tight oil takes far longer to recover, showing only modest growth in the latter part of the 2020s and plateauing for the rest of the forecast period, albeit only just recovering to the pre-pandemic levels (Figure 8.12).

Figure 8.11
Medium-term US tight oil sensitivities



Source: OPEC.

Figure 8.12
Long-term US tight oil sensitivities

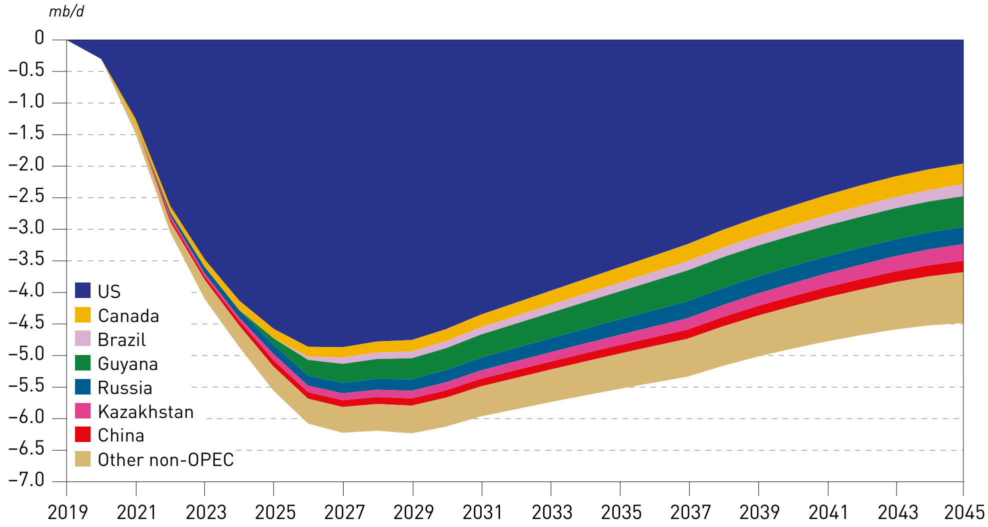


Source: OPEC.

On a basin-by-basin level, this means that only the Permian Basin recovers and shows growth, while the others see declining tight crude output. Unconventional NGLs meanwhile show modest growth.

With regard to other non-OPEC producers, the short- and even medium-term impact is much more muted. Besides those countries participating with OPEC Member Countries in the DoC adjustments, the assumption is that many operators have already done their utmost to cut costs or amend upstream development plans. In many cases, future upstream projects have been postponed; in a few cases, even taken off the drawing board entirely, all of which is already incorporated into the Reference Case for the non-OPEC supply outlook.

Figure 8.13
Non-OPEC liquids Lower Supply Case sensitivity: deviation from the Reference Case



Source: OPEC.

This Lower Supply Case, therefore, includes a variety of assumptions. One form of impact is that, in the medium-term period, some countries that had previously experienced meaningful shut-ins as an immediate impact of the pandemic-related market downturn, simply do not see these barrels return to market, or at least not fully. For instance, it is assumed that Canada, which saw up to 1 mb/d of shut-ins, does not return all of this oil, as some older, higher-cost assets prove uneconomic. To some extent this also applies to countries such as Mexico and North Sea producers including Norway and the UK (Figure 8.13).

But the greater impact on other non-OPEC liquids supply is beyond the medium-term, as a function of longer-term under-investment. Most notably, this affects some sources of major new upstream projects. For instance, in newcomer Guyana, which saw its first oil flow in late 2019, it is assumed that the first three stages in the development of the major Stabroek block go ahead (two stages, Liza 1 and Liza 2, are already sanctioned; one, Payara, shortly to follow), while subsequent stages essentially never materialize. Thus Guyana's output capacity is capped at 0.6 mb/d, as opposed to rising to 1 mb/d and potentially higher in the Reference Case.

