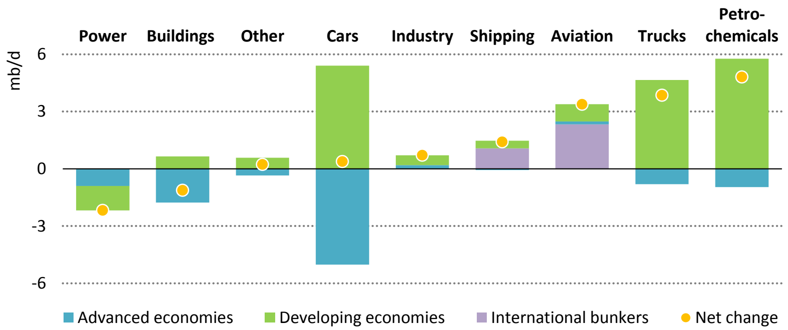
Outlook for oil

Can tight oil avoid a tight oil market?

SUMMARY

- Global oil demand grows by around 1 million barrels per day (mb/d) on average each year to 2025 in the New Policies Scenario; thereafter average annual demand growth slows to around 0.25 mb/d, but global demand does not peak before 2040. All of this growth occurs in developing economies; demand in advanced economies drops by over 0.4 mb/d on average each year to 2040 (Figure 3.1).

Figure 3.1 ▷ Change in global oil demand by sector in the New Policies Scenario, 2017-2040



Petrochemicals, trucks and aviation dominate future oil demand growth

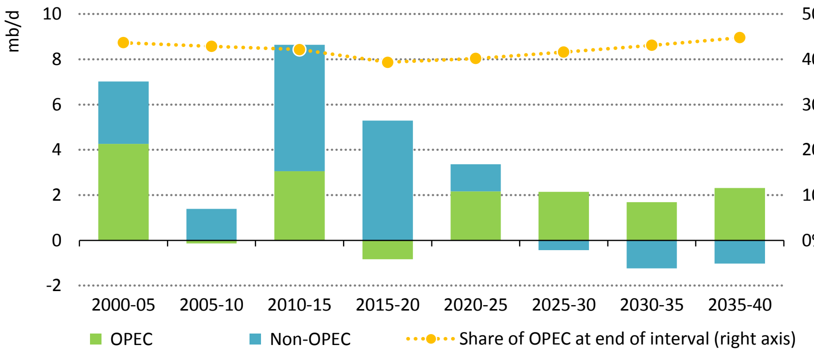
- China overtakes the United States in the New Policies Scenario to become the world's largest oil consumer and by 2040 China is the largest net oil importer in history, importing over 13 mb/d. Demand growth is strong in India and the Middle East: both become larger sources of oil consumption than the European Union around 2030.

- Oil use in cars peaks in the mid-2020s in the New Policies Scenario, even though the global car fleet grows by 80% to over 2 000 million in 2040. Some 300 million electric cars on the road in 2040 avoid 3.3 mb/d of additional demand growth. But efficiency measures are even more important to stem oil demand growth: improvements in the efficiency of the non-electric car fleet avoid over 9 mb/d of oil demand in 2040.

- However, this pace of change is not matched elsewhere. Oil demand for trucks grows by 4 mb/d over the period to 2040, even though vehicle and logistical efficiencies avoid nearly 5.5 mb/d additional demand growth in 2040. Oil use in petrochemicals sees the largest growth (5 mb/d) of any sector. Efforts to increase recycling do not offset the underlying growth in demand for chemical products. If recycling rates were to double, this would cut demand in 2040 by 1.5 mb/d.

- On the supply side, the United States provides nearly 75% of the increase in global oil production to 2025. After 2025, members of OPEC are central to meeting oil demand growth (Figure 3.2). US tight oil reaches 9.2 mb/d in the mid-2020s before declining slowly. But tight oil increases elsewhere, most notably in Argentina.

Figure 3.2 ▷ Change in global oil production in the New Policies Scenario



Non-OPEC countries dominate near-term production increases, but this stalls as US tight oil plateaus and the recent dearth in new approvals hampers growth elsewhere

- The level of conventional crude oil resources approved for development in recent years is in line with the needs of the Sustainable Development Scenario but is far below the level needed to meet demand growth in the New Policies Scenario. If these approvals do not pick up sharply from today's levels, US tight oil production would need to grow to over 15 mb/d by 2025 to satisfy demand. If neither happens, there is a real prospect of damaging price spikes and increased price volatility.

- A wave of 17 mb/d of new refining capacity comes online in the period to 2040, mainly in Asia and the Middle East. This leads to a gradual reshuffling of the competitive landscape for the refining industry. By 2040, China's refinery runs are similar to those in the United States. Near-term pressure on product markets comes from new regulations on the sulfur content of marine fuels which enter into force in 2020. These exert upward price pressure on diesel that only slackens as new fuels are developed and scrubbers are installed across the maritime fleet.

- In the Sustainable Development Scenario, demand not only falls by 25 mb/d between 2017 and 2040, but there is also a major shift in the composition of demand towards lighter products. Adapting to this would represent an unprecedented challenge for refiners, and would bring a risk of mismatches between product demand and refinery configurations that could lead to sharp price movements for individual products.

Introduction

In the wake of the fallout from the 2014 oil price crash, the continued expansion of tight oil production in the United States and the prospect of major structural changes in oil consumption underpinned a view that the oil price was set to stay lower for longer, perhaps for ever. The reality has been different. On the supply side, while tight oil has proved remarkably resilient, the pace of growth has been held back by infrastructure constraints. Geopolitical events, the slump in Venezuelan output, and decisions by major exporters have also weighed on production prospects. Meanwhile, on the demand side, oil consumers responded to lower prices to the extent that the share of oil in the global energy mix has increased in recent years. In September 2018, the oil price surpassed $80/barrel for the first time since 2014.

Where do we go from here? The forces of change in oil markets remain strong. A maturing shale sector is now poised to make money; the cost of new upstream projects has come down; and sales of electric cars continue to break records. But elements of continuity are likewise formidable, and another boom and bust commodity price cycle cannot be ruled out. Against this background, our three main scenarios consider a range of possible future developments. The New Policies Scenario shows a world where oil demand continues to rise, but where its growth is moderated by a variety of new policies. The Current Policies Scenario shows how a failure to implement planned policies could lead to persistent oil demand growth of over 1 mb/d every year to 2040. In contrast, the Sustainable Development Scenario highlights the implications of a near-term peak in oil demand and a long-lasting lower oil price.

The second section of this chapter discusses some key topics in detail:

- What are the drivers of oil demand in road transport, and what is the outlook for cars and trucks in particular? Road transport was the largest source of oil demand growth over the past 15 years and will be central to efforts to stem rises in the future. We set out some of the key uncertainties in projecting transport demand and examine the role of efficiency and alternative fuels in slowing the growth in oil use.
- Are we heading for a possible supply shock? New sources of supply will be needed whether or not demand peaks. As the oil price plummeted in 2014, so did the level of new conventional crude oil projects approved for development. In the *World Energy Outlook-2016 (WEO-2016)* we highlighted the risk that this posed for the long-term equilibrium of oil markets. We revisit this discussion and look at what could fill the gap if approvals do not pick up in the future.
- What are the prospects for the various oil products? The prospects for oil consumption are usually discussed in aggregate terms, but structural changes in demand could mean very different things for individual oil products. Starting from an assessment of the International Maritime Organization (IMO) regulation on marine fuels, which takes effect in 2020, we explore potential shifts in oil product demand and their implications for the refining industry.

Figures and tables from this chapter may be downloaded from www.iea.org/weo2018/secure/.

Scenarios

3.1 Overview

Table 3.1 ▷ Global oil demand and production by scenario (mb/d)

			New Policies		Current Policies		Sustainable Development	
	2000	2017	2025	2040	2025	2040	2025	2040
Road transport	30.1	41.2	44.7	44.9	46.2	53.6	40.5	23.0
Aviation and shipping	8.3	11.5	13.2	16.3	13.8	18.5	11.2	9.3
Industry and petrochemicals	14.5	17.8	20.7	23.3	20.9	23.8	20.0	20.7
Buildings and power	14.3	12.5	11.2	9.2	11.8	10.9	10.2	6.5
Other sectors	10.1	11.8	12.6	12.6	12.9	13.6	12.0	10.4
World oil demand	**77.3**	**94.8**	**102.4**	**106.3**	**105.5**	**120.5**	**93.9**	**69.9**
Share of Asia Pacific	*25%*	*32%*	*35%*	*37%*	*35%*	*37%*	*36%*	*38%*
Biofuels	0.2	1.8	2.8	4.7	2.5	3.5	4.4	7.3
World liquids demand	**77.5**	**96.6**	**105.2**	**110.9**	**108.0**	**124.1**	**98.3**	**77.2**
Conventional crude oil	64.8	66.9	65.6	63.8	67.2	72.6	59.8	40.2
Tight oil	-	4.8	9.8	11.0	10.3	12.1	9.1	7.3
Natural gas liquids	8.9	16.7	19.0	21.1	19.8	22.9	17.5	15.6
Extra-heavy oil and bitumen	1.0	3.7	4.2	5.5	4.3	7.0	3.9	3.5
Other production	0.5	0.7	1.3	2.1	1.4	2.7	1.2	1.3
World oil production	**75.2**	**92.8**	**99.9**	**103.4**	**102.9**	**117.2**	**91.6**	**68.0**
Share of OPEC	*42%*	*43%*	*40%*	*45%*	*40%*	*45%*	*40%*	*44%*
Processing gains	1.8	2.3	2.5	2.9	2.6	3.3	2.3	1.9
World oil supply	**77.0**	**95.1**	**102.4**	**106.3**	**105.5**	**120.5**	**93.9**	**69.9**
IEA crude oil price (2017$/barrel)	**39**	**52**	**88**	**112**	**101**	**137**	**74**	**64**

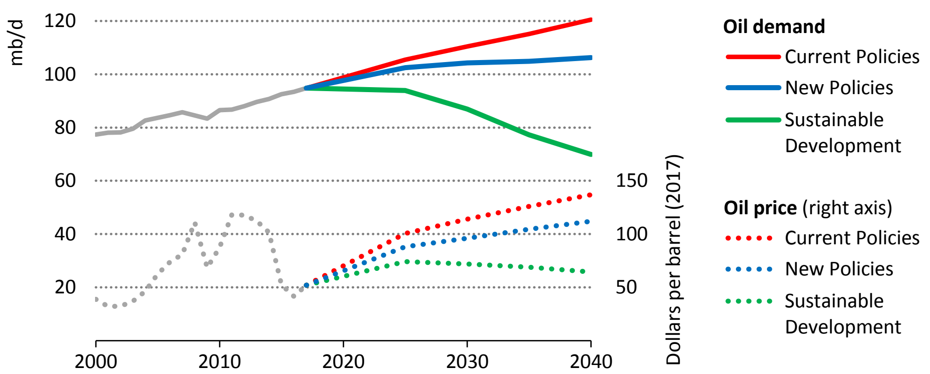
Notes: Other production includes coal-to-liquids, gas-to-liquids, additives and kerogen oil. See Annex C for other definitions. Differences between historical supply and demand volumes are due to changes in stocks.

In the **Current Policies Scenario**, global oil demand rises by around 1.1 million barrels per day (mb/d) on average every year and shows no discernible slowdown to 2040 (Table 3.1). Without strengthened policies on fuel efficiency or the use of alternative fuels, there is little restraint – except steadily higher prices – on the dominant position of gasoline and diesel in the road transport sector, where demand grows by over 7 mb/d by 2025.

China and India are responsible for nearly half of the total increase in demand to 2040. The heavy lifting on supply is led initially by the United States, but later on the Organization of the Petroleum Exporting Countries (OPEC) steadily increases its share of total oil supply.

In the **New Policies Scenario**, demand in 2040 has been revised up by more than 1 mb/d compared with last year's outlook largely because of faster near-term growth and changes to fuel efficiency policies in the United States (Figure 3.3). China leads oil demand growth to 2025, then India and the Middle East take over between the late 2020s and 2040. The United States dominates production growth to 2025, with production increasing by 5.2 mb/d. As in the Current Policies Scenario, US production then starts to fall and OPEC's share of the market starts to climb, reaching 45% in 2040.

Figure 3.3 ▷ Global oil demand and prices by scenario



In 2040, oil demand in the Current Policies Scenario is 51 mb/d higher than in the Sustainable Development Scenario

In the **Sustainable Development Scenario**, determined policy interventions to address climate change lead to a peak in global oil demand around 2020 at 97 mb/d. Demand peaks in nearly all countries before 2030. The main exceptions are India and countries in sub-Saharan Africa where demand grows to at least 2035 (albeit at a subdued pace).

