# Prospects for oil demand

## Growth in a narrowing set of markets

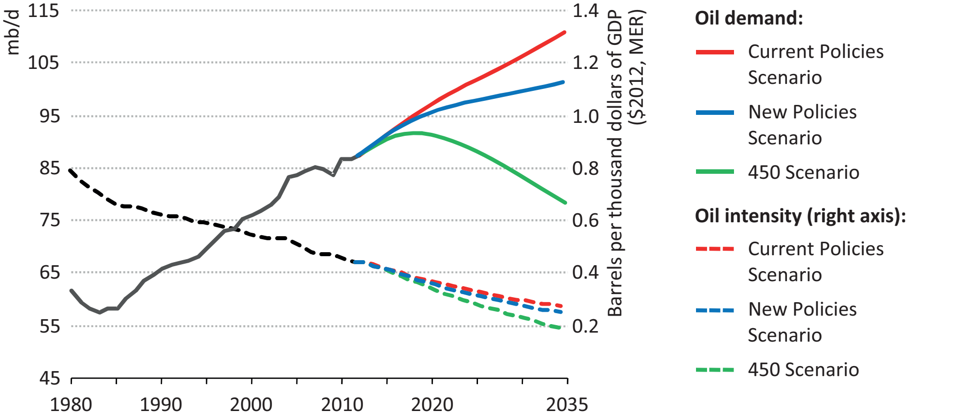
### Highlights

- Demand for oil grows from 87.4 mb/d in 2012 to 101.4 mb/d in 2035 in the New Policies Scenario, but the pace of growth slows steadily, from an average increase of 1 mb/d per year in the period to 2020 to an average of only 400 kb/d in the subsequent years to 2035. This is mainly due to new efficiency policies and fuel switching in OECD countries, where the decline in oil demand accelerates. In 2035, the OECD share of global oil demand falls to one-third, from just under half today.
- Oil use in China increases the most in volume terms, rising by around 6 mb/d to reach almost 16 mb/d, with China overtaking the United States as the largest oil consumer by around 2030. But expanding demand for mobility and for freight transport sees India emerge as a key centre of oil consumption, especially in the period after 2020, when it becomes the largest single source of oil demand growth.
- The Middle East becomes the third-largest centre of oil demand, at 10 mb/d in 2035. The rise in consumption is underpinned by a fast-growing population and subsidies to oil consumption, which were equivalent to $520/person in 2012. Demand growth comes from transport (2.2 mb/d) and the petrochemicals sector (1.1 mb/d). Oil use for electricity generation eventually tails off, as the almost $200/MWh cost of oil-for-power (at international oil prices) is high enough to make all other technologies competitive.
- At global level, oil consumption is increasingly concentrated in just two sectors: transport – where oil use grows by 12 mb/d to close to 60 mb/d in 2035 – and petrochemicals (most of which is feedstock), which sees an increase of more than 3 mb/d. Energy efficiency improvements contribute significantly to curbing oil demand growth and alternatives to oil are also gaining ground, in particular in road transport and shipping: the share of natural gas in transport energy use reaches 5.6% by 2035, up from 3.8% today.
- Oil use as a feedstock for petrochemicals rises to 14 mb/d by 2035. Petrochemicals output in the Middle East and in North America expands, helped by local availability of ethane, resulting from the large rise in production of natural gas liquids. China also sees a large rise in petrochemicals output, using both oil and coal as feedstock.
- Among oil products, demand growth is concentrated in the middle distillates. Across all sectors, diesel sees by far the largest increase in volume terms, rising by more than 5 mb/d to 31 mb/d between 2012 and 2035, compared with a rise in gasoline consumption of 2 mb/d. All of the net increase in diesel demand comes from the road-transport sector in non-OECD countries.

## Global oil demand trends

The relationship between growth in economic activity and in oil demand continues to weaken over the coming decades, as oil use becomes more efficient and substitutes for oil start to eat into its position in the global energy market. The share of oil in the energy mix falls in all three scenarios examined in this *Outlook* over the period to 2035. But the speed at which this change takes effect remains contingent on the policies adopted by governments around the world. For this reason, the actual trajectory for oil demand differs substantially between the three scenarios (Figure 15.1). Additional actions to curb demand are strongest in the 450 Scenario, with the result that global consumption starts to decline by around 2020. Measures adopted in the New Policies Scenario have a less dramatic impact, but still put a measurable brake on consumption growth, compared with the Current Policies Scenario. Demand in the New Policies Scenario reaches 101.4 million barrels per day (mb/d) in 2035 – 14 mb/d higher than in 2012.[1]

**Figure 15.1 ▷ World oil demand and oil intensity by scenario**




Note: MER = market exchange rate.

The average IEA crude import price – used in our analysis as a proxy for the international oil price – was $109 in 2012, just shy of the annual average record price seen in 2011. Even though underlying economic and demographic factors tend to push global oil consumption higher, prices at these levels create incentives for consumers to moderate their demand for oil or to switch away from it entirely, if they can – at least in those countries where consumers are not shielded by subsidies that keep prices artificially low (see focus on the Middle East). High prices can also stimulate governments to implement policies promoting more efficient oil use and to reduce subsidies, where these are in place. In

1. The preliminary data so far available for 2012 relate only to total oil demand. The sectoral breakdown of demand is available up to and including 2011. All sectoral oil demand data presented for 2012 are therefore estimated. Oil demand projections in the World Energy Model at sectoral and product demand level are done using energy units (million tonnes of oil equivalent). They are then converted into volumetric units, using product specific conversion factors, which we have reviewed and revised as part of our more detailed work in *WEO-2013* on oil product demand.

the Current Policies Scenario, reactions by governments are weak or absent (in line with the overall assumptions for this scenario, see Chapter 1), meaning that a higher price is required to keep supply and demand in long-term balance – $145/barrel (in year-2012 dollars). In the New Policies Scenario, there is a stronger response, resulting in a different market equilibrium and an oil price of $128/barrel in 2035. In the 450 Scenario, strong policy intervention to curb demand results in a decline in the international oil price to $100/barrel in 2035; governments are assumed to act in this scenario to keep oil products prices to final consumers at higher levels through higher taxes and subsidy removal.

**Table 15.1 ▷ Oil and total liquids demand by scenario** (mb/d)

| | | | New Policies | | Current Policies | | 450 Scenario | |
|---|---|---|---|---|---|---|---|---|
| | 2000 | 2012 | 2020 | 2035 | 2020 | 2035 | 2020 | 2035 |
| OECD | 44.6 | 40.8 | 39.4 | 32.8 | 40.1 | 37.1 | 38.0 | 24.9 |
| Non-OECD | 26.5 | 39.6 | 48.3 | 59.2 | 49.2 | 64.2 | 45.6 | 45.6 |
| Bunkers* | 5.2 | 7.0 | 7.8 | 9.3 | 7.8 | 9.7 | 7.5 | 7.7 |
| **World oil** | **76.3** | **87.4** | **95.4** | **101.4** | **97.1** | **111.0** | **91.1** | **78.2** |
| World biofuels** | 0.2 | 1.3 | 2.1 | 4.1 | 1.9 | 3.3 | 2.6 | 7.7 |
| **World total liquids** | **76.5** | **88.7** | **97.6** | **105.5** | **98.9** | **114.3** | **93.8** | **85.9** |

* Includes international marine and aviation fuel. ** Expressed in energy-equivalent volumes of gasoline and diesel.

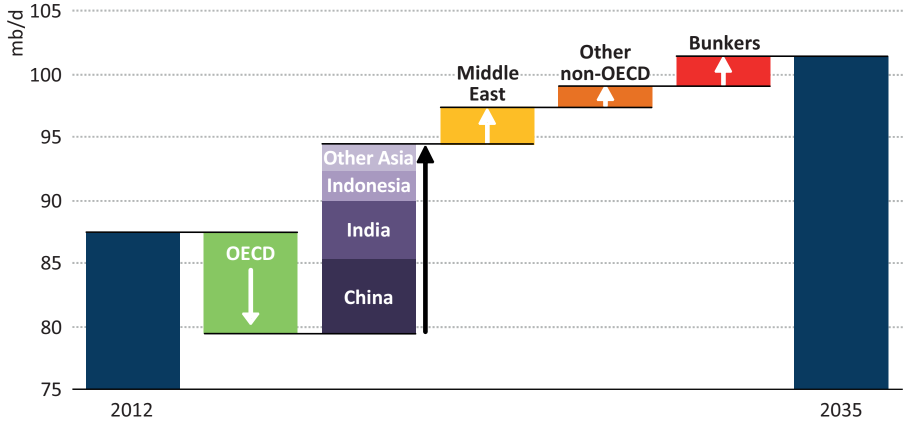
## *Oil demand by region*

In the New Policies Scenario, the annual increase in demand averages around 1 mb/d per year until 2020, but this growth slows significantly thereafter, to an average of some 400 thousand barrels per day (kb/d) per year in the period to 2035, as policies affecting oil consumption (such as new fuel-efficiency standards in OECD) start to have widespread impacts and demand growth starts to level off in major non-OECD consuming countries, notably in China (Table 15.2). The countervailing pressures on oil consumption balance out differently inside and outside the OECD. In the OECD, demand for oil declines as efficiency gains and fuel switching outweigh the impact of economic and population growth. Outside the OECD, the situation is reversed, with increases in demand for personal mobility and freight outpacing projected efficiency gains.

OECD oil demand trends are broadly similar to those of the *World Energy Outlook 2012* (*WEO-2012*), although some revisions have been made on a regional and country level. US oil demand was revised upward due to higher growth expectations in industrial activity especially in the medium term and a slightly more cautious outlook for biofuels following the downward revisions by the US Environmental Protection Agency to short-term biofuels quotas under the Renewable Fuel Standard. For Europe, a lower short-term outlook feeds through into lower long-term demand growth.