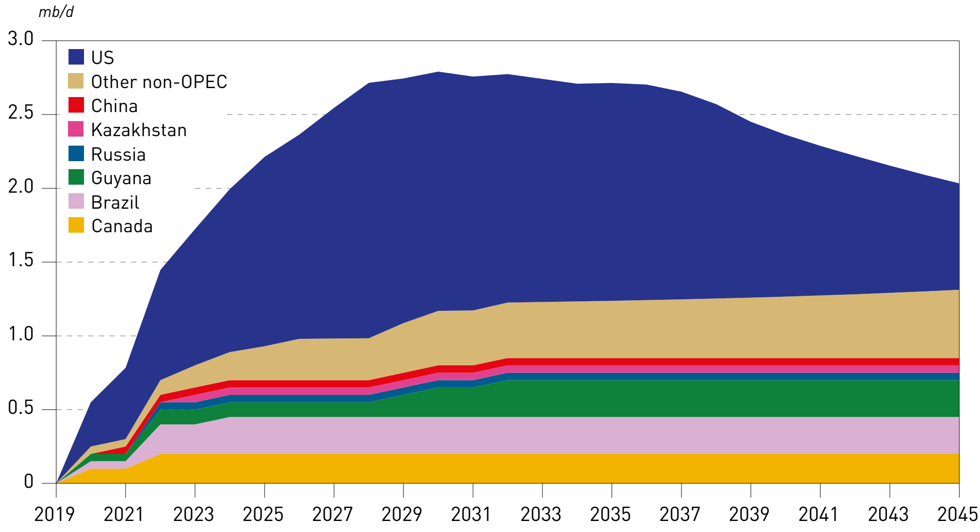
In Brazil, too, some future pre-salt developments are assumed not to go ahead, while in Canada, the scope for future oil sands and other developments is curtailed, resulting in production only just recovering to pre-pandemic levels by 2025 and growing only modestly thereafter. In other, more mature producers, including the North Sea, Other Asia and Africa, lower investment and fewer projects result in a more rapid decline.

As a result, while the shortfall in US tight oil is far greater, rising to nearly 5 mb/d at its peak, the impact on other non-OPEC liquids supply takes longer to materialize, with some 1 mb/d less oil produced by the end of the medium-term. In the longer-term, these two trends shift. For US tight oil, the longer-term profile in the Lower Supply Case is for a long plateauing below 12 mb/d, which means that compared to the Reference Case, which sees pronounced decline in latter years, the relative difference is reduced over time. In contrast, the impact of under-investment and rising decline rates on other non-OPEC producers has a cumulative effect, resulting in total supply being around 2.5 mb/d lower by 2045 when compared to the Reference Case.

Lastly, the significant downside skew this Lower Supply Case outlook implies is partly based upon the assumption that significant policy initiatives are made with a view towards facilitating and accelerating the energy transition, in part in order to fulfil the goals of the Paris Agreement.

In the **Higher Supply Case,** the basic assumption is for a more rapid recovery from the effects of the COVID-19 pandemic in the short-term, including a faster pick-up in the global economy, and thus mobility, trade and oil demand. As in the Lower Supply Case, due to its higher price sensitivity and short-cycle nature, US tight oil responds first. It, therefore, recovers more quickly over the medium-term, rising to 15.8 mb/d by 2025, or 1.3 mb/d higher than the Reference Case (Figure 8.14).

Figure 8.14
Non-OPEC liquids Higher Supply Case sensitivity: deviation from the Reference Case



Source: OPEC.

Thereafter, US tight oil continues to grow at a faster pace than in the Reference Case, though still not as fast as in the boom years of 2018–19. Around the time of its projected peak around 2030, US tight oil supply in the Higher Supply Case rises to about 17.4 mb/d, or 1.7 mb/d higher than the Reference Case (and similar to the Reference Case in the WOO 2019).

With regard to other non-OPEC supply, as in the Lower Supply Case, the response from non-US producers takes longer to materialize. Countries such as Canada and Norway see shut-in volumes return more quickly.

Going forward, growth centres in particular see some upside, with additional project sanctions and a more rapid development timetable in countries such as Guyana and Brazil. The former, for instance, sees an accelerated build-up with output hitting 1 mb/d just beyond the medium-term time horizon, and a higher ceiling thereafter, as more development stages of the Stabroek block are sanctioned. In Canada, prospects for more barrels from oil sands are invigorated, and total country production hits 6 mb/d around 2030. In Mexico, its deepwater potential is more successfully tapped and total supply touches 2 mb/d again in the latter part of the 2020s.

More generally, while market conditions allow for a more optimistic outlook in the Higher Supply Case, upstream investment returns more quickly than in the Reference Case. With more supportive economics, there is scope for an expansion of the resource base, as well as modest breakthroughs in technology, expanding recovery rates and a lengthening of the life of projects.

To summarize, the Higher Supply Case sees total non-OPEC supply rise to 74.4 mb/d by the late 2020s, or 2.7 mb/d higher than the Reference Case. Even though the non-US component continues to rise, with some 1.3 mb/d upside by 2045, the overall upside declines again, with total non-OPEC supply projected at 67.4 mb/d in 2045, or 2 mb/d higher than the Reference Case.