By 2040, cars that rely solely on gasoline and diesel are 40% more efficient than today; there are 930 million electric cars on the road (50% of the global car fleet); a quarter of buses are electric; and nearly 20% of fuels used by trucks are low or zero carbon. As a result, demand in road transport in 2040 in this scenario is more than 18 mb/d lower than today. Demand in aviation falls by 0.8 mb/d by 2040 as a result of enhanced efficiency measures and 1.3 mboe/d growth in biofuels.

The only sector to register any growth is petrochemicals. Plastics recycling increases significantly from today's levels which offsets the need for around 1.5 mb/d of oil demand in 2040. However, with few alternatives available, oil use as a petrochemical feedstock grows by 3.3 mb/d in the period to 2040.

On the supply side, lower demand and prices mean that production levels are down across the board. Although containing many of the least-cost suppliers, members of OPEC are assumed to maintain a policy of market management in this scenario (as in the other scenarios) and so their share of the market remains below 45% to 2040.

3.2 Oil demand by region

Table 3.2 ▹ Oil demand by region in the New Policies Scenario (mb/d)

	2000	2017	2025	2030	2035	2040	2017-2040 Change	2017-2040 CAAGR
North America	23.5	22.3	22.0	21.0	19.9	19.3	-3.0	-0.6%
United States	19.6	17.9	17.8	16.8	15.6	15.1	-2.9	-0.8%
Central and South America	4.5	5.8	5.9	6.0	6.2	6.3	0.5	0.4%
Brazil	1.9	2.4	2.5	2.6	2.7	2.8	0.4	0.7%
Europe	14.9	13.2	12.1	10.9	9.6	8.7	-4.5	-1.8%
European Union	13.1	11.1	9.9	8.6	7.3	6.4	-4.7	-2.4%
Africa	2.2	4.0	4.8	5.3	5.8	6.3	2.3	2.0%
South Africa	0.4	0.5	0.6	0.7	0.7	0.7	0.2	1.3%
Middle East	4.3	7.4	8.4	9.0	9.7	10.6	3.2	1.6%
Eurasia	3.1	3.7	4.1	4.2	4.2	4.2	0.5	0.5%
Russia	2.6	3.0	3.3	3.3	3.2	3.2	0.2	0.3%
Asia Pacific	19.4	30.5	35.8	38.0	39.0	39.5	9.0	1.1%
China	4.7	12.3	14.9	15.7	15.7	15.8	3.5	1.1%
India	2.3	4.4	6.2	7.4	8.4	9.1	4.7	3.2%
Japan	5.1	3.6	3.1	2.7	2.4	2.0	-1.6	-2.5%
Southeast Asia	3.1	4.7	6.0	6.4	6.7	6.8	2.1	1.6%
International bunkers	5.4	8.0	9.2	9.9	10.6	11.4	3.4	1.6%
World oil	**77.3**	**94.8**	**102.4**	**104.3**	**104.9**	**106.3**	**11.5**	**0.5%**
Current Policies			105.5	110.5	115.1	120.5	25.7	1.0%
Sustainable Development			93.9	86.9	77.3	69.9	-24.9	-1.3%
World biofuels	0.2	1.8	2.8	3.4	4.0	4.7	2.8	4.1%
World liquids	**77.5**	**96.6**	**105.2**	**107.7**	**108.9**	**110.9**	**14.3**	**0.6%**

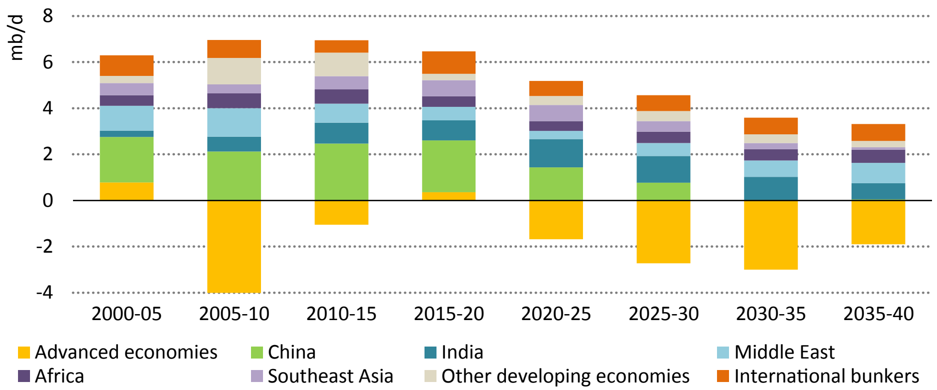
Notes: CAAGR = Compound average annual growth rate. International bunkers include both marine and aviation fuels. See Annex C for definitions.

The 11.5 mb/d global oil demand growth over the outlook period in the New Policies Scenario occurs almost exclusively in **developing economies** (Table 3.2). As demand drops in the United States, China becomes the world's single largest consumer of oil in the 2030s. China's demand growth then grinds to a halt, with the increasing deployment of electric vehicles causing a fall in oil use in road transport.

Oil demand growth is consistently strong in the Middle East and India, and these countries respectively become the world's third- and fourth-largest oil-consuming markets by 2040 (Figure 3.4). India's demand however has been revised down since last year's *Outlook* due to higher projected growth in electric vehicles (see Chapter 8). Nevertheless, increases in these two regions are most pronounced in trucks (oil demand for trucks in India triples to nearly 2.5 mb/d by 2040) and oil use as a petrochemical feedstock (the Middle East becomes the second-largest producer of high-value chemicals soon after 2030).

The pace of oil demand growth in African countries is second only to India's. By 2040, Africa consumes almost as much oil as the European Union, although per capita oil consumption is still 75% lower. Growth in Africa is led by increases in passenger road transport, offset by a 20% improvement in the fuel efficiency of the car fleet: the number of cars on the road in Africa more than doubles between 2017 and 2040.

Figure 3.4 ▷ Change in oil demand in the New Policies Scenario, 2000-2040



Demand in advanced economies falls by 10 mb/d by 2040. Growth in China grinds to a halt after 2030 but increases in India and the Middle East are more consistent.

Note: International bunkers include both marine and aviation fuels.

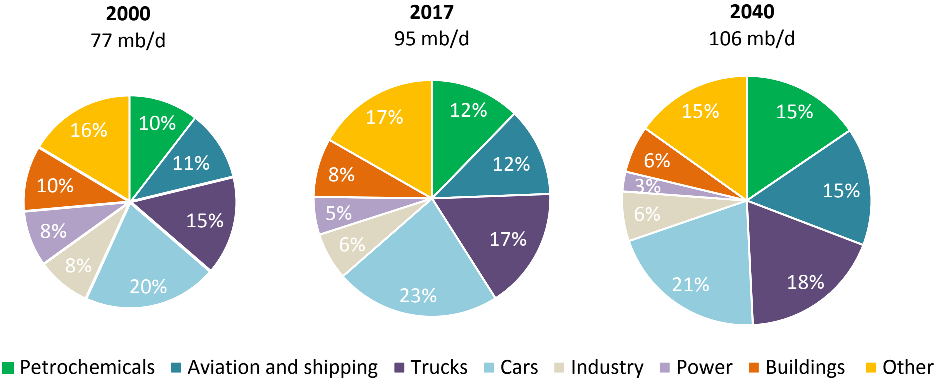
Total oil demand in **advanced economies** falls by over 10 mb/d over the period to 2040. The largest reductions are in road transport, with a 25% drop in North America, a 40% drop in advanced Asian economies and a 45% drop in the European Union. In total, road transport demand in advanced economies falls by over 6 mb/d between 2017 and 2040. In advanced economies, the only sectors to register any significant growth are aviation and shipping, which grow by 0.7 mb/d over the period to 2040.

In the European Union, a new target was set in 2018 to improve energy efficiency by 32.5% by 2030 (compared with a baseline projection of energy demand). New vehicle emissions standards have also been proposed to improve the performance of new cars, vans and heavy-duty vehicles from 2025. As a result, the projected drop in EU oil demand between 2017 and 2040 is 0.3 mb/d steeper than in the *WEO-2017*.

In the United States, improvements in vehicle fuel efficiencies after 2020 have been reviewed to reflect the announced revision to the Corporate Average Fuel Economy (CAFE) standards (see section 3.9). This increases US oil demand in cars in 2040 by 1.2 mb/d compared with the level in the *WEO-2017*.

3.3 Oil demand by sector

Figure 3.5 ▷ Global oil demand by sector in the New Policies Scenario



The share of petrochemicals, trucks, aviation and shipping in total oil demand grows from around one-third in 2000 to one-half by 2040

In the New Policies Scenario, oil use as a petrochemical feedstock grows by nearly 5 mb/d to 2040, the largest increase in any sector (Figure 3.5).[1] While there are increasing efforts to reduce single-use plastics and boost recycling rates, this is more than offset by population and economic growth and by the increasing use of plastics in place of other materials.

The average collection rate for plastic recycling worldwide rises from 15% today to 17% in 2040, mainly as a result of policies to encourage recycling in advanced economies. If average collection rates for recycling were to rise to 34% in 2040 (the level achieved in the Sustainable Development Scenario), this would reduce oil demand by 1.5 mb/d in 2040, but oil demand for petrochemicals would still increase by 3.3 mb/d.

Of the near 4 mb/d increase in oil demand in trucks globally, 40% occurs in India. Goods transport demand in India expands by a factor of four in the period to 2040, but the growth in oil demand is moderated by the new fuel-economy standards that entered into force this year (trucks are discussed in detail in section 3.9).

Oil use in cars in 2040 is only marginally higher than today despite an 80% expansion in the global car fleet to over 2 000 million vehicles. This comes about because of improvements in fuel efficiency, which avoid around 9 mb/d of oil demand in 2040, and because of the rise of alternative fuels (electricity, biofuels and natural gas), which avoid a further 7.5 mb/d in 2040. The number of electric cars on the road exceeds 40 million in 2025 and 300 million in 2040, with broadly equal shares of battery electric and plug-in hybrid vehicles. China leads the way in electric mobility: over 40% of the electric cars in the world are in China in 2040, as well as nearly 60% of the electric buses.

1. For a detailed discussion on petrochemicals, see IEA (2018a).

Oil demand in aviation increases by over 50% over the outlook period and approaches 10 mb/d in 2040. Demand in 2040 is 0.4 mb/d greater than in the *WEO-2017* because of a downward revision to the assumed rate of efficiency improvement of new planes. The energy efficiency of the aviation sector improves by 1.6% each year on average to 2040, slightly below the 2% aspirational goal of the International Civil Aviation Organization. Biofuels account for almost 5% of total fuel use in planes in 2040.

In shipping, the International Maritime Organization (IMO) regulation to limit the sulfur content of marine fuels to no more than 0.5% by 2020 leads to a 2 mb/d drop in high sulfur fuel oil (HSFO) consumption around this time. HSFO is initially replaced by marine gasoil.[2] This exerts upward pressure on diesel prices that slackens only as refiners develop new 0.5% sulfur bunker fuels (such as "very low sulfur fuel oil" made by blending HSFO and gasoil) and as the number of scrubber installations increases (see section 3.11). The share of HSFO in international marine bunker fuels drops from 75% today to less than 25% in 2040, all of which is used in ships equipped with scrubbers. The share of low sulfur fuel oil and marine gasoil grows to 60% in 2040. Use of liquefied natural gas (LNG) as an international bunker fuel also grows in importance, with consumption increasing to nearly 50 billion cubic metres (bcm) in 2040.

The IMO also announced a strategy to reduce greenhouse gas (GHG) emissions from the shipping sector by 50% by 2050 (compared with 2008 levels); this is not achieved in the New Policies Scenario since implementing measures are yet to be defined. This target is achieved in the Sustainable Development Scenario (see Chapter 2).

Oil has lost competitiveness as a fuel source in the industry sector in most regions. Today it provides just over 10% of total energy use in industry. Demand in industry edges up by 0.7 mb/d in the New Policies Scenario, but the share of oil in the sector falls steadily to 2040 in the face of greater growth in all other fuel sources.

Oil consumption in buildings in developing economies grows by 0.6 mb/d to 2040. This takes place mainly in India and sub-Saharan Africa as they switch away from the traditional use of biomass for cooking. However this growth is outweighed by a 1.8 mb/d decline in advanced economies, where oil is displaced by electricity and natural gas.