In line with the trends seen in previous *Outlooks*, the centre of gravity of oil demand growth continues to move towards developing Asia, which accounts for almost two-thirds of the gross increase in demand over the projection period (Figure 15.2). China's oil demand grows most in absolute terms, by 6 mb/d to almost 16 mb/d over 2012-2035, but the pace of China's oil demand growth lessens significantly over time, going from 3.7% per year on average over the period to 2020 to an average of 1.3% per year thereafter. This is related in part to a slowing pace of economic and population growth, but the dynamics of the Chinese transport sector – the main oil-consuming sector – also play a role. Although passenger light-duty vehicle (PLDV) ownership in China in 2035, at a little over 300 vehicles per 1 000 inhabitants, is still far lower than the OECD average of around 540, saturation effects are likely to begin to appear in some regions, mostly in the richer provinces in the coastal areas, while expansion of private vehicle use in other regions is likely to become more and more constrained by the pace at which road infrastructure can develop. Nonetheless China becomes the largest oil market by around 2030, overtaking a US market where consumption peaks at 17.7 mb/d before 2020 and where efficiency policies in road transport and diversification away from oil across all sectors subsequently bring demand down 20% below this level by 2035.

**Figure 15.2 ▹ Growth in world oil demand by region in the New Policies Scenario, 2012-2035**




For the projection period as a whole, demand in India grows at the fastest average rate (at 3.6% per year), representing the largest absolute increase after China. The size of the oil market in India is expected to overtake that of Japan before 2020. Between 2020 and 2035, the volumetric growth in Indian demand is larger than that of China. The volumetric growth in demand in India and Southeast Asian countries combined over this period is almost 75% larger than the expected growth in China, as their economies grow faster and rising incomes per capita spur vehicle ownership (which grows from a lower base than in China). The Middle East, the subject for more detailed analysis in the next section, is also expected to see very significant growth in demand: its domestic oil consumption reaches the level of the European Union before 2030, despite having a population only half the size and an economy only one-fifth of the size of the European Union by that time.

**Table 15.2 ▷ Oil demand by region in the New Policies Scenario** (mb/d)

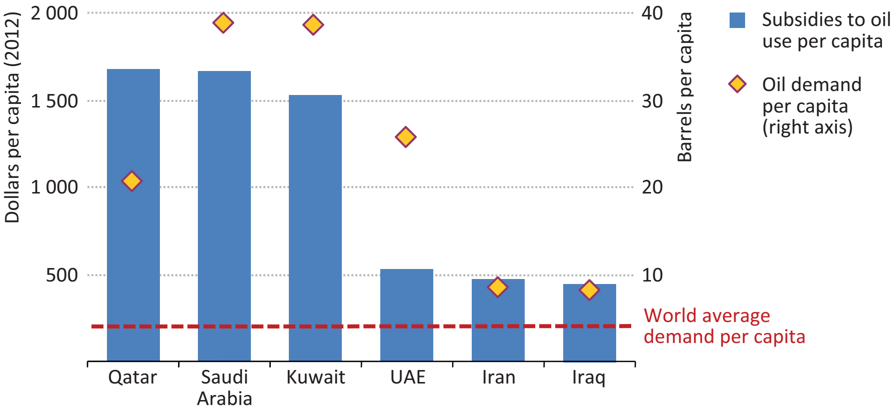
| | 2000 | 2012 | 2020 | 2025 | 2030 | 2035 | 2012-2035 | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Delta | CAAGR* |
| **OECD** | **44.6** | **40.8** | **39.4** | **37.3** | **34.9** | **32.8** | **-8.0** | **-0.9%** |
| Americas | 22.7 | 21.3 | 21.9 | 20.8 | 19.6 | 18.4 | -2.9 | -0.6% |
| United States | 18.7 | 17.1 | 17.5 | 16.4 | 15.1 | 14.0 | -3.1 | -0.9% |
| Europe | 13.7 | 11.7 | 10.9 | 10.2 | 9.4 | 8.9 | -2.9 | -1.2% |
| Asia Oceania | 8.2 | 7.8 | 6.7 | 6.3 | 5.9 | 5.5 | -2.2 | -1.5% |
| Japan | 5.3 | 4.7 | 3.6 | 3.3 | 3.0 | 2.8 | -1.8 | -2.2% |
| **Non-OECD** | **26.5** | **39.6** | **48.3** | **52.3** | **55.8** | **59.2** | **19.6** | **1.8%** |
| E. Europe/Eurasia | 4.2 | 4.7 | 5.1 | 5.2 | 5.3 | 5.4 | 0.7 | 0.6% |
| Russia | 2.6 | 2.9 | 3.1 | 3.1 | 3.2 | 3.2 | 0.3 | 0.4% |
| Asia | 11.5 | 19.3 | 24.8 | 27.6 | 30.1 | 32.5 | 13.2 | 2.3% |
| China | 4.7 | 9.6 | 12.9 | 14.1 | 15.0 | 15.6 | 6.0 | 2.1% |
| India | 2.3 | 3.6 | 4.7 | 5.7 | 6.9 | 8.1 | 4.5 | 3.6% |
| Middle East | 4.3 | 6.9 | 8.2 | 8.7 | 9.3 | 9.9 | 2.9 | 1.6% |
| Africa | 2.2 | 3.4 | 4.0 | 4.2 | 4.4 | 4.6 | 1.2 | 1.3% |
| Latin America | 4.2 | 5.3 | 6.2 | 6.5 | 6.7 | 6.9 | 1.5 | 1.1% |
| Brazil | 1.8 | 2.4 | 2.9 | 3.1 | 3.3 | 3.4 | 1.0 | 1.6% |
| Bunkers** | 5.2 | 7.0 | 7.8 | 8.3 | 8.8 | 9.3 | 2.4 | 1.3% |
| **World oil** | **76.3** | **87.4** | **95.4** | **97.8** | **99.5** | **101.4** | **14.0** | **0.6%** |
| European Union | n.a. | 10.9 | 9.9 | 9.1 | 8.3 | 7.7 | -3.2 | -1.5% |
| World biofuels*** | 0.2 | 1.3 | 2.1 | 2.7 | 3.4 | 4.1 | 2.8 | 5.0% |
| **World total liquids** | **76.5** | **88.7** | **97.6** | **100.5** | **102.9** | **105.5** | **16.8** | **0.8%** |

* Compound average annual growth rate. ** Includes international marine and aviation fuels. *** Expressed in energy-equivalent volumes of gasoline and diesel.

## *Focus on the Middle East*

Alongside its long-standing role as the fulcrum of global oil production, the Middle East is rapidly becoming one of the main centres of oil demand. Since 2000, oil consumption in the region has risen by 2.6 mb/d, reaching 6.9 mb/d in 2012, accounting for almost one-quarter of the net increase in global demand. At 4%, the average annual growth in oil consumption over this period was not far behind that of China (6.2%), although the starting point for oil demand per capita in the Middle East, at nearly 10 barrels per year in 2000, was already more than double the global average. Today's oil consumption per capita in the Middle East as a whole is 50% higher than in the European Union and on a converging path with the United States, despite the fact that average incomes are much lower. The average figure for the Middle East conceals some wide variations within the region: per-capita oil consumption in Saudi Arabia, for example, is around 39 barrels/person/year (or some 17 litres/person/day), followed by the United Arab Emirates at 26 barrels/person/year, while the figure for Iraq and Iran is around 8 barrels and that for Yemen just above 2 (Figure 15.3).

**Figure 15.3 ▷ Oil consumption subsidies and oil demand per capita by selected countries in the Middle East, 2012**



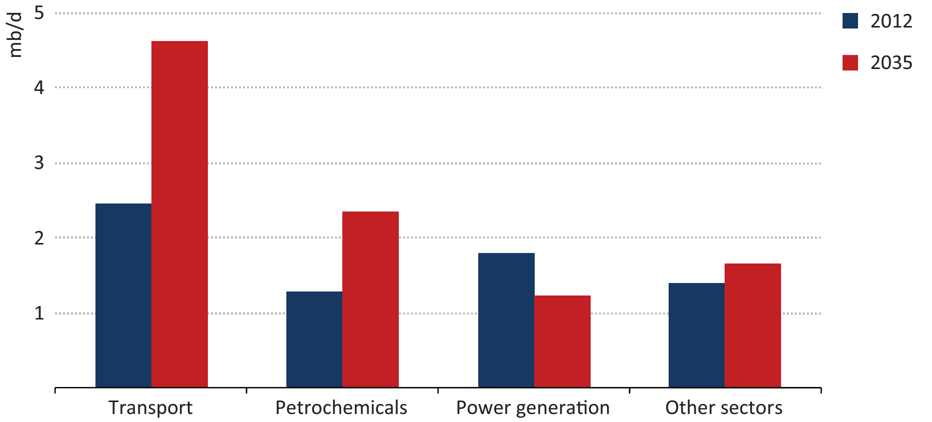

The rapid increase in oil demand in the Middle East has been underpinned by subsidised oil product prices. Gasoline and diesel prices across the region are among the lowest in the world and other oil products are also sold at prices well below their international market value, the benchmark for our calculation of subsidy values. We estimate that the cost of the subsidies provided in the Middle East for oil products in 2012 was $112 billion (or 13% of oil-export revenues), with the largest share in Saudi Arabia, Iran and Iraq. Expressed on a per-capita basis, oil consumption subsidies were equivalent to about $500/person in Iraq, Iran and the United Arab Emirates (UAE), and over $1 500/person in Kuwait, Saudi Arabia and Qatar. Adding in the subsidies provided to natural gas and electricity (most of which is generated by fossil fuels), the total for the region rises to $203 billion, representing almost 40% of global fossil-fuel consumption subsidies in 2012 (see Chapter 2).