Annex A
Abbreviations

API	American Petroleum Institute
ASEAN	Association of Southeast Asian Nations
ATAG	Air Transport Action Group
b/d	Barrels per day
bcm	Billion cubic metres
BECC	Bioenergy with carbon capture
BEV	Battery electric vehicle
boe	Barrels of oil equivalent
BoJ	Bank of Japan
BLI	Boundary-layer Ingestion
bt	Billion tonnes
BWB	Blended wing body
CAFC	Corporate Average Fuel Consumption
CAFE	Corporate Average Fuel Economy
CAPEX	Capital expenditure
CCE	Circular carbon economy
CCGT	Combined cycle gas turbine
CCPP	Combined cycle power plants
CCS	Carbon capture and storage
CCU	Carbon capture and utilization
CCUS	Carbon capture, utilization and storage
CGD	City Gas Distribution
CH_4	Methane
CHP	Combined heat and power
CNG	Compressed natural gas
CO_2	Carbon dioxide
COP	Conference of Parties
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
COVID-19	Coronavirus disease 2019
CTLs	Coal-to-liquids
DAC	Direct air capture
EC	European Commission
EIA	Energy Information Administration (US)
EOR	Enhanced oil recovery
EPA	Environmental Protection Agency (US)
ETBE	Ethyl tertiary butyl ether
ETS	Emissions Trading System
EU	European Union
EV	Electric vehicle
FCC	Fluid catalytic cracking
FCV	Fuel cell vehicles
FED	US Federal Reserve
FEED	Front-end engineering design
FPSO	Floating production storage and offloading vessel
GDP	Gross domestic product
GECF	Gas Exporting Countries Forum
GHG	Greenhouse gas
GST	Goods and services tax
GTLs	Gas-to-liquids

Gt	Gigatonne
GW	Gigawatt
HEV	Hybrid electric vehicle
HSFO	High sulphur fuel oil
IAEA	International Atomic Energy Agency
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICE	Internal combustion engine
IEA	International Energy Agency
IED	Industrial Emissions Directive
IMO	International Maritime Organization
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
kg	Kilogramme
km	Kilometre
kWh	Kilowatt hour
LCCs	Low cost carriers
LFP	Lithium iron phosphate
LIB	Lithium ion battery
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MARPOL	International Convention for the Prevention of Pollution from Ships
mb/d	Million barrels per day
mboe	Million barrels of oil equivalent
MOMR	Monthly Oil Market Report (OPEC)
mpg	Miles per gallon
mt	Million tonnes
mtoe	Million tonnes of oil equivalent
MTBE	Methyl tertiary butyl ether
mtpa	Million tonnes per annum
MW	Megawatts
N	Nitrogen
NCA	Lithium nickel cobalt aluminium oxide
NDC	Nationally determined contribution
NECP	National energy and climate plans
NEV	New energy vehicle
NGLs	Natural gas liquids
NGV	Natural gas vehicle
NHTSA	National highway traffic safety administration (US)
NMC	Nickel manganese cobalt oxide
NMEEE	National Mission on Enhanced Energy Efficiency (India)
N_2O	Nitrous oxide
NO_x	Nitrogen oxide
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
ORB	OPEC Reference Basket (of crudes)
ORTM	OPEC Road Transportation Model
OWEM	OPEC World Energy Model

p.a.	Per annum
PADD	Petroleum Administration for Defense Districts
PEMEX	Petróleos Mexicanos
PHEV	Plug-in hybrid electric vehicles
ppm	Parts per million
PPP	Purchasing power parity
PV	Photovoltaic
PWh	Petawatt hour
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 (US)
SDGs	Sustainable Development Goals
SOx	Sulphur oxides
SPR	Strategic petroleum reserves
SUV	Sport utility vehicle
SWB	Strut-braced wing
tb/d	Thousand barrels per day
TWh	Terawatt hour
UAE	United Arab Emirates
UK	United Kingdom
ULEV	Ultra-low emission vehicle
ULEZ	Ultra-low emission zone
ULS	Ultra-low sulphur
UN	United Nations
UNDP	UN Development Programme
UNFCCC	UN Framework Convention on Climate Change
VGO	Vacuum gasoil
VLCCs	Very large crude carriers
VLSFO	Very low sulphur fuel oil
VMT	Vehicle miles travelled
VTOL	Vertical take-off and landing
WCSB	Western Canadian Sedimentary Basin
WOO	World Oil Outlook (OPEC)
WTI	West Texas Intermediate
ZEV	Zero emission vehicle