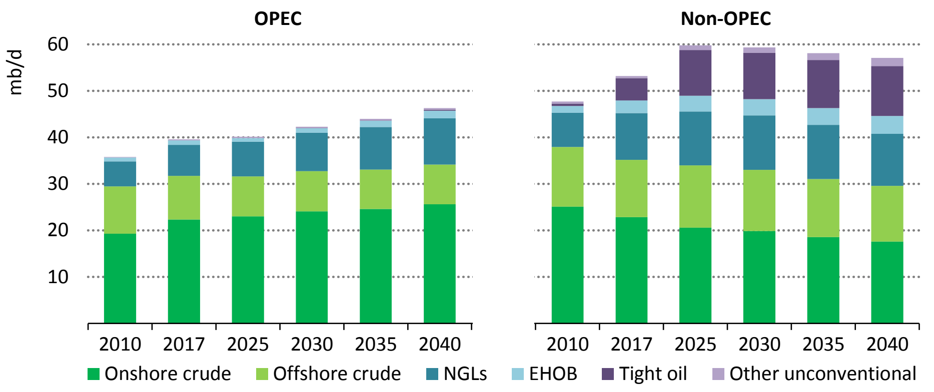
Nearly 5 mb/d of oil is consumed in the world's power sector today, of which almost 40% is in the Middle East. Oil use in the power sector falls across almost all regions and is generally replaced by natural gas and renewables. The decline is slower in the Middle East, where large volumes of low-cost (and often subsidised) oil are available and the region accounts for half of the 2.7 mb/d oil used for power in 2040.

Oil use in other sectors such as agriculture, petroleum refineries, oil extraction, transport modes such as trains, and some non-energy uses (e.g. asphalt, bitumen and lubricants) creeps up by just under 0.2 mb/d over the *outlook* period.

2. Marine gasoil is similar to diesel.

3.4 Oil supply by type

Figure 3.6 ▷ Oil production by type in the New Policies Scenario



NGLs and unconventional oil provide nearly half of non-OPEC oil supply in 2040

Note: NGLs = natural gas liquids; EHOB = extra-heavy oil and bitumen.

Global conventional crude oil production peaked in 2008 at 69 mb/d and has since fallen by just over 2.5 mb/d. In the New Policies Scenario, it drops by a further 3 mb/d by 2040 and its share in the global supply mix falls from 72% today to 62% in 2040 (Figure 3.6).

Onshore conventional crude oil production worldwide grows by less than 0.5 mb/d between 2017 and 2040. OPEC production grows by 5 mb/d but this is largely offset by Non-OPEC declines.

Offshore projects were often delayed or cancelled in the wake of the oil price crash in 2014. Revised designs were proposed that simplified, standardised and often downsized plans, and costs for new projects have fallen substantially. Project approvals are now picking up from a low ebb, but offshore conventional crude oil production remains around today's level of 27 mb/d to the mid-2020s.

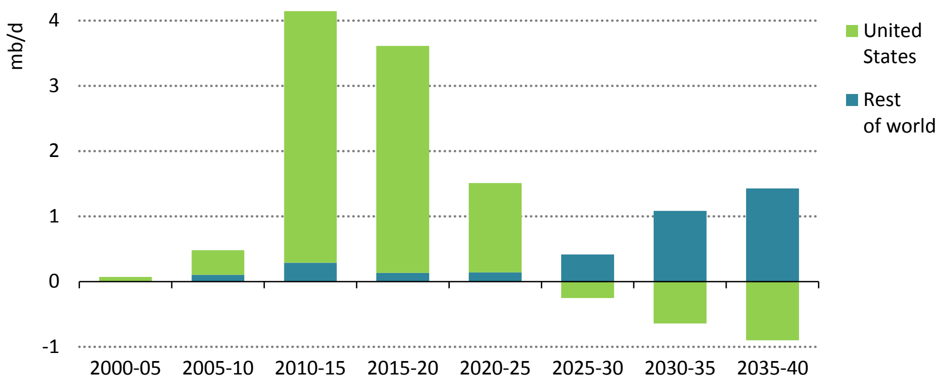
The offshore sector becomes increasingly reliant on production from deepwater fields to stem declines in more mature shallow water areas. Brazil is by far the largest source of future deepwater growth, nearly doubling its current output by 2040. There have also been a number of large deepwater discoveries in Guyana, whose giant Liza field is due to come online around 2020. Mexico successfully tendered a new round of exploration licenses in 2018 and this helps deepwater production growth in the long term. In total, the share of deepwater in total offshore production rises to 30% in 2040 (from 23% today). A number of projects on the Arctic shelf have begun production or been approved; these are relatively high-cost and output from the Arctic offshore reaches 0.4 mb/d in 2040.

Enhanced oil recovery (EOR) is being considered in an increasing number of countries as a means to reinvigorate production in mature basins. EOR production rises slowly to 2025 and then accelerates as investment opportunities dry up elsewhere. Total production more than doubles from today to reach 4.6 mb/d in 2040.

Natural gas liquids (NGLs) grow by nearly 2.5 mb/d to 2025 – a 15% increase in line with the increase in gas production. NGLs production continues to rise after this, but at a slower pace, reflecting a shift towards the development of drier gas resources.

Tight oil production in the United States more than doubles to 9.2 mb/d by 2025 as infrastructure constraints in the Permian Basin are gradually resolved. Thereafter, as the core areas within plays are depleted, production reaches a plateau in the mid-2020s and eventually falls by 1.5 mb/d during the 2030s (Figure 3.7). Tight oil resources have been increased by 10% to 116 billion barrels in this year's *Outlook*, and production in 2025 is around 0.9 mb/d higher than in the *WEO-2017.*

Figure 3.7 ▷ Change in tight oil production in the New Policies Scenario



The United States dominates tight oil production until the mid-2020s, when resource constraints hold back further expansion and output elsewhere starts to ramp up

Tight oil growth outside the United States ramps up after 2025. Most of this occurs in Argentina, Russia, Canada and Mexico, but there are also increases in Australia, China and the United Arab Emirates, which all hold good tight oil resource potential. There is more than 3.5 mb/d of tight oil production from areas outside the United States in 2040.

Extra-heavy oil and bitumen (EHOB) production rises by 2 mb/d in the period to 2040. Multiple new projects approved before the drop in oil prices come on stream in Canada, where EHOB production increases around 0.7 mb/d by 2025. Production growth then slows markedly until a new wave of in-situ projects come online in the 2030s. No new greenfield mining projects are commissioned. Extra-heavy oil production in Venezuela has proved more resilient than other sources of production; while it is not immune from the economic and political issues engulfing the country, it can provide the basis for a long-term recovery in output.

3.5 Oil supply by region

Table 3.3 ▷ Non-OPEC oil production in the New Policies Scenario (mb/d)

							2017-2040	
	2000	2017	2025	2030	2035	2040	Change	CAAGR
North America	14.2	20.3	26.2	26.3	26.1	25.3	5.0	1.0%
Canada	2.7	4.9	5.6	5.7	5.9	6.0	1.1	0.9%
Mexico	3.5	2.2	2.1	2.4	2.7	3.1	0.9	1.5%
United States	8.0	13.2	18.5	18.3	17.5	16.2	3.0	0.9%
Central and South America	3.2	4.6	5.4	5.9	6.5	7.1	2.5	1.9%
Argentina	0.9	0.6	0.6	0.7	0.9	1.2	0.6	3.2%
Brazil	1.3	2.7	3.7	4.3	4.8	5.2	2.4	2.8%
Europe	7.1	3.7	4.0	3.5	3.1	2.8	-0.9	-1.2%
Norway	3.3	2.0	2.5	2.2	1.9	1.8	-0.2	-0.5%
Africa	1.2	1.4	1.4	1.5	1.4	1.3	-0.1	-0.3%
Middle East	2.2	1.2	1.2	1.2	1.2	1.2	-0.1	-0.3%
Eurasia	7.9	14.3	14.6	14.2	13.3	12.6	-1.6	-0.5%
Kazakhstan	0.7	1.8	2.1	2.4	2.5	2.5	0.6	1.3%
Russia	6.5	11.4	11.5	10.9	10.0	9.4	-2.0	-0.8%
Asia Pacific	7.8	7.7	7.0	6.7	6.6	6.8	-0.9	-0.6%
China	3.2	3.9	3.3	3.2	3.1	3.1	-0.7	-0.9%
India	0.8	0.9	0.9	0.9	0.9	0.9	0.0	0.2%
Conventional crude oil	36.4	35.2	34.0	33.0	31.0	29.6	-5.6	-0.7%
Tight oil	-	4.8	9.8	10.0	10.4	10.8	5.9	3.6%
United States	-	4.4	9.2	8.9	8.3	7.4	3.0	2.3%
Natural gas liquids	6.1	10.0	11.6	11.7	11.6	11.2	1.1	0.5%
Canada oil sands	0.6	2.7	3.4	3.5	3.6	3.8	1.1	1.5%
Other production	0.4	0.5	1.0	1.2	1.5	1.7	1.3	5.9%
Total non-OPEC	**43.6**	**53.2**	**59.8**	**59.3**	**58.1**	**57.1**	**3.9**	**0.3%**
Non-OPEC share	*58%*	*57%*	*60%*	*58%*	*57%*	*55%*	*-2%*	*n.a.*
Current Policies			61.3	62.5	63.5	64.2	11.0	0.8%
Sustainable Development			54.7	49.0	42.7	38.1	-15.1	-1.4%

Notes: CAAGR = Compound average annual growth rate. See Annex C for definitions.

The United States provides around 75% of the global increase in production to 2025 in the New Policies Scenario and there is also pronounced growth in Brazil and Canada (Table 3.3). As a result, non-OPEC's share in global oil production rises to 60% by 2025. However, US tight oil plateaus after 2025 and the baton gradually passes to OPEC to meet continued (albeit slowing) growth in global oil demand. A number of OPEC members are currently facing adverse political and security environments that are affecting production and investment levels: our projections assume a gradual improvement in these areas over time.

Table 3.4 ▷ OPEC oil production in the New Policies Scenario (mb/d)

							2017-2040	
	2000	2017	2025	2030	2035	2040	Change	CAAGR
Middle East	21.3	30.0	31.6	33.6	34.6	36.1	6.0	0.8%
Iran	3.8	4.7	4.8	5.2	5.4	5.5	0.8	0.7%
Iraq	2.6	4.6	5.1	5.6	6.1	6.8	2.3	1.8%
Kuwait	2.2	3.0	3.4	3.5	3.5	3.4	0.4	0.6%
Qatar	0.9	2.0	2.2	2.4	2.5	2.6	0.6	1.1%
Saudi Arabia	9.3	12.0	12.2	12.7	12.9	13.3	1.3	0.4%
United Arab Emirates	2.6	3.8	3.9	4.1	4.2	4.4	0.6	0.7%
Non-Middle East	10.3	9.5	8.5	8.7	9.4	10.2	0.7	0.3%
Algeria	1.4	1.5	1.4	1.4	1.3	1.3	-0.2	-0.6%
Angola	0.7	1.7	1.4	1.4	1.5	1.5	-0.2	-0.6%
Congo	0.3	0.3	0.3	0.2	0.2	0.1	-0.1	-2.8%
Ecuador	0.4	0.5	0.4	0.4	0.4	0.3	-0.2	-2.1%
Equatorial Guinea	0.1	0.2	0.1	0.1	0.1	0.1	-0.1	-4.5%
Gabon	0.3	0.2	0.2	0.1	0.1	0.1	-0.1	-2.7%
Libya	1.5	0.9	1.2	1.2	1.4	1.6	0.8	2.8%
Nigeria	2.2	2.0	2.1	2.2	2.4	2.6	0.7	1.3%
Venezuela	3.4	2.2	1.5	1.7	2.1	2.5	0.3	0.5%
Conventional crude oil	28.4	31.7	31.6	32.7	33.1	34.2	2.4	0.3%
Natural gas liquids	2.8	6.6	7.4	8.2	9.1	9.9	3.2	1.7%
Venezuela extra-heavy oil	0.4	1.0	0.8	1.0	1.3	1.7	0.7	2.4%
Other production	0.1	0.3	0.3	0.3	0.4	0.6	0.3	3.5%
Total OPEC	**31.6**	**39.6**	**40.1**	**42.3**	**44.0**	**46.3**	**6.7**	**0.7%**
OPEC share	*42%*	*43%*	*40%*	*42%*	*43%*	*45%*	*2%*	*n.a.*
Current Policies			41.6	45.2	48.6	53.0	13.4	1.3%
Sustainable Development			36.8	35.8	32.5	29.9	-9.7	-1.2%

Notes: CAAGR = Compound average annual growth rate. See Annex C for definitions.

In the **United States**, tight oil accounts for a third of total US oil production today. This grows to 50% over the next five years. Costs for new deepwater projects have fallen substantially and there has been an uptick in interest in new projects in the Gulf of Mexico. Offshore US production nevertheless falls as new developments are not sufficient to offset declines from existing sources of production.

Mexico has recently seen an acceleration in field declines. It will take time for new projects, launched as a result of recent licensing rounds, to bear fruit. Production falls to a low of just over 2 mb/d in the early 2020s, before increases are led first by shallow offshore fields and then by deepwater projects, EOR and tight oil.