Governments in the Middle East are becoming increasingly aware of the implications of fossil-fuel consumption subsidies, but removing these subsidies is a politically delicate matter. Iran announced a subsidy reform plan in 2010, designed gradually to replace subsidised prices by targeted assistance (both to households and to industry); but implementation has been patchy. The reform has been criticised for contributing to inflation and is complicated by the absence of good data on incomes, meaning that it has proved difficult to target assistance effectively; under the initial reform plan, over 90% of the population indicated their eligibility for aid. In Saudi Arabia, policy has been focused more on efforts to improve efficiency and to diversify away from oil than on reducing energy subsidies, but senior officials went on record in 2013 to express their concern about the implications for the national budget and the distortions that subsidies introduce into the national economy. Failure to reform the existing system has a high economic price.

Over the *Outlook* period, oil demand in the Middle East increases by 2.9 mb/d to reach almost 10 mb/d in 2035, fuelling a rapidly growing economy and responding to a 40% increase in population (Figure 15.4). Transport demand grows by over 2 mb/d, as the PLDV fleet expands by close to 2 million vehicles per year, at a rate similar to economic growth.

The fuel economy of the vehicle fleet improves at a slower rate than in other parts of the world, as subsidies continue to limit the incentive for consumers to switch to more efficient vehicles. At the extremely low gasoline prices prevailing in Saudi Arabia today, an investment in a more efficient car (consuming half the gasoline per 100 kilometres (km) of the average car on Saudi Arabia's roads today) would pay back only after almost twenty years. Preference for gasoline-fuelled cars over diesel persists over the *Outlook* period, and passenger transport grows faster than freight. As a result, road gasoline demand increases by 1.2 mb/d, 30% more than road diesel.

**Figure 15.4 ▷ Oil demand by sector in the Middle East**



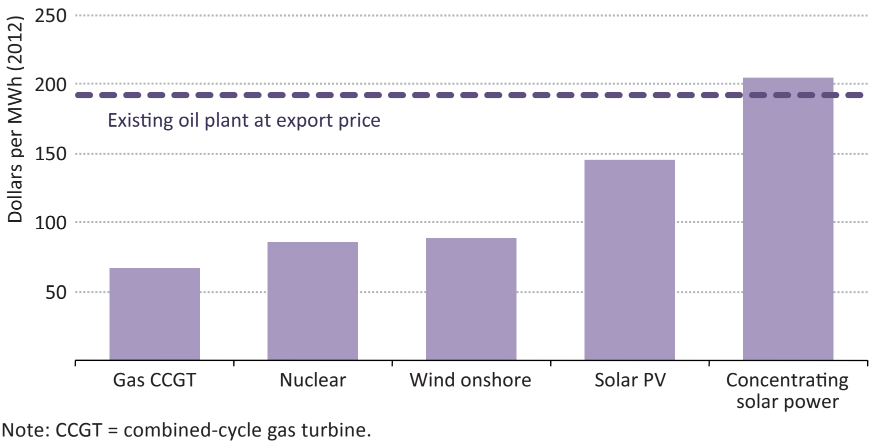

Note: Other sectors include energy transformation, buildings, agriculture and non-energy use other than petrochemical feedstocks. Power generation includes oil use for new combined water desalination and power plants.

In an effort to diversify the reliance of their economies on fuel production, countries in the Middle East have started investing heavily in the petrochemicals sector (and in export refineries). Petrochemicals capacity in the region has doubled over the past five years and implementation of plans to continue this expansion will result in a doubling of oil use as feedstock and fuel over the *Outlook* period. By 2035, the use of oil in petrochemicals production is second only to its consumption in the transport sector and the share of those two areas in oil use jumps from just over half today to 70% in 2035.

Efforts to diversify the Middle East power generation mix have not kept pace with soaring demand, meaning that large volumes of oil continue to be used for electricity generation – particularly during the summer months, when seasonal demand for air conditioning is at its highest. Outside the Middle East, the share of oil-fired plants in total power generation has become marginal, at 4% in 2012. But in the Middle East, these plants account for more than one-third of total power generation and absorb almost 2 mb/d of oil. With international oil prices above $100 per barrel, this is a very costly way of generating electricity: cheaper options are available, such as natural gas or some low- or zero-carbon technologies. At today's international prices, the cost of oil as a fuel to produce one megawatt-hour (MWh) of electricity is just below $200. This is not the cost paid by oil-fired power plants in the Middle East, as the price they pay is heavily subsidised. But it is a cost that is borne by the economy at large. With an eye on the international market value that is forgone, authorities are seeking ways to switch away from oil in power generation whenever possible. When the benchmark is set by short-run marginal costs for oil-fired power around $200 per MWh, almost every alternative technology for power generation looks attractive (Figure 15.5).

Since 2000, oil use in the power sector has grown less than electricity demand, and the amount of new installed natural gas capacity has been four times larger than that of oil. Natural gas is an obvious choice for the Middle East, given the large size of the gas resource base (although its development is hindered by a relatively under-developed transmission and distribution network in many countries). With large volumes of associated gas anticipated from its huge southern oil fields, the Iraqi government plans a major shift over the coming decades away from oil-firing to more efficient gas-fired generation. The Government of Saudi Arabia is pursuing a broad range of diversification options in the power sector, encompassing not only natural gas but also renewables-based projects. The stated ambition is to generate between 150-190 terawatt-hours (TWh) of electricity from renewables by the early 2030s, with the largest contribution coming from concentrating solar power, followed by solar photovoltaics (PV), wind energy, waste-to-energy and some geothermal. Nuclear power is also being considered in the region: since 2012, the United Arab Emirates have started the construction of two out of the four reactors planned at the Barakah nuclear power plant.

**Figure 15.5 ▹ Electricity generating costs by technologies in the Middle East, 2015**



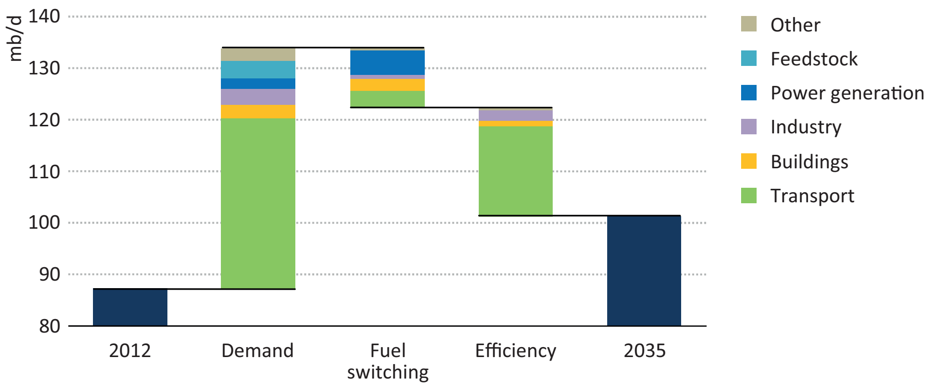

Note: CCGT = combined-cycle gas turbine.

In our projections, the Middle East makes progress with the diversification of its power mix. After continuing to rise during the current decade, output from oil-fired plants peaks before 2020 and is well below current levels by 2035. With oil use declining, natural gas accounts for the largest share of the growth in regional power generation, an increase of more than 700 TWh over the period to 2035, followed by renewable technologies (whose contribution grows by more than 200 TWh) and nuclear (a rise of 60 TWh). The costs of failure to substitute for oil in the power sector would be high, both for the region and for the world. Maintaining today's fuel mix would mean an extra 2 mb/d of oil being used in the Middle East's power sector by 2035, representing both a financial drain on the region's fiscal balances (although partly alleviated if oil prices increased correspondingly) and a diminution of its oil exports.

## Oil demand by sector

Oil demand responds in large part to three variables: the level of economic activity in each sector; the efficiency levels of the end-use transformation process; and the economical and commercial availability of alternatives to oil. Government levers act primarily on the latter two and they have increasingly been used to contain rapidly rising import expenditures, to diminish the environmental impact of oil use or, in some instances, to expand the country's ability to export oil. The measures introduced by governments range from efficiency standards to fuel pricing policy, from modal shifts in transport to encouraging fuel switching (Table 15.3). All these measures play a role in our oil demand projections, with improvement in efficiency being the most important in the New Policies Scenario (Figure 15.6). The increase in vehicle ownership, industrial activity and number of dwellings would imply, other things being equal, a growth in oil demand over the level in 2012 of 46 mb/d. But anticipated efficiency improvements, resulting from both policy interventions and technological improvements, curb 45% of this consumption growth while delivering the same level of service. Fuel switching also plays an important role, displacing almost 12 mb/d of oil consumption.

**Figure 15.6 ▷ Impact of fuel switching and efficiency on global oil demand in the New Policies Scenario**




The degree to which oil can be substituted varies according to the service demanded and sector concerned. Over the last few decades, oil has lost market share to other fuels in providing heating services in buildings and for power generation, for reasons of both cost and – except where replaced by coal – environmental impact. Today, oil meets only a small share of total energy use in these sectors and its share is expected to decline even further in the future.