A

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
Eswatini
Ethiopia
Gambia
Ghana
Guinea
Guinea-Bissau
Jordan
Kenya
Lebanon
Lesotho
Liberia
Madagascar
Malawi
Mali
Mauritania
Mauritius
Mayotte
Morocco
Mozambique
Namibia
Niger
Oman
Qatar
Réunion
Rwanda
Sao Tome and Principe
Senegal
Seychelles
Sierra Leone
Somalia
South Africa
South Sudan
Sudan
Syrian Arab Republic
Togo
Tunisia
Uganda
United Republic of Tanzania
Western Sahara
Yemen
Zambia
Zimbabwe

INDIA
India

CHINA
People's Republic of China

Other Asia
Afghanistan
American Samoa
Bangladesh
Bhutan
Brunei Darussalam
Cambodia
China, Hong Kong SAR
China, Macao SAR
Cook Islands
Democratic People's Republic of Korea
Fiji
French Polynesia
Indonesia
Kiribati
Lao People's Democratic Republic
Malaysia
Maldives
Micronesia (Federated States of)
Mongolia
Myanmar
Nauru
Nepal
New Caledonia
Niue
Pakistan
Papua New Guinea
Philippines
Samoa
Singapore
Solomon Islands
Sri Lanka
Thailand
Timor-Leste
Tonga
Vanuatu
Viet Nam

OPEC
Algeria
Angola
Republic of Congo
Equatorial Guinea
Gabon
IR Iran
Iraq
Kuwait
Libya
Nigeria
Saudi Arabia
United Arab Emirates
Venezuela

EURASIA

Russia
Russian Federation

Other Eurasia
Albania
Armenia
Azerbaijan
Belarus
Bosnia and Herzegovina
Bulgaria
Croatia
Cyprus
Georgia
Gibraltar
Kazakhstan
Kyrgyzstan
Malta
Montenegro
Republic of Moldova
Romania
Serbia
Tajikistan
Republic of North Macedonia
Turkmenistan
Ukraine
Uzbekistan

Annex C
World Oil Refining Logistics and Demand: definitions of regions

US & CANADA

United States of America
Canada

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/Eastern Mediterranean

Algeria
Egypt
Lebanon
Libya
Mediterranean, Other
Morocco
Syrian Arab Republic
Tunisia

West Africa

Angola
Benin
Cameroon
Republic of Congo
Côte d'Ivoire
Democratic Republic of Congo
Equatorial Guinea
Gabon
Ghana
Guinea
Guinea-Bissau
Liberia
Mali
Mauritania
Niger
Nigeria
Senegal
Sierra Leone
Togo

East/South Africa

Botswana
Burkina Faso
Burundi

Cape Verde
Central African Republic
Chad
Comoros
Djibouti
Eritrea
Eswatini
Ethiopia
Gambia
Kenya
Lesotho
Madagascar
Malawi
Mauritius
Mayotte
Mozambique
Namibia
Réunion
Rwanda
Sao Tome and Principe
Seychelles
Somalia
South Africa
South Sudan
Sudan
Uganda
United Republic of Tanzania
Western Sahara
Zambia
Zimbabwe

EUROPE

North Europe
Austria
Belgium
Denmark
Finland
Germany
Iceland
Ireland
Luxembourg
Netherlands
Norway
Sweden
Switzerland
United Kingdom

South Europe
Cyprus
France
Gibraltar
Greece
Italy
Malta
Portugal
Spain
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
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
Daily Caller
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
ETEnergyWorld
EUREL
European Automotive Manufacturers Association (ACEA)
European Commission (EC)
European Council
European Environment Agency
Eurostat
Evaluate Energy
Financial Times
Fraunhofer Institute
Gas Exporting Countries Forum (GECF)
Global Carbon Capture and Storage Institute (GCCSI)
Global Commission on the Economy and Climate
Global Wind Energy Council
Goldman Sachs

GSMA Intelligence
Harvard Business Review
Haver Analytics
HSBC
Hydrocarbon Processing
International Commodities Exchange
IEA Monthly Oil Data Service (MODS)
IEA Oil Market Report
IEA World Energy Outlook
IHS Markit
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 for International Development (OFID)
OPEC Monthly Oil Market Report (MOMR)
OPEC World Oil Outlook (WOO)
Oxford Economics
Oxford Institute for Energy Studies
Petrobras
Petroleum Economist
Petroleum Intelligence Weekly
Platts
PricewaterhouseCoopers
pv Europe
REN21 – Global Status Report 2017
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 International Labour Organization (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

Organization of the Petroleum Exporting Countries
Helferstorferstrasse 17
A-1010 Vienna, Austria
www.opec.org
ISBN 978-3-9504890-0-2

www.opec.org

ISBN 978-3-9504890-0-2