Canada and **Brazil** follow a similar pattern to 2025. A number of major unconventional and ultra-deepwater projects were sanctioned in these countries prior to the oil price crash. These projects have long lead times and production from them continues to rise in the coming years. However after 2025 the rate of production growth in these countries stalls given the severe drop in new project approvals since 2015.

Production in **Norway** increases to 2025 as the giant Johan Sverdrup field more than offsets declines elsewhere. In the longer term, despite some projected growth from the Arctic, production falls to 1.8 mb/d in 2040.

Companies in **Russia** have weathered the storm since 2014 relatively well, helped by the impact of a lower rouble on production costs. The Vienna Agreement constrained output somewhat in 2017, but near-term prospects look strong. Over the longer term, the difficulty to bring on more remote (e.g. Arctic) or hard-to-develop resources (e.g. tight oil), especially if sanctions are maintained, pushes projected output into gradual decline.

There are plans to resume production from the Neutral Zone, held jointly by Saudi Arabia and Kuwait, in 2019: this would help compensate for underlying declines in other mature basins. As reliance on the **Middle East** increases in the second-half of the outlook period, production from Saudi Arabia rises by over 1 mb/d after 2025. NGLs contribute nearly 70% of the increase in production as new gas projects such as the Karan field come online.

Iraq has increased production by more than 2 mb/d since 2009, largely because of investments from international companies in existing fields. Investment has fallen back in recent years and the Iraqi authorities have sought to adjust contract terms to speed up development. Our projected growth in Iraq is slower than the official capacity target of 6.5 mb/d by 2022: this level of output is reached in the 2030s in the New Policies Scenario.

Prospects for oil production in Iran have worsened since the recent re-imposition of US sanctions targeting oil exports and foreign investment. We have adjusted downwards our projection of major new investments that could raise long-term capacity in Iran. Production growth to 2025 is muted and production in 2025 is 0.3 mb/d lower than in last year's *Outlook*.

Bahrain recently discovered a low permeability offshore oil field with 80 billion barrels of oil in place. There are likely to be many technical hurdles to overcome and pending appraisal we are cautious at this point, but this represents considerable upside potential for Bahrain from today's production level of 0.2 mb/d. Many producers, even in resource-rich areas, are facing the need to go after more challenging fields.

It has been over a decade since **Nigeria** conducted bidding rounds for new offshore licences and production has fallen by over 0.5 mb/d since its peak in 2010. Our outlook sees a continuation of this decline over the next five years but there is an uptick in investment from the mid-2020s, leading to steady growth in both onshore and deepwater areas during the 2030s.

3.6 Refining and oil product demand

Table 3.5 ▷ World liquids demand in the New Policies Scenario (mb/d)

	2017	2025	2030	2035	2040	Change 2017-40
Total liquids	**96.6**	**105.2**	**107.7**	**108.9**	**110.9**	**14.3**
Biofuels	1.8	2.8	3.4	4.0	4.7	2.8
Total oil	94.8	102.4	104.3	104.9	106.3	11.5
CTL, GTL and additives	0.7	1.3	1.4	1.7	2.0	1.3
Direct use of crude oil	1.0	0.6	0.4	0.3	0.2	-0.8
Oil products	93.1	100.6	102.4	102.9	104.1	11.0
LPG and ethane	11.3	14.0	14.4	14.8	15.1	3.9
Naphtha	5.8	7.3	8.0	8.6	9.2	3.5
Gasoline	24.1	25.4	25.4	24.5	23.8	-0.3
Kerosene	7.3	8.0	8.6	9.4	10.3	3.0
Diesel	27.4	29.9	29.9	29.9	30.2	2.8
Fuel oil	7.1	6.4	6.4	6.4	6.4	-0.7
Other products	10.3	9.7	9.6	9.3	9.1	-1.2
Fractionation products from NGLs	9.9	12.0	12.3	12.6	12.5	2.6
Refinery products	83.2	88.6	90.1	90.2	91.6	8.4
Refinery market share	*86%*	*84%*	*84%*	*83%*	*83%*	*n.a.*

Notes: CTL = coal-to-liquids; GTL = gas-to-liquids; NGLs = natural gas liquids; LPG = liquefied petroleum gas; n.a. = not applicable. See Annex C for definitions.

Demand for petrochemical feedstocks (ethane, liquefied petroleum gas [LPG] and naphtha) and for kerosene increases by 1.6% per year to 2040. This is almost three-times the rate of growth in total liquids demand. In contrast, gasoline demand peaks in the late-2020s. There is also a sharp downturn in fuel oil use around 2020 as the IMO sulfur regulation comes into force. These changes lead to a shift in the composition of demand towards lighter products in the New Policies Scenario, a move that is amplified in the Sustainable Development Scenario (see section 3.11).

The New Policies Scenario sees robust growth of biofuels and products fractionated from NGLs. These liquids bypass the refining sector, so the increase in demand for refinery products (8.4 mb/d) is 40% lower than demand growth for total liquids (Table 3.5). To add to the pressure on refiners, a wave of 17 mb/d of new refining capacity (a 13 mb/d net increase) comes online in the period to 2040, almost entirely in the east of Suez region (Asia Pacific and the Middle East). Since new refineries in general are more efficient than older ones, and since they tend to benefit from either low-cost feedstock or demand growth in adjacent markets, this results in a gradual reshuffling of the competitive landscape of the refining industry.

Table 3.6 ▷ Refining capacity and runs by region in the New Policies Scenario (mb/d)

	Refining capacity			Refinery runs			Capacity at risk
	2017	2025	2040	2017	2025	2040	2040
North America	22.5	23.1	22.1	19.3	18.8	17.3	3.0
Europe	16.2	16.0	14.9	13.8	12.3	9.7	5.1
Asia Pacific	34.0	38.8	42.3	28.5	31.3	35.3	3.4
Japan and Korea	6.7	6.5	5.9	6.3	5.4	4.5	1.6
China	15.3	18.0	18.2	11.3	13.0	14.2	1.7
India	4.8	5.7	7.8	5.0	5.6	7.5	-
Southeast Asia	4.9	6.2	7.8	4.1	5.3	6.9	-
Middle East	9.0	11.4	13.0	7.5	9.9	11.7	-
Russia	6.6	6.8	6.6	5.7	5.4	4.6	1.5
Africa	3.4	4.3	5.1	1.8	3.3	4.4	0.1
Brazil	2.2	2.2	2.5	1.7	2.0	2.3	-
Other	4.8	5.0	5.0	2.9	3.3	3.5	1.0
World	**98.6**	**107.4**	**111.4**	**81.2**	**86.1**	**88.6**	**14.2**
Atlantic Basin	55.1	56.8	55.6	44.9	44.5	41.2	10.7
East of Suez	43.5	50.7	55.8	36.3	41.6	47.4	3.4

Notes: "Capacity at risk" is defined as the difference between refining capacity and refinery runs, with the latter including a 14% allowance for downtime. Projected shutdowns beyond those publicly announced are also counted as "capacity at risk".

Today, refinery outputs from the east of Suez region are smaller than those from the traditional refining centres in advanced economies. This situation is reversed by the late-2020s. Refinery runs in the Middle East overtake those in Europe around 2030. By 2040, China's refinery runs approach the level of those in the United States (today's largest refining centre) and India becomes the third-largest refining centre in the world. As a result, refining activity in the east of Suez region is 15% higher than in the Atlantic Basin in 2040. (Table 3.6).

Almost all new refining capacities under development today integrate some petrochemical processes (IEA, 2018b). This appears to be part of a long-term strategy both to seek additional margins and to hedge against the perceived risk of a peak in global oil demand (since demand for petrochemical feedstock is likely to increase even if total oil demand peaks). This trend continues in the New Policies Scenario, bringing the refining and petrochemical industries closer together than ever before.

This challenge for the refining industry in the New Policies Scenario is increased in the Sustainable Development Scenario, in which refinery outputs in 2040 are some 35% lower than in the New Policies Scenario (see section 3.11).

3.7 Trade[3]

Table 3.7 ▹ Oil trade by region in the New Policies Scenario

Net importer in 2040	Net imports (mb/d)				As a share of demand			
	2000	2017	2025	2040	2000	2017	2025	2040
China	1.7	8.9	12.2	13.3	34%	69%	77%	79%
Other Asia Pacific	2.1	5.5	7.6	10.2	40%	67%	77%	84%
India	1.5	3.4	5.4	8.4	65%	74%	84%	88%
European Union	10.7	11.0	10.3	7.5	73%	85%	86%	88%
Japan and Korea	7.3	6.2	5.9	4.5	97%	95%	97%	96%
Rest of world	-1.4	1.1	0.5	0.8	n.a.	30%	14%	21%
Net exporter in 2040	**Net exports (mb/d)**				**As a share of production**			
	2000	2017	2025	2040	2000	2017	2025	2040
Middle East	18.9	23.1	23.6	25.8	80%	74%	71%	69%
Russia	3.9	8.2	7.9	5.9	59%	71%	69%	62%
North America	-9.7	-2.3	4.1	5.6	n.a.	n.a.	15%	22%
Central and South America	2.4	1.1	1.0	3.1	33%	15%	13%	31%
Caspian	0.8	2.2	2.2	2.2	59%	74%	72%	68%
Africa	5.3	4.0	3.0	2.1	68%	48%	37%	23%

Note: n.a. = not applicable.

Robust demand growth in developing economies in Asia leads to mounting import needs; total net import requirements expand by 80% in the period to 2040. China becomes not only the largest net oil importer in the world by 2040, but also the largest net oil importer in the history of oil markets.

India's import needs grow by two-and-a-half times during the outlook period, surpassing those of the European Union in the late 2030s. Declining demand in advanced economies leads to a further shift in global oil trade flows towards Asia (Table 3.7).

The Middle East remains the world's largest oil exporter by a wide margin. Crude oil exports represent the majority of its exports today, and although production increases by 6 mb/d between 2017 and 2040, this is matched by a 2 mb/d increase in oil use for petrochemical feedstocks and a 4 mb/d increase in refining activity. The bulk of future export growth therefore comes from oil products rather than crude oil.

Increases in tight oil production lead the United States to become a net oil exporter in the early 2020s. As a result, North America becomes the world's third-largest oil exporting region by 2040. Robust production growth in Brazil increases Central and South America's net exports after 2025. Russia's net exports decline steadily as a result of waning production.

3. Unless otherwise stated, trade figures in this chapter reflect volumes traded between regions modelled in the *WEO*, and therefore they do not include intra-regional trade.

3.8 Investment

Table 3.8 ▷ Cumulative oil and natural gas supply investment by region in the New Policies Scenario, 2018-2040 ($2017 billion)

	Total oil and gas	Upstream oil and gas	Transport		Refining oil	Annual average upstream oil and gas
			Oil	Gas		
North America	5 258	4 295	163	666	134	187
Central and South America	1 875	1 609	102	120	44	70
Europe	1 758	1 270	25	375	89	55
Africa	2 033	1 703	80	185	66	74
Middle East	2 989	2 283	205	317	184	99
Eurasia	2 716	2 273	57	334	53	99
Asia Pacific	3 651	2 296	85	822	448	100
Shipping	427	n.a.	299	128	n.a.	n.a.
World	**20 708**	**15 730**	**1 015**	**2 946**	**1 017**	**684**
Current Policies	25 316	19 520	1 348	3 172	1 277	849
Sustainable Development	13 455	9 824	452	2 531	649	427

Note: n.a. = not applicable.

In the New Policies Scenario, upstream oil and gas spending rises from $450 billion in 2017 to an annual average of $580 billion between 2018 and 2025 and $740 billion between 2025 and 2040. The upstream investment required between 2018 and 2040 is around 5% larger than in the *WEO-2017* ($640 billion per year). In total, nearly $10 trillion investment in upstream oil projects is required to 2040. If this level of investment does not materialise, there would be a real risk of a mismatch between supply and demand, especially in the medium term (see section 3.10).

Global average upstream costs for conventional crude oil projects fell by about 30% between 2014 and 2017, and are expected to increase only modestly in 2018 (IEA, 2018b). Some of these reductions are assumed to be structural: together with continued technological innovation, these help keep costs down. As oil demand and prices rise, however, unit costs increase and projects become more complex and less productive. In the New Policies Scenario, the average capital cost of executing a project in 2025 remains below the 2014 level, but it is 30% higher than today.