**Table 15.3 ▷ New policies in 2012/2013 with a potential impact on oil demand**

| | Sector | New policy measures |
|---|---|---|
| **United States** | Transport efficiency | Intention announced to increase fuel-economy standards for heavy-duty vehicles beyond 2018. |
| | Industry | The Boiler MACT (Maximum Achievable Control Technology) Rule is an emissions standard that requires industrial, commercial and institutional boilers, and process heaters located at major sources to meet specific emissions limits for hazardous air pollutants. |
| **Canada** | Transport efficiency | Proposed extension of emissions standard for passenger and commercial light-duty vehicles beyond 2016, requiring an annual reduction in greenhouse-gas emissions of 3.5-5% to 2025. |
| **European Union** | Transport efficiency | Agreement on emissions standards for new cars of 95g $CO_2$/km by 2020. |
| | Transport fuel switch | Proposed Clean Fuel Strategy, with provision for certain levels of infrastructure for clean fuels. |
| **China** | Subsidies reform | Energy price reform, including more frequent adjustments in oil product prices and an increase in the price of natural gas by 15% for non-residential consumers. |
| | Industry | New large industrial facilities must satisfy energy efficiency assessments as well as environmental assessments. |
| **Brazil** | Transport efficiency | Inovar-Auto programme approved that requires car manufacturers to produce more efficient vehicles in order to qualify for a tax discount. |
| **India** | Subsidies reform | In January 2013, state fuel retailers were allowed to start increasing the price of diesel on a monthly basis until it reaches market levels and the price cap on liquefied petroleum gas cylinders was raised. Plans were adopted to nearly double natural gas prices from April 2014, and to revise them quarterly until 2017. |
| | Transport fuel switch | National Mission for Electric Mobility adopted, targeting 6-7 million vehicles on the road by 2020. |
| **Indonesia** | Subsidies reform | Increased price of gasoline by 44% and diesel by 22% in June 2013. Promotion of natural gas use in transport to reduce oil subsidies. Continuing successful kerosene-to-LPG conversion programme, which started in 2007. |
| **Iran** | Subsidies reform | In January 2013, subsidised gasoline for cars with engines of 1 800 cubic centimetres and above was discontinued, and sales of subsidised gasoline restricted near border areas. |

Nonetheless, today oil remains the dominant fuel in providing mobility, in particular in road transport, aviation and navigation. In the case of road transport, oil-based fuels still account for around 95% of total energy use – a share that is barely lower than in 1971 – due to practical and economic barriers to the deployment of alternative fuels. The industry sector also remains a substantial consumer of oil – one-fifth of global oil consumption – both as an energy source and for non-energy uses (mainly as a feedstock for production of petrochemicals).[2] In this section, we review the scope for substitution of oil in the different sectors and examine in more detail the prospects for oil use in transport and in petrochemicals.

**Table 15.4 ▷ Oil demand by sector in the New Policies Scenario** (mb/d)

| | 2000 | 2012 | 2020 | 2025 | 2030 | 2035 | 2012-2035 | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Delta | CAAGR* |
| **Total primary oil demand** | **76.3** | **87.4** | **95.4** | **97.8** | **99.5** | **101.4** | **14.0** | **0.6%** |
| Power generation | 5.7 | 5.5 | 4.1 | 3.4 | 2.9 | 2.7 | -2.7 | -3.0% |
| Transport | 38.4 | 46.7 | 52.7 | 54.9 | 56.9 | 58.8 | 12.1 | 1.0% |
| Petrochemicals | 9.7 | 11.9 | 13.7 | 14.5 | 15.0 | 15.5 | 3.6 | 1.2% |
| of which feedstock | 8.2 | 10.6 | 12.4 | 13.1 | 13.6 | 14.1 | 3.5 | 1.2% |
| Other industry | 5.1 | 5.1 | 5.5 | 5.5 | 5.4 | 5.3 | 0.2 | 0.1% |
| Buildings | 7.9 | 7.6 | 7.5 | 7.2 | 6.9 | 6.6 | -1.0 | -0.6% |
| Other** | 9.5 | 10.6 | 12.0 | 12.2 | 12.4 | 12.4 | 1.8 | 0.7% |

* Compound average annual growth rate. ** Other includes agriculture, transformation, and other non-energy use (mainly bitumen and lubricants).

Two sectors – transport and petrochemicals – drive growth in oil consumption out to 2035 (Table 15.4). Transport oil demand grows by 12 mb/d and consumption in the petrochemicals sector (most of it for feedstock purposes) rises by 3.6 mb/d. All other sectors (except non-energy use) are stable or in decline. All of the net increase in transport demand occurs in non-OECD countries; oil use for transport falls in all three OECD regions, thanks to efficiency gains and, to a lesser extent, switching to other fuels. By 2035, oil use in transport and in petrochemicals accounts for three-quarters of global consumption, six percentage points higher than their share today. Although transport accounts for the largest share (58%) in 2035, petrochemicals use (more than 15 mb/d in 2035) is larger than today's oil demand for all purposes in China, India and Indonesia combined.

## *Transport*

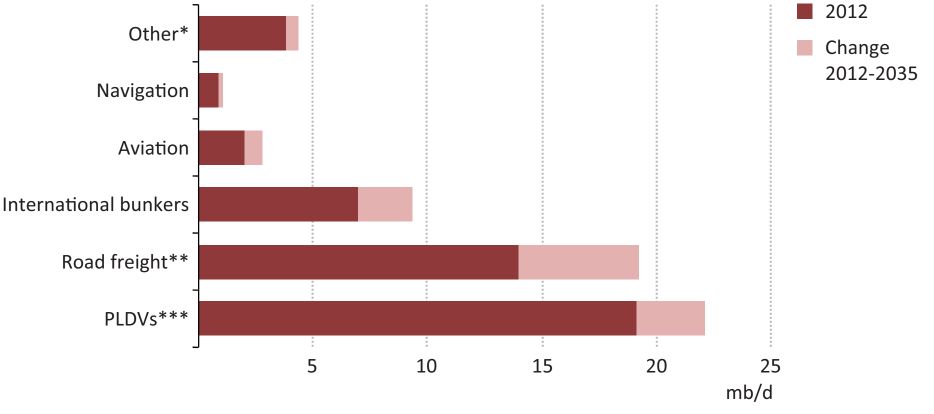
### *Modal trends*

PLDVs are the leading component of transport oil demand and this is projected to remain the case in 2035 in the New Policies Scenario, even though road freight and aviation grow at faster rates (Figure 15.7). Of the total increase in transport oil demand, PLDVs account for around one-quarter, as oil use by PLDVs rises from 19 mb/d in 2012 to 22 mb/d in 2035. Road freight accounts for nearly 45% of transport oil demand growth. Developing

2. In the remainder of the chapter, if not explicitly mentioned otherwise, oil use in the industry sector is understood to include the use of oil as a petrochemical feedstock.

Asia contributes around two-thirds of this growth. In energy tems one-third of global net oil demand growth arises from the use of oil in road freight trucks and light-commercial vehicles in developing Asia alone. Demand for international marine and aviation bunkers, predominantly heavy fuel oil and jet kerosene, grows at a rate of 1.3% per year, from 7 mb/d in 2012 to 9.3 mb/d in 2035 and accounts for about 20% of transport oil demand growth. Aviation accounts for another 7% of transport oil demand growth, its growth rate averaging 1.5% per year between 2012 and 2035, faster than that of any other mode of transport.[3]

**Figure 15.7 ▹ World oil demand for transport by sub-sector in the New Policies Scenario**



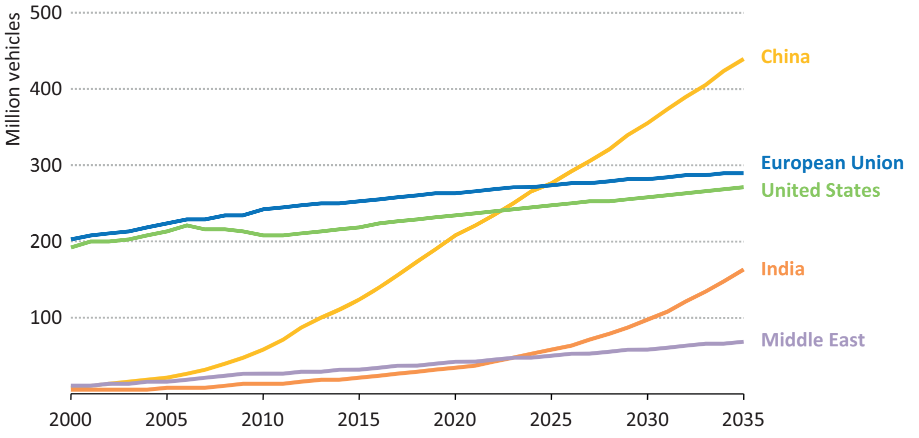

* Includes other road, rail, pipeline and non-specified transport. ** Includes light-commercial vehicles and freight trucks. *** Passenger light-duty vehicles.

Demand for oil to run PLDVs is determined not just by the underlying demand for personal mobility (which reveals itself in the number of vehicles in circulation and the average distance driven), but also by the choice of fuel or vehicle technology and the fuel efficiency of the vehicle. The PLDV fleet worldwide is projected to expand from around 900 million in 2012 to over 1.7 billion in 2035. Most of this growth comes from non-OECD countries (Figure 15.8), a trend which is also reflected in the figures for PLDV oil use across regions. These fall in all parts of the OECD, reflecting saturation of the car market, tightening fuel-economy standards and increasing fuel substitution; but they rise rapidly in many other parts of the world, alongside rising levels of car ownership. Most of these new cars are oil-powered (gasoline, diesel and liquefied petroleum gas [LPG]), but biofuels, natural gas and electricity claim a growing share of the PLDV stock over the projection period. Our projections incorporate major improvements in the fuel efficiency of PLDVs (including wider use of hybrid vehicles), stimulated by a combination of high international oil prices and

3. Aviation here refers to domestic aviation, *i.e.* it excludes international aviation. International aviation is referred to as international aviation bunkers in IEA statistics.

government initiatives (including the removal of subsidies, the imposition of fuel-economy standards and efficiency labelling, financial incentives, and research and development), which greatly reduce the overall increase in oil demand for road transport. The average PLDV on the road in 2035 in the New Policies Scenario consumes around 30% less fuel than today.