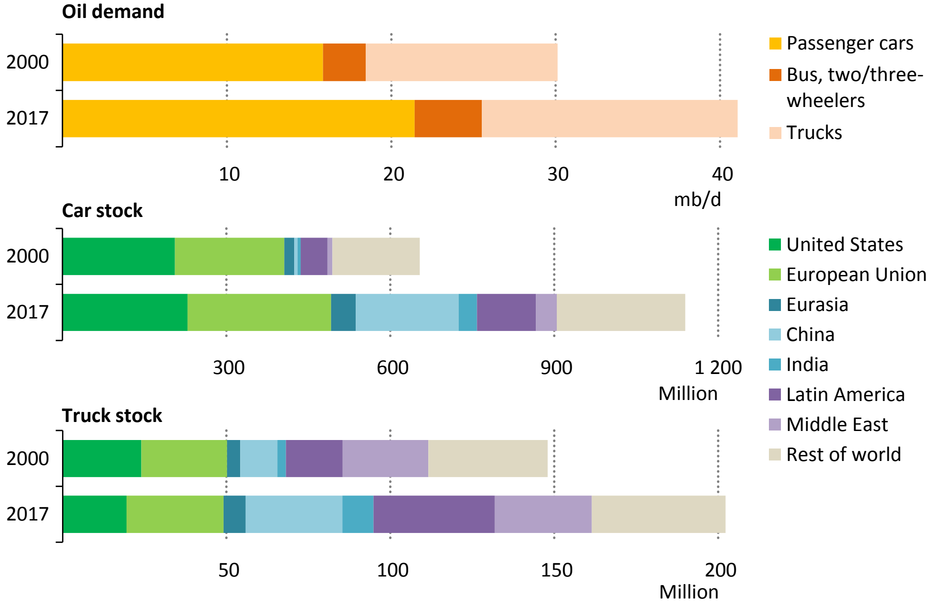
In the Sustainable Development Scenario, fewer new developments are required and there is less need to develop projects at the top of the supply cost curve. Lower demand and prices also lead to lower unit costs for supplies and services and to even greater incentives for companies to maintain strict control over budgets and project execution. The result is average annual upstream oil and gas investment in the Sustainable Development Scenario of nearly $430 billion between 2018 and 2040 (Table 3.8). This is 40% lower than in the New Policies Scenario, but only marginally lower than the amount spent in 2017.

Key themes

3.9 Will road transport remain the stronghold of oil demand?

Nearly 90% of the cars, trucks, motorbikes and buses on the road today rely on engines fuelled by oil. Road transport is responsible for 44% of consumption globally: by far the largest single component of global oil demand. Despite the attention paid to alternative modes of road transport in recent years, oil demand in road transport has grown by around 11 mb/d since 2000, the largest increase in any sector over this period. Around half of this increase came from cars, nearly 40% from road freight and the remainder from two/three-wheelers and buses (Figure 3.8). Yet this increase would have been even bigger were it not for the use of alternative fuels such as biofuels, which avoided a further 2.5 mb/d increase in oil demand, and the proliferation of energy efficiency improvements, which avoided another 1.2 mb/d.[4]

Figure 3.8 ▷ Oil demand by road vehicles, and car and truck fleets by region



Cars are responsible for half of the increase in global road transport oil demand since 2000, reflecting a large increase in the number of cars in developing economies

4. A review of current policies and the outlook for energy efficiency and biofuel deployment is presented in Chapter 6. Part B discusses the current state of play and future deployment of electric road vehicles.

This battle between efficiency, technological innovation and the rise of alternative fuels on the one hand, and economic and population growth on the other, is central to the future of oil demand in road transport, and, by extension, the future of global oil demand. In this section we unpick the causes of oil demand growth in road transport and look in detail at the outlook for demand in cars and trucks in the New Policies Scenario.

What drives road transport oil demand?

When modelling the outlook for road transport demand it is helpful to consider separately cars (passenger cars, sport-utility vehicles, crossovers and pick-ups), trucks (light commercial vehicles, medium-duty trucks and heavy-duty trucks) and other passenger transport modes (motorbikes, tuk-tuks and buses). For cars, the two key demand factors are the number of cars on the road and the distances that they are driven (usually combined into a single activity metric called "vehicle kilometres"). Growth in both of these is a function of growth in gross domestic product (GDP) and population, fuel prices, population density, urban population and public transport policies. For trucks, the increase in freight activity (usually given in "tonne-kilometres") is related to GDP growth and domestic industrial output.

New mobility services such as car leasing, ride sharing and hailing, as well as the application of new technologies such as platooning, automation and connected vehicles, will all likely have a major impact on mobility. But this is subject to a huge degree of uncertainty. They could lead to increased vehicle occupancy, optimised routes and congestion reduction, but they could just as easily lead to the opposite.[5]

How road transport demand translates into oil demand depends on the types of vehicles used and the amount of fuel they consume. There is wide geographic variation in this, with distinctions caused partly by different consumer preferences, partly by variations in fuel taxes and partly by differing fuel-economy policies, emissions standards and levels of support for alternative fuels. Biofuels and electric vehicles have enjoyed the most policy support in the past, but LPG and compressed natural gas (CNG) have also been promoted in some countries to encourage fuel diversification and to reduce local air pollution.

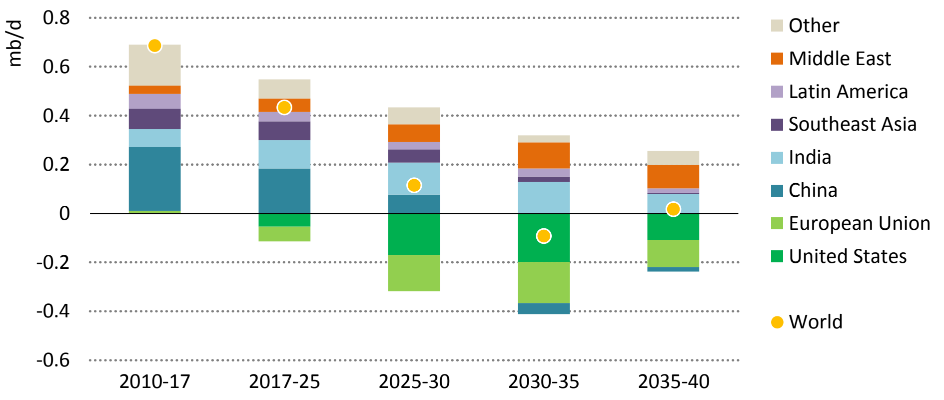
In the New Policies Scenario, the increase in oil demand for road transport (cars, trucks and other modes) slows markedly from the growth rates observed historically. The average annual increase of 0.6 mb/d between 2000 and 2017 drops to 0.4 mb/d to 2025 and then scarcely grows for the 15 years after that. The increase to 2025 is mainly caused by growth in demand in emerging economies in Asia, offset slightly by decreases in demand in the United States and the European Union as a result of energy efficiency improvements and fuel switching away from oil (Figure 3.9).

After 2025, efficiency measures and alternative fuels continue to supress demand in advanced economies, and growth slows in developing economies. This is particularly the case

5. See the forthcoming IEA publication, *Automated, Connected, Electric and Shared Vehicles* (2019).

in China, where oil demand in road transport falls after 2030 in response to its major push for energy efficiency, and plug-in hybrid and battery electric vehicles. There is a slight uptick in total road transport demand after 2035 as there is a slowdown in the rate of reductions in advanced economies and sustained growth in India, the Middle East and Africa.

Figure 3.9 ▹ Average annual change in road transport oil demand by region in the New Policies Scenario



Oil demand from road transport increases steadily in the mid-term, mainly in emerging economies in Asia, but growth levels off as efficiency measures increasingly take hold

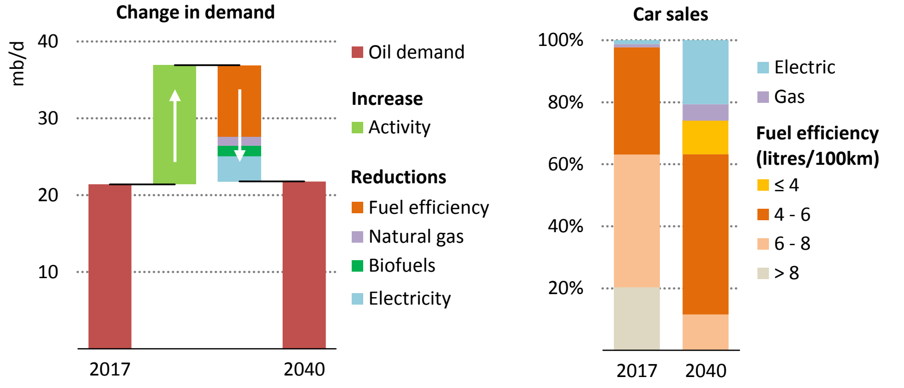
A closer look at cars in the New Policies Scenario

Some 500 million cars joined the global car fleet between 2000 and 2017. Three-quarters of these were added in developing economies, and nearly 40% were added in China alone. Today there are around 1 100 million cars on the road, nearly all fuelled by oil: electric cars account for 1% of current annual car sales and represent less than 0.3% of the global car fleet.

In the New Policies Scenario, the global car fleet grows by 80% by 2040 as the world's population becomes larger and wealthier. Every year around 40 million new cars are added to the global total: China and India account for more than 60% of these. Yet global oil demand for passenger cars barely changes, from 21.4 mb/d today to just over 23 mb/d in the late 2020s and then back to just above today's level by 2040.

Improvements in fuel efficiency of the global car fleet are the single largest contributor to moderating oil demand growth in cars in the New Policies Scenario. These measures avoid around 9 mb/d of oil demand in 2040 (Figure 3.10). A significant portion of these savings do not depend on any major technological breakthroughs. For example, bringing the fuel efficiency of the global car fleet in line with that of cars in the European Union today (7.3 litres/100 km) would reduce global oil consumption by almost 6 mb/d.

Figure 3.10 ▷ Oil demand from cars, oil displacement and car sales globally in the New Policies Scenario



Energy efficiency is the key mechanism that curbs oil consumption in cars. By 2040 there are no cars sold that have an efficiency worse than 6.5 litres/100 km.

Notes: Fuel efficiency refers to the efficiency of oil-fuelled cars only. Displacement in 2017: biofuels = 1.2 mb/d; natural gas = 0.5 mb/d; electricity = 0.05 mb/d.

One change in efficiency policies that has an impact on our oil outlook comes from the United States. Between 2009 and 2014, a combination of the CAFE standards and high oil prices led to an annual improvement in the average fuel efficiency of new cars sold in the United States of around 1.6%. Since the drop in the oil price in 2014, however, there has been a rise in the number of sport-utility vehicles sold and improvements in the average fuel efficiency of new cars have stagnated. In August 2018, the United States Environmental Protection Agency announced that fuel-economy and GHG emissions standards for cars and light trucks for the period 2021 to 2026 would be revised. The effect of this change is to slow the rate of improvement in fuel efficiency post-2020. As a result, oil demand for cars and light trucks in the United States in 2040 is 1.2 mb/d higher than in the *WEO-2017*.

Besides efficiency measures, biofuels offset 2.5 mb/d of oil demand in 2040 while natural gas offsets 1.6 mb/d oil demand. The 300 million electric cars on the road in 2040 displace around 3.3 mb/d of oil demand. The volume of oil avoided by electric cars is not just a function of whether they are plug-in hybrid or battery electric (of the 300 million electric cars in 2040, there are broadly equal proportions of plug-in hybrid and battery electric cars), but also of the cars they are assumed to replace. Replacing a more efficient car will displace less oil than one which is not as efficient, and this assumption varies by region and over time. In 2040, the average gasoline car is around 30% more efficient than today, which means that adding an electric car in 2040 leads to less of a reduction in oil demand than putting an extra electric car on the road today. Electric cars may also replace other non-oil based vehicles such as CNG vehicles. We estimate that 100 million electric cars in 2017 would displace around 1.7 mb/d oil demand, but the same number of electric cars in 2040 would displace around 1.1 mb/d.

A closer look at trucks in the New Policies Scenario

Trucks have been one of the main sources of oil consumption growth in recent years, with demand up by around 4 mb/d between 2000 and 2017. The vast majority of this increase has come from developing economies (a quarter of the increase came from China alone). Today trucks are the second-largest oil-consuming sector after cars, with total consumption in 2017 of almost 16 mb/d.

Translating freight activity into oil demand depends on how activity is split between light commercial vehicles, medium-duty trucks and heavy-duty trucks.[6] This in turn depends on the logistical operations required in the supply chains of different goods. Some deliveries can only be made by lighter vehicles and these have higher oil use per tonne-kilometre than heavy-duty trucks. For example, light commercial vehicles currently provide only 5% of the tonne-kilometres served by trucks, but are responsible for nearly 25% of total oil use for trucks. In contrast, heavy-duty trucks provide nearly 65% of goods transport on land but account for less than 50% of the sector's oil consumption.

In the coming years, the continued expansion of online commerce is expected to boost the amount of goods transportation undertaken by lighter vehicles, but it could also enable optimisation of routes from centralised warehouses to delivery points. Maximising vehicle utilisation is key to reducing oil consumption: options currently being explored include cross-company collaboration at warehouses, backhauling (delivering cargo on return trips) and co-loading (bundling shipments across different product categories).

In the New Policies Scenario, global road freight activity grows by 3.1% per year, with China, India and the United States accounting for nearly half of the increase.[7] In contrast to the outlook for cars, oil demand in trucks grows by 4 mb/d in the period to 2040 and is a key source of total oil demand growth in the New Policies Scenario (Figure 3.11).

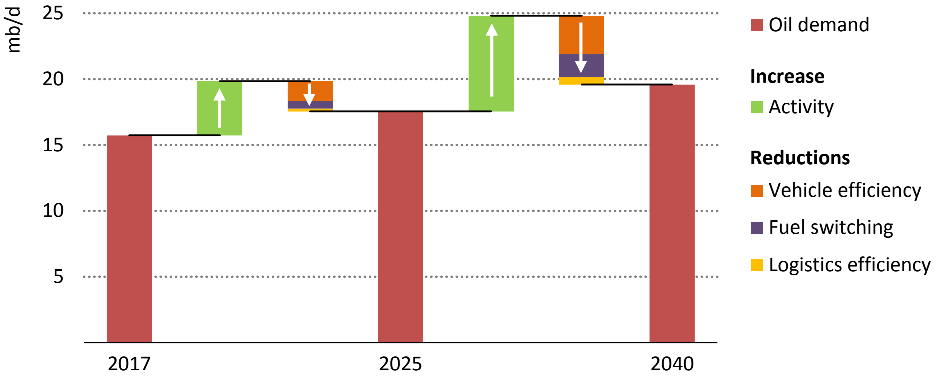
This increase would be much larger were it not for improvements in vehicle and logistics efficiency. These bring a major divergence in trends between freight activity on the one hand and oil demand on the other. For example, in advanced economies, freight activity grows by 2.1% on average each year, yet oil demand falls annually by 0.5%. This divergence is less apparent in developing economies, but there are a number of fuel-economy standards that prevent even higher growth in oil demand (e.g. recent fuel-economy standards for heavy-duty trucks in India). In total, improvements in vehicle and logistics efficiency avoid nearly 5.5 mb/d oil demand growth in 2040. There are 300 000 LNG-fuelled trucks on the road in China today and the use of natural gas grows throughout the New Policies Scenario, especially in China and the United States. The use of biofuels for trucks avoids 1.2 mb/d of

6. Light-duty trucks are vehicles with total weight lower than 3.5 tonnes, medium-duty trucks weigh between 3.5 tonnes and 16 tonnes and heavy-duty trucks weigh more than 16 tonnes.

7. Growth in the transport of goods is assumed to be constant across all scenarios modelled in this *Outlook*.

oil demand in 2040, natural gas displaces more than 1.1 mb/d of oil demand, while electric trucks avoid 0.6 mb/d.

Figure 3.11 ▷ Oil demand from trucks and oil displacement globally in the New Policies Scenario



Efficiency is instrumental in curbing the increase in oil demand for goods transportation alongside improvements in logistics and fuel switching

Note: Displacement in 2017: biofuels = 0.6 mb/d; natural gas = 0.2 mb/d.

Conclusion

Road transport remains a major consumer of oil through to 2040 and beyond but it is no longer a primary cause of demand growth in the New Policies Scenario. One reason is the rise in electrification and the digitalization of mobility services. But the more significant factor is the increase in vehicle and logistics efficiency for both cars and trucks. In total, these avoid almost 15 mb/d additional oil demand in 2040. While many of these efficiency improvements do not depend on major technological breakthroughs, they are contingent on continued policies supporting fuel-economy and emissions standards. In this area, as in others, government actions will be pivotal in determining the pathway that the world follows.

3.10 Crunching the numbers: are we heading for an oil supply shock?

In all *WEO-2018* scenarios, new sources of oil supply steadily come online at the right time to meet changes in oil demand and to keep the system in equilibrium. This smooth matching of supply and demand minimises oil price volatility and would likely be a desirable outcome for many of the world's oil consumers; it could also be better in the long run for many of the world's producers (IEA, 2018c). Yet it does not reflect the way that commodity markets often work in practice. A case where new upstream oil investments do not materialise in a timely manner and the oil price is forced ever higher to avoid a mismatch between supply and demand cannot be ruled out.

In the light of the dramatic drop in new upstream projects approved after the oil price drop in 2014 the *WEO-2016* explored the risks and implications of a future mismatch between supply and demand. We now have two more years of data on US tight oil production, on costs and project approvals elsewhere and a considerably higher starting number for global oil demand. We therefore revisit the issue: can a future oil supply "crunch" now be safely ruled out? Or are we facing an imminent risk of a rocky ride for oil markets in the coming years?

To answer these questions, we look at how oil from currently producing sources can be expected to decline in the future; we assess changes in global demand; and we examine the various ways that any gaps between supply and demand could be filled by new sources of production.

Decline rates

Many different decline rates are discussed in the context of conventional crude oil production, but some are much more useful than others when estimating how production from currently producing fields will evolve in the future. Here we explain the differences between these rates, how they can be interpreted, and what they tell us about future production prospects.[8]

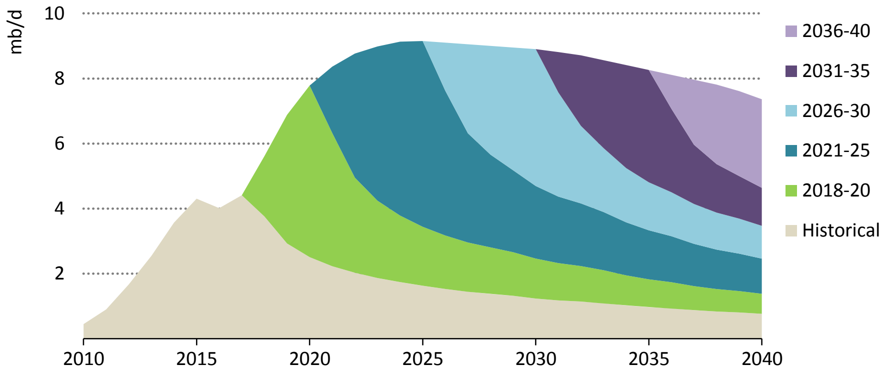
Decline rates vary depending on the location and type of oil in question. At one end of the spectrum is extra-heavy oil and bitumen. There is typically a slow ramp-up to maximum production – for example, projects in Canada approved since 2005 have taken between four and ten years after receiving development consent – but little decline in production after this until the project reaches the end of its lifetime and is shut down. At the opposite end of the spectrum is tight oil. Here there is typically a short gap between approval and maximum production, but a very rapid decline thereafter (Box 3.1). Lying between these two extremes is conventional crude oil production.

Box 3.1 ▷ Declines in tight oil production

Production from tight oil wells is characterised by an initial peak in production, followed by a sharp decline and then a long tail of low level production. New tight oil wells must therefore be drilled continuously to maintain or increase production. Nearly 70% of the 8 500 tight oil wells completed in 2017 in the United States were needed simply to compensate for declines at existing wells. If no new wells were completed after the end of 2017, then tight crude oil production would fall by around 1.8 mb/d within 12 months and by a further 0.6 mb/d during the year thereafter. However the long tail of production from wells provides an important baseload of production in the longer term. Around 80 000 tight oil wells had been completed by the end of 2017, and they will still provide around 1.6 mb/d production in 2025, even though they are all well past their production peaks (Figure 3.12).

8. This work is based on a detailed analysis of historical production in over 30 000 oil assets in the Rystad Energy UCube database.

Figure 3.12 ▷ Tight oil production according to well start-up date in the United States in the New Policies Scenario



Tight oil production drops rapidly in the absence of new well start-ups, but the large number of legacy wells provide an important base load of production

Tight oil production is a relatively new production technique and operators are continuing to make technological progress, for example in optimising the lateral length of horizontal wells and the amount of proppant used during hydraulic fracturing. Technological improvements are in a continuous battle with the effects of depletion (as is the case for all sources of production). By the mid-2020s, with the recoverable resource that we assume in the New Policies Scenario, many of the most productive areas will have been exploited. This means the average well drilled in 2025 is less productive than today and so a larger number of wells need to be completed to maintain or increase production. In 2025 over 20 000 new wells are drilled in the New Policies Scenario and production is maintained at just over 9 mb/d.

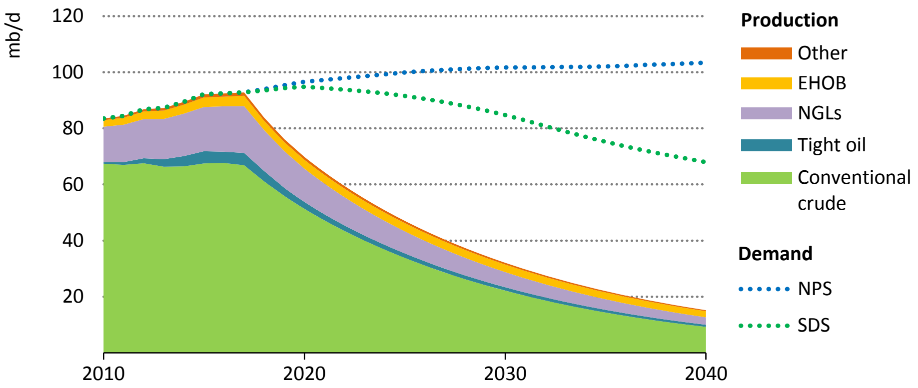
The natural decline rate is the drop in production from all currently producing fields that would occur if capital investment were to cease immediately. If there were to be no further capital expenditure, total production globally would fall by over 8% per year to 2025, an average loss of nearly 6 mb/d every year. Global production in 2040 would be just above 15 mb/d (Figure 3.13).[9] This pace of decline is significantly faster than the decline in oil demand in the Sustainable Development Scenario, highlighting the importance of continued upstream investment even during the transition away from a fossil-based energy system.

In practice, decline rates are usually lower than the natural decline rate since there is continued investment in producing fields. Another important decline rate is therefore the

9. The natural decline rate for conventional crude oil only is closer to 9%; see www.iea.org/weo/weomodel/ for further details, including how decline rates are calculated.

"observed post-peak decline rate". This is the compound annual decline in production from currently producing fields whose production has already peaked but with continued capital investment in these fields.[10] Post-peak decline rates vary according to production phase (they tend to rise as fields become more mature), field size (small fields tend to decline faster than large fields) and location (offshore fields exhibit faster decline rates than onshore fields). The global average observed post-peak decline for conventional crude oil today is 6.1% – around three percentage points lower than the global average natural decline rate.

Figure 3.13 ▷ Oil production with no new investment from 2018 and demand in the New Policies and Sustainable Development scenarios



With no new investment, global oil production would halve by 2025: an average loss of nearly 6 mb/d every year

Note: EHOB = extra-heavy oil and bitumen; NGLs = natural gas liquids; NPS = New Policies Scenario; SDS = Sustainable Development Scenario.

However this decline rate does not correspond with the loss in production from the global oil balance. The decline rate for post-peak fields producing in 2017 will change over time as fields become more mature. Further, less than 50% of global oil production today comes from post-peak conventional crude oil fields. Other categories of fields and types of production therefore need to be considered, including:

- Ramp-up fields (13% of global production in 2017): conventional crude oil fields that were brought online since 2010 and have yet to reach peak production.
- Legacy fields (11% of global production in 2017): conventional crude oil fields that were brought on line before 2010 and have yet to reach peak production. These tend

10. Observed decline rates are often aggregated to provide an average post-peak decline rate for specific countries, regions, field sizes, etc. When aggregating post-peak declines from a set of fields, we weight by cumulative production since this incorporates information from fields that peaked some time ago and currently have a very low level of production.

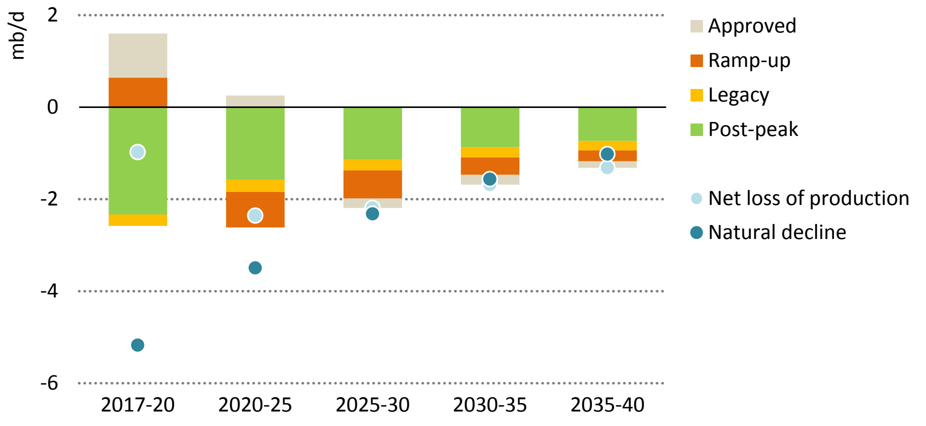
to have been subject to above-ground constraints (e.g. OPEC quota requirements) and so are hard to include in any usual post-peak field analysis. This includes a number of the "super-giant" fields in the Middle East and Russia.