**Figure 15.8 ▷ PLDV vehicle fleet growth by region in the New Policies Scenario**




Oil consumption by road freight vehicles worldwide is boosted by rising economic activity and the more limited scope for switching away from oil-based fuels in heavy-duty vehicle (HDV) engines. Freight tonne-kilometres (freight-mass times the distance over which it is transported by road) is expected to remain correlated with economic growth. This link gradually weakens in some advanced OECD countries, but there are relatively few opportunities (via rail or inland waterways) to move freight off the road. Road freight demand for oil jumps from 14 mb/d in 2012 to more than 19 mb/d in 2035 in the New Policies Scenario. While improved fuel economy of HDVs means that fuel demand grows less rapidly than freight activity, the lack of targeted and well-designed efficiency policies to reduce fuel consumption in many countries is still a major barrier to a more widespread dampening of demand growth in this sector (IEA, 2012).

Oil use in road transport will continue to be dominated by gasoline and diesel. In the New Policies Scenario, the share of gasoline (used to a large extent in PLDVs) falls from 57% in 2012 to 50% in 2035 – while the share of diesel rises from 41% in 2012 to 47% in 2035 mainly because of the rapid rise in diesel use for HDVs. Autogas – LPG used as an automotive fuel – currently accounts for the remaining 1.6% of road-transport oil use, a share that is expected to increase only modestly over the *Outlook* period (see section on demand by product).

**Box 15.1 ▷ Could the world ever fall out of love with the automobile?**

In our projections, vehicle use (*i.e.* the kilometres driven per car) grows broadly in line with increasing income, moderated by price effects – the historical pattern. There is another school of thought, however, known as "peak car", which implies that car use will eventually peak – or has already peaked in some advanced economies. While the idea of peak car is not new, it has gained increasing attention in recent years, as statistical data in some countries (and especially in cities) indeed shows, at least, a reduction in the growth of car use (Goodwin, 2012).

Despite a great interest in this phenomenon, the forces at work are less well understood. While the changes observed in recent years may well be explained by the economic recession and increasing fuel prices, the reasons could be somewhat more structural and be explained by cultural, social and policy considerations. These include, but are not confined to: improved availability and comfort of public transport; greater reliance on social media; reactions to congestion; difficulties related to parking; and insurance and fuel costs. In some OECD countries, there may be a more general perceived decline in the attractiveness of suburban lifestyles and a desire to shift back into more concentrated urban living. Recent work on the demographics of licensed US drivers shows that the share of young people holding driving licenses is considerably lower than 30 years ago (Schoettle and Sivak, 2013) and that young people in the United States increasingly use alternative means of transportation, in part as a matter of preference (Davis and Dutzik, 2012).

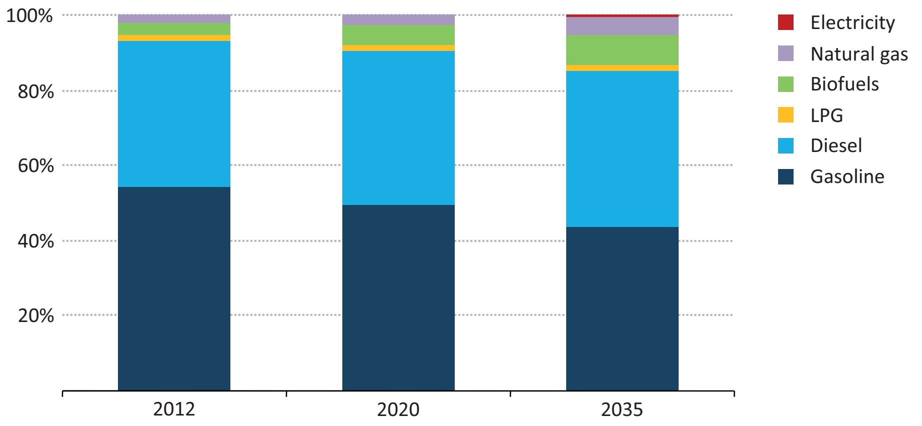
The question whether this phenomenon of peak car exists cannot easily be answered, and there is almost certainly not one single reason for the observed changes in car use patterns. But this topic deserves attention, particularly in advanced economies, as it could have an impact on projected levels of oil demand. In developing countries the projected pace of growth of the vehicle stock is probably of greater uncertainty to future oil demand than the extent of changes to the average level of car use: in the event that PLDV motorisation in non-OECD countries were to grow 1% faster per year than the projected level of 4.3%, then this would add 3.4 mb/d to the global oil consumption in 2035 (assuming all else equal). But the downside also holds true: if growth were 1% slower per year than projected, global oil demand in 2035 would be 2.7 mb/d lower.

### *The impact of alternative fuels on transport oil demand*

The rate of penetration of alternative fuels and technologies is a key factor affecting oil use in all modes of transport. While oil has been largely replaced in stationary uses of energy, it remains king in transport – partly because alternative fuels, for the most part, have so far proved unappealing to end-users. The leading alternative to petroleum fuels today is biofuels, their use being led by the United States and Brazil. In most cases they are blended into conventional gasoline or diesel, requiring no change to the vehicle if mixtures are kept within certain limits (see Chapter 6 and the special focus on Brazil, Chapters 9-12).

In the New Policies Scenario, we project biofuels use in road transport to expand from 1.3 million barrels of oil equivalent per day (mboe/d) in 2012 to 4.1 mboe/d in 2035. Their share of total road-transport energy use increases from 3% to 8% over the same period (Figure 15.9). The projections for biofuels in the New Policies Scenario are contingent on continued government support, largely through blending mandates and subsidies. But the use of biofuels has come under critical scrutiny in recent years in many countries, owing to the direct and indirect impacts on other agricultural uses for the land, uncertainty about the actual greenhouse-gas savings that biofuels offer, doubts about the feasibility of reaching supply targets in view of blending restrictions (*e.g.* the "blend wall" debate in the United States), the acceptability of biofuels to consumers, delays in achieving commercial feasibility of advanced biofuels and the costs associated with various forms of biofuels support. This has led us to revise our biofuels projections downward, compared with *WEO-2012*, although we have assumed that government support remains widespread.

**Figure 15.9 ▷ Fuel mix in road-transport energy demand in the New Policies Scenario**




Note: Shares for oil products are calculated on a volumetric basis; the contributions of other fuels are shown as equivalent volumes of the oil product that they displace.

Beyond biofuels, the main alternatives to oil as a transport fuel in the medium- to long-term are natural gas (in compressed or liquefied form) and electricity (in plug-in hybrids and battery-electric vehicles). Both options require a fundamental change in vehicle technology or refuelling infrastructure, or both. Another possibility is hydrogen used in fuel cells installed in the vehicle, but they do not play a significant role in meeting transport energy needs worldwide in the New Policies Scenario within the timeframe of our projections, given the technical and economic barriers.

Natural gas is currently seen as the most promising alternative, given the abundance of its availability, often at low prices. Moves are underway to use gas in various transport sectors. Liquefied natural gas (LNG) can be used as a locomotive fuel for trains: in North America, the General Electric and Caterpillar companies are developing a LNG-powered engine, and

BNSF – the largest rail company in the United States – is testing the technology. But, even if the results are positive, large-scale deployment will take time and volumes will be small, due to the small size of the rail market (global oil demand from rail was 0.6 mb/d in 2012). The use of LNG in rail is not expected to make a significant dent in oil demand over the projection period.

LNG can also be used as a fuel for maritime navigation. Stricter emissions regulations, as proposed by the International Maritime Organization (IMO), could stimulate a switch away from heavy fuel to alternatives, among which LNG is likely to be prominent. A new supply infrastructure would be required in the world's major ports, so, for the moment, we have adopted a cautious view about the extent of LNG use in the maritime sector. This reaches just over 5 billion cubic metres (bcm) in 2035, displacing 90 kb/d of oil.

In terms of volumes, road transport is the most attractive sector for the use of natural gas. Today, natural gas accounts for just 2% of total energy use in road transport, and this use is highly concentrated in just a few countries: Iran, Pakistan, Argentina, Brazil and India account for 68% of the global natural gas vehicle (NGV) fleet.[4] In most other countries, natural gas for transport use is minimal, but moves are afoot to expand its use, particularly in North America, where a large price differential with liquid fuels has emerged. Historical evidence from countries where NGVs successfully entered the market (such as Pakistan, Iran or India) or failed to do so (like New Zealand) suggest that, besides the availability of natural gas resources and/or an extensive network of gas pipelines, long-lasting and targeted policy support is essential in order to overcome initial hurdles to investment – including insufficient refuelling infrastructure and higher investment costs per vehicle. Our projections in the New Policies Scenario assume a generally supportive policy environment for NGVs, although this varies by country and region. Global sales of NGVs increase four-fold over the period to 2035 and the share of natural gas in the road-transport market reaches 2.8% in 2020 and 4.8% in 2035.

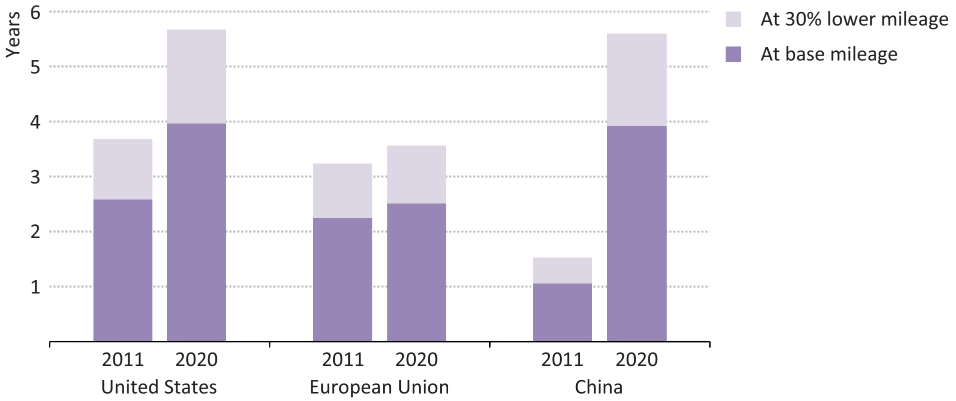
Natural gas can be used in liquefied form or as compressed natural gas (CNG) in road vehicles. Depending on the application, it would replace diesel (if used *e.g.* in trucks) or gasoline (if used in PLDVs). CNG has a lower energy density than LNG, making it a less attractive substitute for diesel in long-haul trucks, as the fuel tank occupies too much space and adds too much weight. LNG is therefore considered a more viable option than CNG for long-distance trucks, despite the higher upfront cost of building LNG refuelling infrastructure and the vehicle itself. CNG is often considered more attractive for PLDVs or local-service fleet applications, such as buses and refuse trucks (that can benefit from centralised refuelling), although the development of a refuelling network for PLDVs in densely populated regions, such as Europe, could, in theory, also facilitate an uptake of CNG for long-distance trucks.

In North America, growth in natural gas use for road transport is expected to come primarily, at least in an initial phase, from HDVs. Around half of all sales of new waste collection trucks and a large proportion of new buses in the United States today are CNG-fuelled, a share

4. Detailed statistics on NGV fleets can be found at *www.iangv.org/current-ngv-stats/*.

that is likely to climb further in the coming years. In addition, a number of North American road-haulage companies are considering switching to LNG as an alternative to diesel for long-haul trucking. In North America, LNG may be a financially attractive option, as the higher initial cost of an LNG truck, compared to a conventional vehicle (of up to $75 000), and the additional safety precautions and training required in using LNG can be recouped over time by the fuel-cost savings: the payback period is currently estimated at around two to four years for long-haul trucks, though it is sensitive to the number of miles travelled, the price differential between diesel and LNG, the incremental cost of the vehicle and its residual value (Figure 15.10). Such payback periods are attractive for large fleet operators with adequate financial means for the required upfront investment and who can justify investment in a centralised refuelling network. But, for many companies, shorter payback periods will probably be necessary to entice them to make the switch. In the United States, most trucking companies are very small, with limited financial resources and borrowing power, and so may be reluctant or simply unable to adopt what is still a relatively unproven technology.[5] Where trucks are often operated on average only six to eight years, payback periods must be low to justify the investment.

**Figure 15.10 ▷ Estimated payback periods of LNG-powered long-haul trucks in selected markets, 2011 and 2020**




Notes: Assumes annual base mileage of 200 000 km (United States), 130 000 km (European Union) and 160 000 km (China). Gas prices for the European Union and United States are IEA domestic end-user prices for the services sector (including taxes), assuming a distribution cost of $2.5 per million British thermal units (MBtu) and an additional liquefaction cost of $3/MBtu for the United States. For China, LNG prices are assumed to be 60% of gasoline end-user prices for 2011, and 75% for 2020. The cost premium for LNG trucks is assumed to be $75 000 (United States), $55 000 (European Union) and $20 000 (China) in 2011. For China, it is assumed that this cost increment rises to EU levels in 2020 due to a transition from gasoline-type engines to diesel-type engines for LNG trucks. Generally, regional cost differences reflect different typical truck types and sizes; no subsidies are assumed.



The establishment of a viable LNG market in North America is hampered by a dilemma over investment (Box 15.2): who invests first, those building the infrastructure or those buying

5. According to the American Trucking Association, 97% of the more than 620 000 registered companies operate fewer than 20 trucks.

the vehicles? The business model being envisaged to solve this problem involves retailers building refuelling stations along corridors of major truck use, to limit initial infrastructure construction costs, and to target a small number of high-volume fuel users, such as large, long-distance fleet operators. Several partnerships between HDV fleet operators, including some leading courier companies and LNG retailers, have been announced recently and a number of refuelling points have already been built along some routes. Initial investment requirements for LNG refuelling stations can be significantly higher than those for diesel stations and, as the range of single-tank LNG trucks is, typically, only half of that of diesel trucks, the refuelling infrastructure density has to be higher than for conventional vehicles to accommodate large LNG truck fleets (TIAX, 2012).[6] Initial volumes are therefore set to be small, and regionally concentrated, but, if pilot programmes are successful, the market could grow rapidly in the coming years. We project LNG and CNG use in road transport to grow quickly in the United States, but it still accounts for just 0.7% of total fuel use in road transport in 2020, displacing around 70 kb/d of oil use, and 5% in 2035 (450 kb/d). Additional policy support for the deployment of NGVs, wider price differentials than we assume and/or lower NGV construction costs could lead to a much bigger shift to gas.

### Box 15.2 ▷ Of chickens, eggs, trucks and cars

A major barrier to the creation of a market for natural gas as a fuel for road vehicles is the classic chicken-and-egg dilemma: vehicle owners are discouraged from buying an NGV until refuelling stations are available, while potential fuel retailers are reluctant to invest in new gas fuel pumps until demand for the fuel is high enough to yield an acceptable return on investment. Other than through government intervention, overcoming this dilemma requires a gamble by either the retailers or consumers on the demand or supply materialising, or active collaboration between the retailers and large potential consumers to guarantee a market. This is easier in the case of HDVs, where large road-haulage companies can get together to agree with bulk fuel retailers on infrastructure investments. In the LDV market, there are more players on both the retail and vehicle sides, making co-ordination much harder, though large LDV fleet operators with high mileage and established routes may be able to negotiate a deal with one or more large retailers. Gas use in transport in new markets, such as the United States, is likely to be driven primarily by long-distance HDVs, which means that gas will probably be sold largely as LNG rather than CNG.

Natural gas has the potential to make significant inroads into oil use for road transport in China, too. The number of NGVs in China has increased sharply over the last few years, reaching around 2 million at the end of 2012, most of which were CNG light-duty vehicles (LDVs) – many of them taxis, which drive around 300 kilometres a day on average. But the use of LNG is also increasing: at end-2012, there were an estimated 71 000 LNG vehicles on the road in China and over 800 LNG refuelling stations. LNG trucks constitute about 60%

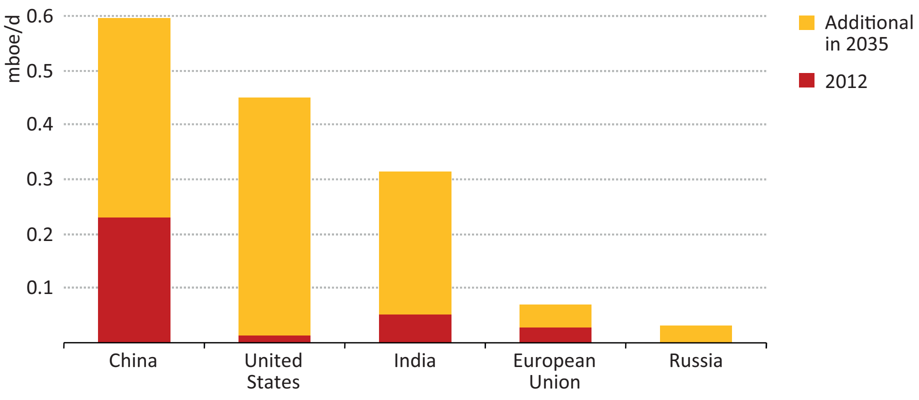
6. A possible solution is dual-tank trucks, but they carry significantly higher upfront investment costs.

of this stock, with much of the remainder being inter-city buses. The sales of LNG HDVs in China increased by 60% in 2012.

The purchase of an LNG long-haul truck in China breaks even after only about one to two years at current prices and average mileage, despite prevalent use of gasoline-type engines in China's LNG trucks today (which entails a very high fuel consumption penalty). For taxis, breakeven has been reported to be of the order of a few months only. However, payback periods are set to rise sharply with the current roll-out of gas-pricing reforms, which are expected to lead to a significant increase in natural gas prices in most regions. On an energy-equivalent basis, the cost of gas at present is around 60% of 90-RON gasoline, but the central government plans to raise this to around 75%. Nonetheless, the central government remains committed to the use of LNG in HDVs in order to curb the growth in oil demand and imports, for energy security reasons and, more urgently, to reduce tailpipe emissions of soot and other pollutants in response to worsening urban pollution. In addition, a growing number of provincial and city governments are providing financial support for LNG refuelling infrastructure and vehicle manufacturing.

In the New Policies Scenario, we project a continuing increase in China's use of natural gas for road transport through to 2020, driven mostly by CNG use in taxis and urban buses, but also by LNG use in HDVs. Demand grows more slowly thereafter, as we do not yet expect significant growth in CNG use in the passenger vehicle segment, which is the major segment of the growth in road-transport energy demand in the latter half of the projection period. By 2035, natural gas demand in China's road transport sector reaches almost 0.6 mboe/d, around three times higher than today's levels (Figure 15.11).

**Figure 15.11 ▻ Natural gas demand for road transport by selected regions in the New Policies Scenario**




In Europe, gas use in transport is projected to grow more slowly than in the United States or China, despite policy moves to promote a range of alternative fuels and the fact that taxes on diesel and gasoline are high, implying a relatively low payback period on purchases of natural gas-fuelled vehicles. An estimated 14% of the 100 000 refuse trucks and urban buses in Europe already run on CNG and further penetration of this sector by gas is likely.

15

But the use of CNG in PLDVs at a larger scale is so far confined to a few countries like Italy or Sweden, as the lack of a widespread availability of refuelling stations reduces the attractiveness of CNG vehicle for many consumers.

There is significant potential for LNG in the European long-haul HDV fleet, which is still largely fuelled by diesel. But for LNG use to take off, the first requirement is a refuelling network along the main highways. At present, there are only 38 LNG refuelling stations in Europe, and creating such a network would require active government support, in the absence of industrial initiatives. In recognition of this, the European Commission proposed in January 2013 an ambitious package of measures to encourage the development of alternative fuel stations across Europe, including LNG refuelling stations. It is now preparing a directive, but, as this is still a policy area under development, we take a cautious view of the prospects. In our projections, European Union gas use in road transport in the New Policies Scenario climbs from 1.4 bcm in 2011 to around 3.8 bcm in 2035, its share of total road-fuel energy demand rising from 0.4% to 1.3%. Gas displaces around 70 kb/d of oil by 2035, compared with just 26 kb/d in 2012.