- Approved fields: conventional crude oil fields that have been approved for development but have not yet started production. This includes a number of major new developments such as Johan Sverdrup in Norway and the Liza field in Guyana.
- NGLs (18% of global production in 2017), tight oil (5%), EHOB (4%) and a minor contribution from coal-to-liquids, gas-to-liquids and additives (1%).

The risk of an emerging supply-demand "gap"

How production evolves for post-peak, ramp-up, legacy, and approved conventional crude oil fields determines the annual loss of conventional crude oil production from the global oil balance (Figure 3.14). If there were to be no new fields approved after 2017, total conventional crude oil production would fall by around 1 mb/d each year to 2020 (an average annual decline rate of around 1.5%). This drop in production is smaller than the decline in post-peak fields, which fall by around 2.5 mb/d each year to 2020, given the increases in production from approved and ramp-up fields, and is much smaller than the natural decline rate (an annual loss of 5.2 mb/d conventional crude oil to 2020). Thereafter, as more fields enter decline and as the pipeline of new projects begins to dry up, the annual loss in production would accelerate to around 2.5 mb/d. This corresponds to a decline rate of around 4.5% during the 2020s, similar to the average post-peak decline of large fields.

Figure 3.14 ▷ Average annual change in production from conventional crude oil fields with no new approvals



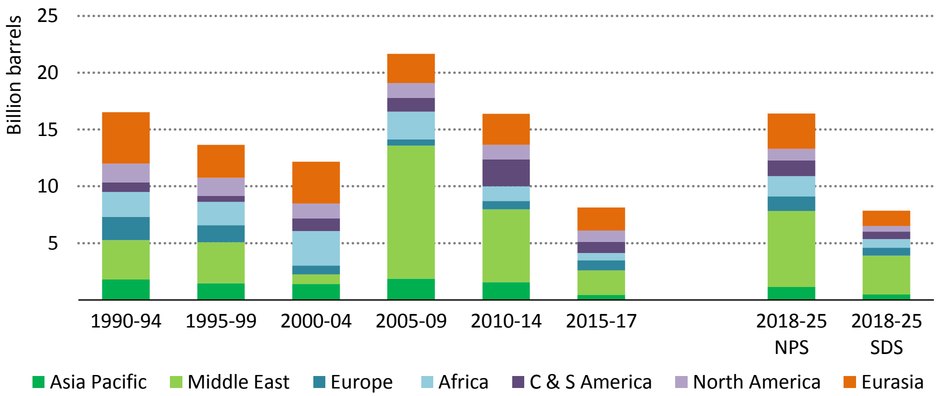
Production from ramp-up and approved fields initially offsets some of the decline in post-peak fields, but the drop in production soon escalates without new approvals

Notes: Fields are categorised as of their status in 2017. The net loss of production is the decline in conventional crude oil fields from 2017 if no new field developments are approved.

New approvals needed in the New Policies and Sustainable Development scenarios

In the New Policies Scenario, there is a 7.5 mb/d increase in demand between 2017 and 2025, and a 14.5 mb/d drop in production from currently producing and approved conventional crude oil fields (the aggregate net loss in production to 2025 shown in Figure 3.14). A 22 mb/d supply-demand gap therefore needs to be filled by new projects. Some of this gap is filled with growth in tight oil, NGLs and other unconventional sources of oil: in the New Policies Scenario these collectively grow by around 9 mb/d between 2017 and 2025. But that still leaves a gap of 13 mb/d.

Figure 3.15 ▷ Annual average conventional crude oil resources approved for development historically and volumes needed in the New Policies and Sustainable Development scenarios



Annual resource approvals in the Sustainable Development Scenario are broadly in line with approval levels since 2015; the New Policies Scenario requires double this volume

Note: C & S America = Central and South America; NPS = New Policies Scenario; SDS = Sustainable Development Scenario.

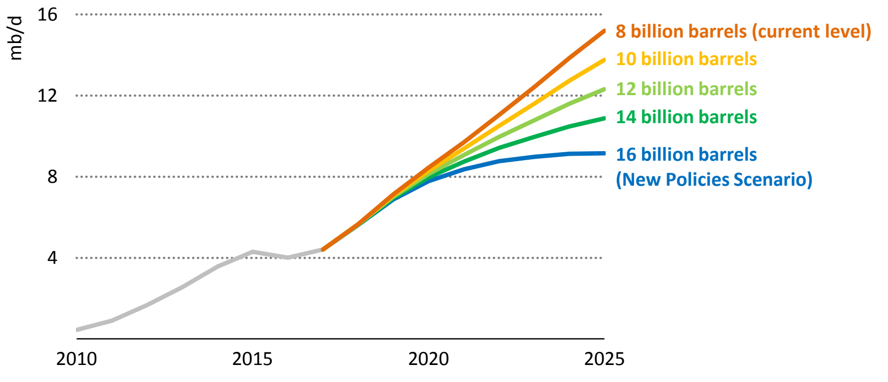
Sources: IEA analysis; Rystad Energy for historical levels.

We estimate that around 16 billion barrels of new conventional crude oil resources would need to be approved each year between now and 2025 to avoid any potential "mismatch" between supply and demand (Figure 3.15).[11] This takes into account the various locations and types of remaining conventional crude oil resources that are available, which have very different lag times between approval, first production and ramp-up. The average annual

11. This is slightly lower than the level described in the *WEO-2016* for the situation when resources approved between 2015 and 2017 remained at 6.5 billion barrels (the level of approvals projected in 2015 when the analysis was carried out). Approvals actually averaged around 8 billion barrels over this timeframe and tight oil and NGLs production in 2025 is around 4 mb/d higher than was estimated in the *WEO-2016*. However this increase is offset by a 4 mb/d increase in projected global oil demand in 2025 between the New Policies Scenario in the *WEO-2016* and in this year's *Outlook*.

level of new resources approved since the oil price crash in 2014 was around 8 billion barrels: the volumes sanctioned increased slightly in 2017, but were still well below levels in the early 2010s. The volume of conventional crude oil resources approved for development therefore needs to more than double from current levels if there is to be a smooth correspondence between supply and demand in the New Policies Scenario.

Figure 3.16 ▷ US tight oil production needed to meet demand in the New Policies Scenario at different levels of conventional resources approved each year between 2018 and 2025



If annual conventional crude oil approvals stay at the level seen since the oil price crash in 2014 (8 billion barrels), then US tight oil production would need to exceed 15 mb/d in 2025

If insufficient new conventional crude oil resources are approved for development, members of OPEC could decide to reduce their spare capacity and bring more oil to the market. This would provide something of a buffer, but it would only fill a small portion of the supply-demand gap and would weaken the ability of markets to respond to unforeseen disruptions. Another possibility is that US operators might manage to increase tight oil production at a much faster rate than is assumed in the New Policies Scenario, in which it reaches 9.2 mb/d in 2025. If the volume of resources approved globally each year were to stay at today's level of 8 billion barrels, then US tight oil would need to grow by an additional 6 mb/d between now and 2025 (Figure 3.16). With a sufficiently large resource base – much larger than we assume in the New Policies Scenario – a 1.3 mb/d annual increase in US tight oil production every year to 2025 could be possible. However distribution infrastructure bottlenecks are currently inhibiting tight oil production growth. Even if these were to be overcome as new pipelines are built, increasing production to this level would require a level of capital investment and a number of tight oil rigs that would far surpass the previous peaks in 2014. Against this backdrop, it would appear risky to rely on a tripling of US tight oil production from today's level by 2025 to offset the absence of new conventional crude oil projects.

In the Sustainable Development Scenario, there is also a 15 mb/d drop in production from currently producing fields or approved projects between 2017 and 2025 while demand falls by 1 mb/d over this period. A 14 mb/d gap therefore needs to be filled by new projects. Tight oil, NGLs and EHOB all grow from today's levels in this scenario, albeit to a lesser extent than in the New Policies Scenario given the lower oil price. A gap of around 7.5 mb/d therefore needs to be filled in the Sustainable Development Scenario in 2025 from conventional crude oil fields that have yet to be approved. Providing this level of supply would require approvals of around 8 billion barrels between now and 2025: similar to the level seen over the past few years. This places the implications of "peak oil demand" in context. Even with a near-term peak and subsequent reduction in demand of around 1 mb/d by the mid-2020s, there remains a critical need to develop new fields to fill the supply-demand gap.

Why has there been a dearth of new conventional crude oil approvals recently? Since the drop in the oil price, companies have placed greater emphasis on cost management and executing projects with shorter pay-back periods (such as tight oil), often to the detriment of investment in longer lead time conventional crude oil projects (IEA, 2018b). This could in part reflect concerns over the trajectory of future oil demand. In addition, many national oil companies are facing constrained capital budgets, limiting their ability to invest in new projects. Geopolitical events may also be discouraging an upturn in investment in some areas.

There are a number of options for policy makers to help avoid any shortfall in supply. One option is to introduce policies to reduce oil demand. Another is to provide a more attractive climate for investment, especially for projects that would have low upstream emissions intensities (see Chapter 11). With the rise in the oil price so far in 2018, companies have expressed greater interest in investing in new conventional crude oil projects, and it is possible that much higher levels of investment will materialise in the coming years without any, or much, help from governments. Depending on developments in the global economy and demand and the timeliness of project approvals and developments, it is still possible that a supply crunch will be avoided, but this pathway is a narrow one.

Conclusion

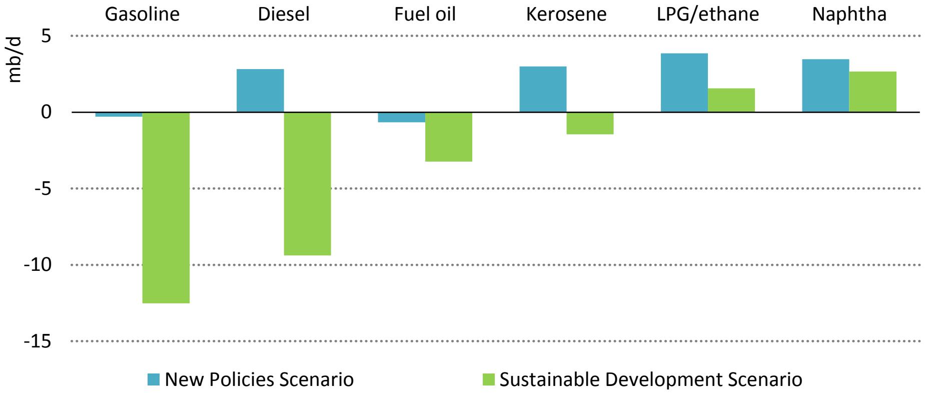
The level of new upstream oil resources approved in the years since the crash in the oil price is broadly in line with the needs of the Sustainable Development Scenario. But it is currently far from sufficient to meet the oil demand trajectory based on the policies and continued levels of economic growth in the New Policies Scenario. Current investment in demand points towards ever increasing oil consumption, while investment in oil supply appears to be geared towards a world of stagnant or even falling demand. Either demand or supply projections could yet change so as to close the gap, however the longer this dichotomy continues, the greater the risk of damaging price spikes and increased volatility.

3.11 Oil product demand: where are the winners and losers, and what could be the unintended consequences?

While global oil consumption has been on an almost unbroken rising trend for decades, there have been divergent trends for individual oil products. Demand for heavy fuel oil, for example, has been declining since the 1980s, while the pace of demand growth for lighter products (such as ethane, LPG and naphtha) has been almost triple that of total oil demand. In the New Policies Scenario, heavy fuel oil is set to face another blow when the IMO's regulation on the sulfur content of bunker fuels comes into effect from 2020 (see Spotlight). Gasoline demand also peaks in the late 2020s and is around 0.3 mb/d lower than today in 2040 as efficiency improvements, fuel switching and electrification weigh on oil demand for cars. However, there are sectors where efficiency improvements or electrification are less effective in curbing oil demand, most notably the petrochemical sector.

As a result, demand for ethane, LPG and naphtha (mainly used as petrochemical feedstocks) continues to grow much faster than total oil demand in the New Policies Scenario. Robust growth in these lighter products (also known as the "top of the barrel") means that their share of total oil consumption rises from 18% today to 23% in 2040. In contrast, the share of gasoline and heavy fuel oil declines from 33% to 28%. Refiners have coped with divergent trends for different oil products in the past, but the pace and extent of the changes envisaged in the New Policies Scenario still pose a significant test.