Other countries are also looking at the potential for using natural gas as a road fuel. Russia's Gazprom has been a long-standing promoter of gas use in transport and is investing in Russian refuelling infrastructure, as well as teaming up with other companies to develop and test CNG vehicles. In India, the NGV fleet – made up largely of CNG-powered buses, taxis and motorcycles – has grown rapidly in recent years, largely thanks to public mandates to switch to the fuel in New Delhi and several other large cities, in response to worsening air pollution. Air quality benefits are the primary justification for policy support for natural gas in transport in many countries (though modern diesel particulate filters reduce the air quality advantage of LNG *vis-à-vis* diesel), and reduced imports of oil can bring energy security and economic benefits too.

We remain cautious about the medium-term prospects for the uptake of electric vehicles (EVs) – plug-in hybrids and battery-electric vehicles – in view of the continuing difficulties in bringing to market commercially attractive models. Sales are rising, but still represent only a small fraction of total vehicle sales (and it will be a major struggle to attain the levels of deployment for 2020 required in the 450 Scenario). A mere 100 000 EVs were sold worldwide in 2012, mostly in the United States and Japan, despite additional measures in many countries to encourage sales. But subsidies and other incentives are so far not big enough to make the price of EVs attractive to most private motorists, and the ambitious targets of several countries are accordingly under critical scrutiny.

At around 100 000 EVs and plug-in hybrids on the road in the United States, the US administration's target, announced in 2011, of putting 1 million EVs and plug-in hybrids on the road by 2015 is distant. In Europe, the European Commission is set to propose measures to promote EVs under its new clean fuel strategy, including mandating a minimum number of recharging points and adopting a standard plug across member states. Among EU member countries, Germany has re-stated its goal of 1 million EVs on the road by 2020, but with just 72 000 sold up to end-2012, it is far from reaching this target. In China, the government is targeting 500 000 EVs on the road by 2015 and 5 million by 2020, but sales amounted to less than 13 000 in 2012, far below the government expectations. In India, a new "National Mission for Electric Mobility" was launched in January 2013, with a target of putting 6-7 million EVs on the road by 2020, of which 4-5 million are expected to be two-wheelers (a proven technology that is already in widespread use in China). A note of caution in relation to EV projections arises from the failure of the world's first large-scale public battery-swap and EV-charging network, developed by Better Place in Israel, which filed for bankruptcy and was subsequently sold, having failed to achieve targeted levels of use.

As with any emerging technology, projecting the expansion of the EV market is extremely difficult. Present sales are low, but several major car manufacturers and premium brands are launching EV models. A large improvement in the performance of batteries and a big fall in their cost could lead to rapid take-off in demand; but without these advances, EVs are likely to remain a niche market. In the New Policies Scenario, global EV sales reach only about 500 000 vehicles in 2020 – far below the aggregate of targets of 7 million around the world – and less than 4 million in 2035. The projected oil savings from EVs globally total around 35 kb/d in 2020 and about 235 kb/d in 2035 – far smaller than those from biofuels or natural gas. In the 450 Scenario, in which the deployment of EVs expands much more rapidly, savings reach 73 kb/d and 1.5 mb/d respectively.

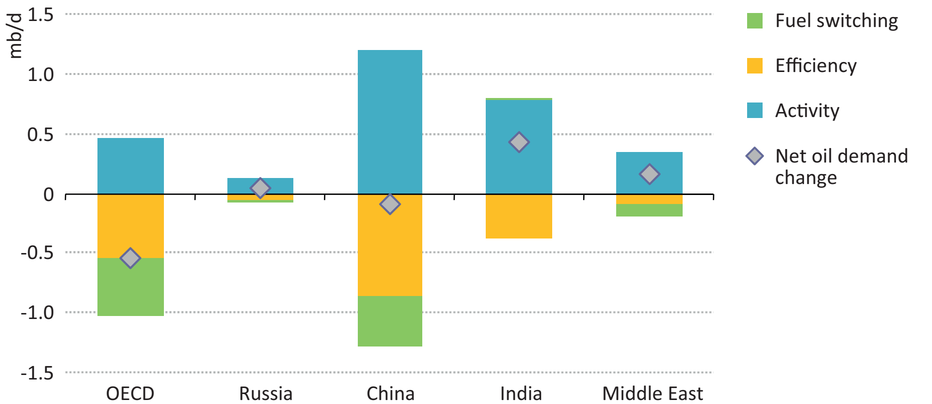
### *Industry*

Every day the global industry sector consumes 17 million barrels of oil products, 19% of total demand. Industry is the second most important oil consumer after transport. The largest share of this oil, 11 mb/d, is used for non-energy purposes, mainly as feedstocks in the petrochemical industry, while the rest is used for steam production, process heat and off-road vehicles. The outlook for the two categories differs in the New Policies Scenario: oil use for petrochemical feedstock use increases by 1.2% per year up to 2035, but oil for heating, steam production and off-road vehicles barely grows at 0.2% per year.

As a source of fuel for the industry sector, oil has to compete against a full range of alternative energy sources and, as oil prices have risen, oil has lost competitiveness in most regions. Natural gas, which has become more widely available, is often preferred to oil for steam production and direct heat, as it is more efficient and cheaper. It is also a cleaner fuel, emitting fewer noxious pollutants and a lower level of carbon dioxide. Where environmental regulations permit, coal has also been substituted for oil, on grounds of cost. For these reasons, global final oil consumption in industry peaked in the late 1970s (before the second oil price shock in 1979) and has since declined substantially. Oil's share of total industrial final consumption of energy has halved since 1980, reaching 13% in 2012. A modest absolute increase in industrial oil use in non-OECD countries over this period was more than outweighed by a sharp fall in the OECD.

We do not expect significant changes in these trends over the projection period. In the New Policies Scenario, industrial oil consumption as a fuel rises slowly in absolute terms over the coming decade, levelling off in the 2020s, but its share of industrial fuel use continues to decline. All of the increase comes from non-OECD countries, with OECD consumption continuing to tail off and, by 2035, oil meets only 10% of industry's energy needs (excluding feedstocks). Efficiency improvements in steam systems and process heat contribute to this slower growth in oil demand (Figure 15.12). A significant portion of industrial oil consumption for non-feedstock purposes is consumed to provide steam, and we project that energy savings of 10-15% are achieved in steam systems over the *Outlook* period, through waste heat recovery, better maintenance and process control. In China, since oil is the most expensive option to provide steam and there still exists large potential for higher energy efficiency, fuel switching (to natural gas) and efficiency gains offset increasing demand for oil. In steam cracking, the core process of the petrochemical industry, large differences in the improvement potential exist between regions, with crackers in the United States using about 30% more energy than those in Japan and Korea (UNIDO, 2010).

**Figure 15.12 ▷ Change of industrial oil demand (excluding feedstocks) by driver in the New Policies Scenario, 2012-2035**




### *Petrochemicals*

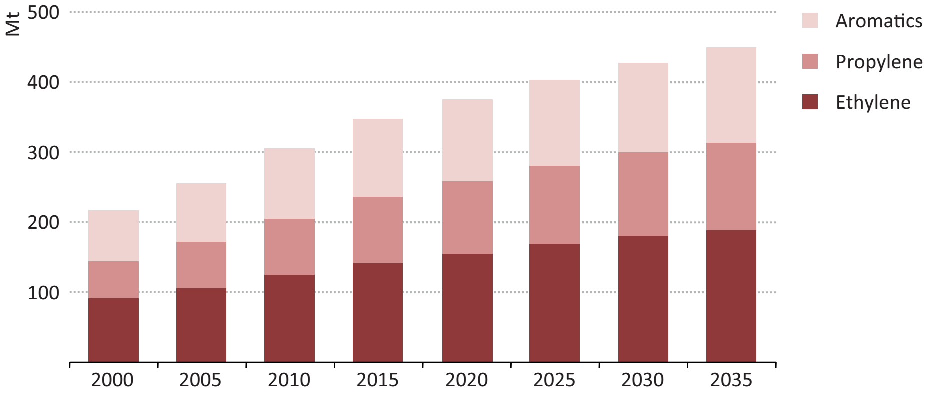
Among energy-intensive industries, petrochemicals are – along with paper – expected to see the fastest growth in output over the projection period, entailing high demand for oil as feedstock. Products in high demand include plastics, fibre and rubber. In the past, plastic products have replaced traditional materials, such as wood, glass or ceramic, for purposes as diverse as packaging, toys, furniture and piping. Given future population and economic growth, together with the relatively low cost of plastics, their versatility and resistance to water, demand for plastic products is expected to be robust (Box 15.3).

In the New Policies Scenario, output of high-value chemicals (HVO)[7] expands by 1.6% per year on average between 2012 and 2035, with ethylene output rising by 1.7% per year. Growth in propylene demand is expected to outpace that of ethylene, with an annual growth rate of 1.9%, primarily due to strong demand for polypropylene, the second most important polymer (Figure 15.13). Demand for ethylene and other petrochemicals had outpaced gross domestic product (GDP) growth until the start of the present century,

7. High-value chemicals include ethylene, propylene and aromatics (benzene, toluene and xylenes).

but has since matched GDP growth more closely. In the New Policies Scenario, this trend continues, with growth in petrochemical demand close to the trajectory of global GDP in the earlier part of the projection period, but then falling lower in the later years. One contributing factor is a rise in the recycling of plastics. This is costly today, compared with disposal in landfills, and policy support is limited, so that global recycling rates are far lower than for other products, such as paper; but positive exceptions exist, such as in Japan. In the latter part of the *Outlook* period, we see recycling playing a more important role on a global scale, supported by technology improvement and stronger policy intervention.