Figure 3.17 ▷ Change in global oil product demand by scenario, 2017-2040



The diverging sectoral oil demand outlook underpins a large-scale shift towards lighter products in the Sustainable Development Scenario

In the Sustainable Development Scenario, the share of "top of the barrel" products grows to an even greater extent. Oil demand in cars drops significantly; consumption for other transport modes – trucks, ships and aviation – also declines; but use in the petrochemical sector remains robust due to strong demand growth for chemical products in developing economies. These changes engender a major shift in the composition of oil product demand. Demand for gasoline and diesel fall by some 50% and 35% respectively between today and 2040. Demand for kerosene and fuel oil also falls. By contrast, given the growth in petrochemicals, demand for ethane, naphtha and LPG grows by around 25% (Figure 3.17). LPG is also key in this scenario to provide access to clean cooking facilities and to tackle the negative health impacts associated with the traditional use of solid biomass as a cooking fuel in many developing countries. As a result, the share of lighter products rises to over 30% by 2040 in the Sustainable Development Scenario, from 18% today.

SPOTLIGHT

Achieving the IMO regulation: plain sailing or stormy seas ahead?

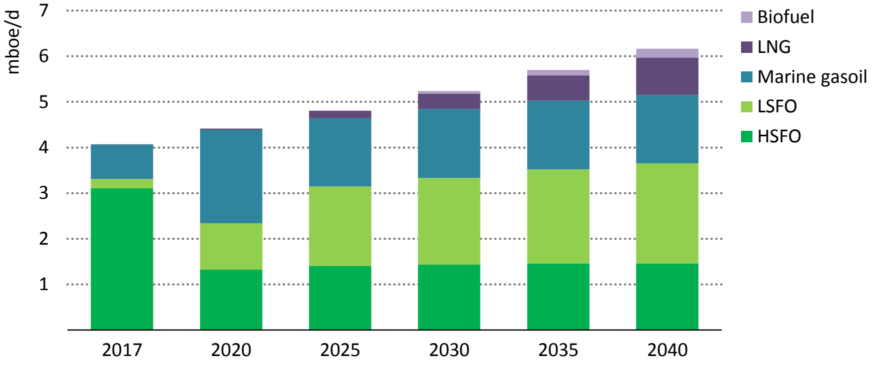
The international shipping sector has been the last large-scale refuge for high sulfur fuel oil (HSFO) in recent years. HSFO consumption in 2017 was just over 3 mb/d and the shipping industry was responsible for 12% of total energy-sector sulfur dioxide (SO_2) emissions. The IMO has now introduced a regulation to limit the sulfur content of marine fuels to no more than 0.5% (the "sulfur regulation") that will enter into force in 2020. This promises to yield substantial environmental and health benefits, but it will also have profound impacts on oil markets. In April 2018, the IMO also announced a strategy to reduce GHG emissions from the international shipping industry by at least 50% from 2008 levels by 2050 (the "GHG strategy"), which will also have major longer term implications.

There are a number of options available to the maritime industry to comply with the sulfur regulation. These include installing exhaust gas cleaning systems (known as "scrubbers"), fuel switching to LNG, or changing to use low sulfur fuel oil (LSFO) or marine gasoil (MGO).

The use of scrubbers would allow continued use of HSFO, but this is unlikely to be the main avenue for compliance: it would be capital intensive; there is a mismatch between the interests of ship owners and ship charterers; there would be loss of revenue during the idle period when the scrubber is installed; smaller ships may not easily be able to handle large scrubbers; and there is uncertainty over the cost of disposing the sludge they create. Shifting to use LNG is also likely to be relatively limited, at least in the short term, as it is expensive to convert ships to use LNG and bunkering infrastructure is not for the moment widely available. The need for eventual compliance with the GHG strategy announced in April 2018 may also militate against both scrubbers and LNG. Installing scrubbers provides no CO_2 reduction and the reduction in emissions provided by switching to LNG would not be sufficient on its own to achieve the long-term target.

The use of compliant fuels such as LSFO or MGO is therefore likely to be the most widespread option for compliance post-2020. In the New Policies Scenario, HSFO demand drops by around 2 mb/d around 2020, but filling this gap is not straightforward. The supply of LSFO from refineries is limited to around 600 kb/d, and so a large part of the remainder would need to be met by MGO (Figure 3.18). This raises the prospect of a spike in diesel prices around 2020 (IEA, 2018d). Refiners are also developing a new 0.5% sulfur bunker fuel (often called "very low sulfur fuel oil") that blends HSFO and MGO, which is likely to find a market even if there are still some technical and specification issues to be resolved. Nevertheless, many uncertainties remain that could affect this picture, including the preference of ship owners for compliant fuels over more capital-intensive options, the availability of low sulfur products, the rate of uptake of new blended products and the pace of development of new technologies.

Figure 3.18 ▷ Fuel mix for the international shipping sector in the New Policies Scenario



Low sulfur compliant fuels are the main fuels chosen in the New Policies Scenario

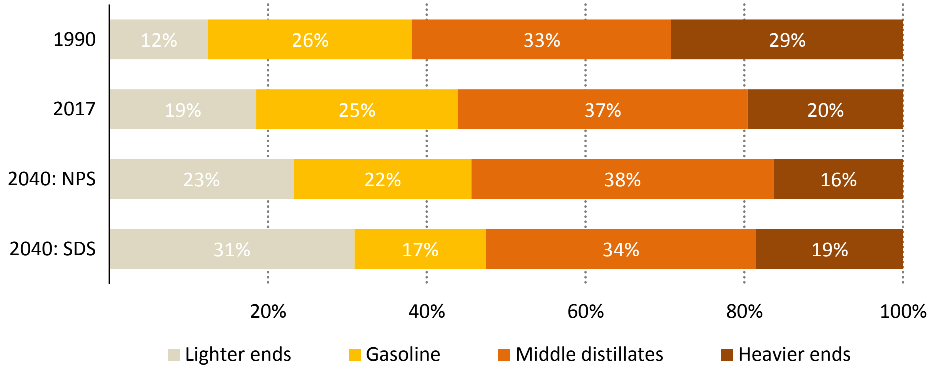
Notes: mboe/d = million barrels of oil equivalent per day; HSFO = high sulfur fuel oil; LSFO = low sulfur fuel oil. LSFO includes both straight-run LSFO and LSFO produced by blending HSFO and gasoil.

While filling the gap left by HSFO is a significant task for the shipping industry, dealing with the displaced HSFO also represents a major challenge for the refining industry. In the absence of sufficient storage capacity, the displaced HSFO could be upgraded or consumed for power generation. But this would not be sufficient to absorb all the displaced volume, implying a significant drop in HSFO prices. The sulfur regulation may therefore take a heavy toll on simple refineries that have high HSFO yields, many of which are not in a position to consider multi-billion dollar investment in upgrading units or desulphurisation units for HSFO. It could though benefit more complex refineries via higher MGO prices and cheaper HSFO feedstock. These changes could potentially add to other pressures for further restructuring of the global refining industry.

The ripple effects of the IMO sulfur regulation could spread beyond oil product markets. With elevated demand for MGO, complex refineries would increase throughput to maximise diesel outputs, which could push up prices for crude oil and sweeter crudes in particular (simpler refineries are likely to prefer to process sweet grades to minimise the yield of HSFO). This would push up fuel costs for freight across the board (both maritime and road) around 2020, which could have broader economic ramifications.

Refiners are used to coping with changing demand patterns. In the past, these efforts were mainly focused on reducing heavier yields and increasing the output of gasoline and middle distillates (diesel and kerosene). The challenge in the Sustainable Development Scenario comes from a different angle: to increase the yield of lighter products and reduce the output of traditional refined products such as gasoline and diesel (Figure 3.19). Growth in the availability of NGLs and lighter crude oil eases some of the pressure on refiners, at least in the near term. However, production of NGLs and of tight oil are both projected to fall back post-2025, while demand for lighter products continues to increase.

Figure 3.19 ▻ Change in the composition of global oil product demand



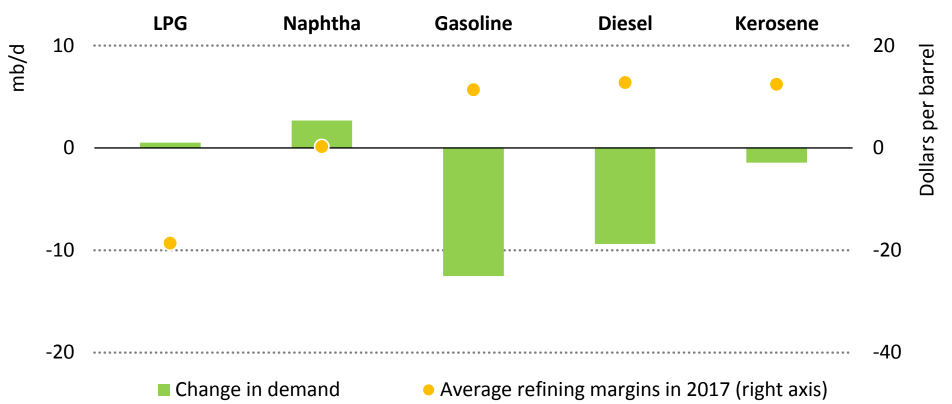
The past challenge for refiners has been reducing the "bottom of the barrel", but the future challenge comes from increasing yields of the "top of the barrel" products

Notes: NPS = New Policies Scenario; SDS = Sustainable Development Scenario. Lighter ends include ethane, LPG and naphtha. Middle distillates include diesel and kerosene. Heavier ends include fuel oil, asphalt, petroleum coke, wax, etc.

The mismatch between refinery configurations and product demand in the Sustainable Development Scenario would increase the incentives for refiners to deepen integration with petrochemical operations, and thereby boost the direct production of chemical products relative to transportation fuels. There are various technological pathways to increase chemical product yields beyond the levels that a refinery can typically produce (less than 10%). Several Asian refineries have co-located steam crackers and para-xylene facilities that provide higher chemical yields; high-severity fluid catalytic cracking technologies allow companies to achieve chemical product yields of over 30%; while companies in China are building integrated petrochemical and refining facilities that aim to have chemical yields of around 40%. There are even more ambitious schemes being pursued in the Middle East to bypass refining operations and produce chemicals directly from crude oil (IEA, 2018c).

The changes in product demand could also have profound implications for the business model of the refining industry. Today, refiners typically earn most of their profit from selling road transport fuels such as gasoline and diesel. Prices for petrochemical feedstocks – the main sources of demand growth in this scenario – often trend lower than crude oil prices. The significant reduction in road transport fuel demand in the Sustainable Development Scenario may therefore challenge this traditional pattern (Figure 3.20). In theory, foregone profits in one area would be compensated by higher prices for products in high demand such as naphtha and LPG. While it is conceivable for the prices of these products to increase to some degree, it is hard to envisage a rise that fully compensates for the reduction in road transport fuels sales. The current interest in petrochemical integration reflects a desire to hedge against this risk by seeking out new business lines and revenue streams.

Figure 3.20 ▷ Average refining margins today and change in demand in the Sustainable Development Scenario by product, 2017-2040

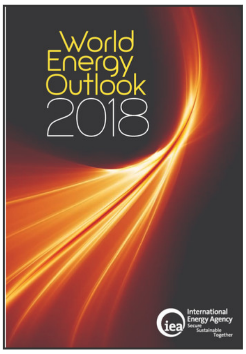


The product demand pattern in the Sustainable Development Scenario would pose major challenges for today's refining business models

Note: Refining margins are differentials between northwest Europe product prices versus North Sea dated prices.

Conclusion

The IMO sulfur regulation provides an illustration of how changes in product demand can send ripples through the refining industry and then through the wider energy system. Our projections highlight other possible mismatches between products demanded and refinery configurations, causing spikes or slumps in the price of individual oil products. While policy makers need to try to minimise the potential impacts of price spikes on energy consumers, they would also need to be attentive to the unintended influences of price slumps. For example, if policy action were concentrated narrowly on the passenger car segment while other sectors – such as trucks, aviation, shipping and petrochemicals – were left relatively untouched, it would be difficult to avoid a glut of gasoline on the market once demand started to fall back. Efforts to curb oil use in passenger cars would therefore face much stronger headwinds because cheap gasoline would make efficiency improvements and electrification more difficult and expensive. Avoiding such rebound effects would require removing fossil fuel subsidies or putting in place an offsetting tax or duty that maintains end-user prices at higher levels. Anticipating and mitigating these feedbacks from the supply side needs to be a central element of the discussion about orderly energy transitions.



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