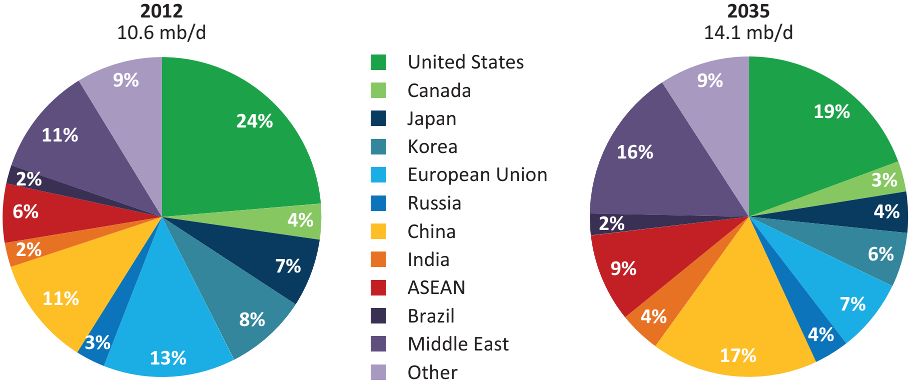
**Figure 15.13 ▷ Production of high-value chemicals in the New Policies Scenario**




The laws of chemistry dictate the feedstock requirements that are needed to support these production increases. On the supply side, the growth in production of natural gas liquids (NGLs) brings with it greater availability of LPG and ethane, both inputs for the petrochemical industry. The expansion of refinery capacity also increases the supply of naphtha as a petrochemical feedstock. These trends result in oil consumption for feedstock purposes increasing from today's 10.6 mb/d to some 14.1 mb/d in 2035.

While the overall outlook is for steady growth in the use of oil-based petrochemical feedstock, there are marked differences across regions (Figure 15.14). Demand is projected to grow rapidly in the Middle East, where the relevant industrial capacity has doubled over the last five years and where we assume that it will double again to 2035. Currently, Saudi Arabia is the dominant petrochemical producer in the region, accounting for roughly 60% of ethylene production, with Iran, Qatar, the United Arab Emirates and Kuwait accounting for most of the remainder. These countries are expected to be the main sources of output growth, with the United Arab Emirates and Qatar seeing the fastest relative increases in production. The expansion of the petrochemicals sector in the Middle East is based on the availability of cheap feedstock: natural gas supply grows by almost 60%, with a corresponding increase in the volume of NGLs, providing a ready source of ethane that makes the region the cheapest global producer of ethylene. However, as petrochemical production increases faster than ethane supply, a gradual shift towards heavier feedstock is projected in the long term.

**Figure 15.14 ▷ Demand for oil as petrochemical feedstock by region in the New Policies Scenario**



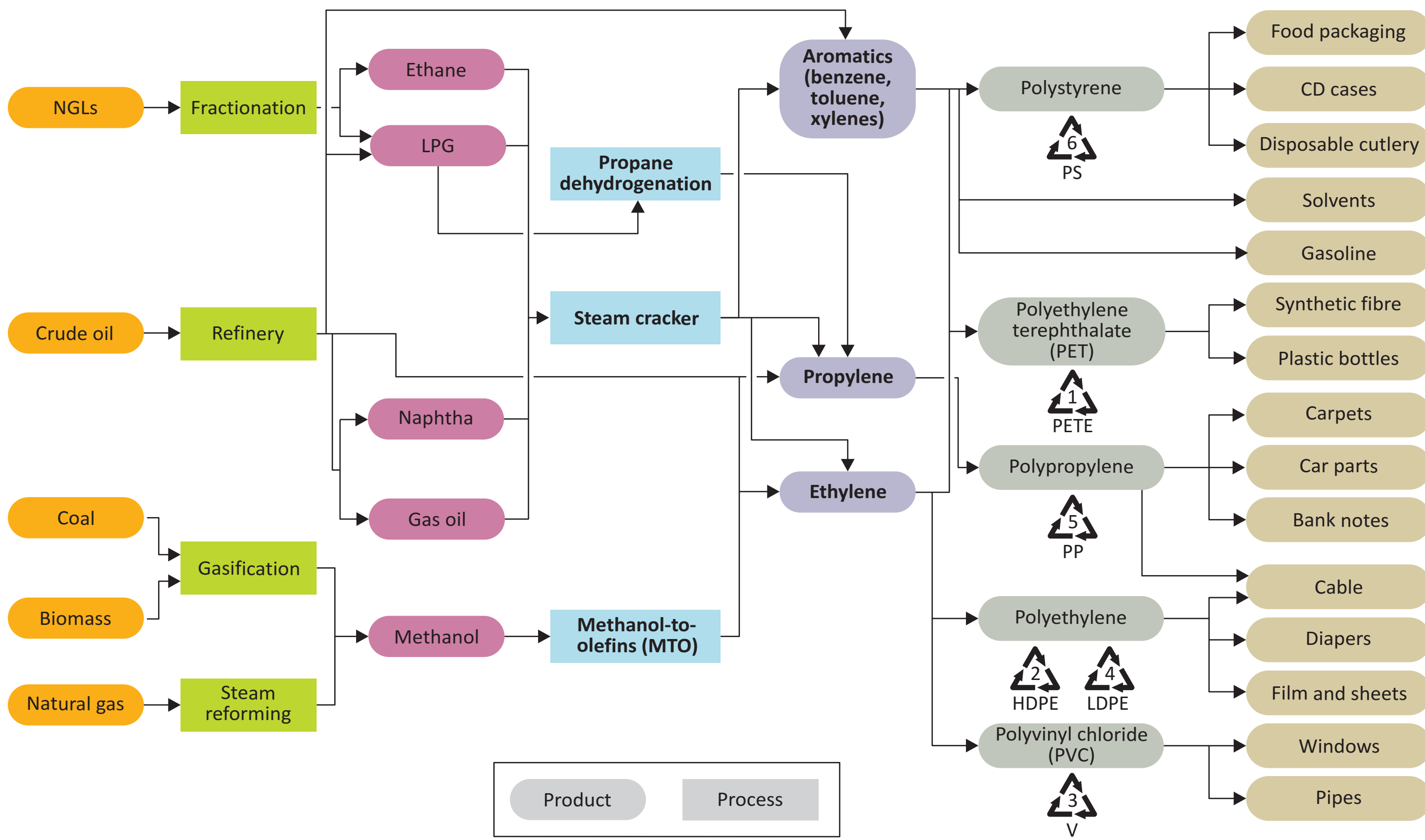

### Box 15.3 ▷ A guide to petrochemicals

Petrochemicals are chemical products traditionally derived from crude oil, though some chemical compounds are nowadays also obtained from coal and biomass. The main feedstocks are naphtha, LPG (propane and butane), ethane and diesel (gasoil). In our modelling, we track production of the major, high-value petrochemical building blocks, divided into two broad categories: olefins, including ethylene and propylene; and aromatics, including benzene, toluene and xylenes. These petrochemical products come mainly from steam cracking and oil refining and are further processed, sometimes in combination to produce a range of plastics, synthetic rubbers, resins, fibres and solvents, which are used in a variety of household and industrial applications, such as plastic bottles, clothing, paints and automobile parts (Figure 15.15).

The petrochemical industry is highly energy-intensive, requiring a large amount of energy both in the production process for heat and as feedstock. Steam cracking – the key petrochemical process – and other conversion processes are carried out in large plants in order to profit from economies of scale. The choice of feedstock is determined by availability and price, as well as the desired range of products: yields vary according to the mix of feedstock. For example, one tonne of ethane yields 0.80 tonnes of ethylene, while the yield of ethylene from naphtha is 0.32 tonnes and from propane 0.47 tonnes. Propane and naphtha also produce propylene and other chemicals as by-products, but ethane produces almost no by-products.

Recently, alternative process routes have gained in importance. These include methanol-to-olefins (MTO), a process that yields ethylene and propylene, via a catalytic process, from methanol. The methanol can be produced from a variety of feedstocks, including natural gas, oil, biomass and, particularly in China, from coal (coal-to-olefins). Another alternative is bio-based olefin production; Braskem started the first polyethylene plant based on renewable feedstock in Brazil in 2010 and several bio-plastic plants, for example to produce polylactic acid, are in operation that produce polyesters directly from maize or other biomass types, instead of producing olefins first.

**Figure 15.15 ▹ Simplified principal petrochemical product chains**



Emerging petrochemical producers in Asia, particularly China, the ASEAN countries and India also see substantially higher oil feedstock consumption, driven by a rapidly increasing demand for plastics. Currently the region as a whole is a net importer of petrochemical intermediate products, but the anticipated increase in domestic production capacity reduces this dependence on imports over the coming decades. Under the 12th Five-Year Plan, China is targeting an increase in ethylene production capacity of 27 million tonnes (Mt) by 2015, an addition of 11 Mt compared with 2011, equivalent to the entire capacity of Germany and the Netherlands combined. Driven by close proximity to the big Chinese market and the ASEAN-China free-trade agreement, oil demand for petrochemical feedstocks almost doubles in ASEAN countries. Growth is anticipated to be held back somewhat in India (despite increasing demand for plastics) by slow licensing procedures for new capacity and tariff barriers for imported equipment.

Among the OECD markets, the United States is the only one that is able to increase petrochemical production. As in the Middle East, this is based on the availability of ethane from increasing production of NGLs, the prospect of cheap feedstock having spurred a wave of interest in new ethylene and derivate processing plants (Box 15.4). Up to 11 Mt of new ethylene capacity is planned, but we anticipate that, due to limited ethane supply, only around half the amount results in additional production through to 2020. This, nonetheless, represents a 20% increase over current production. Most of the output from the new US petrochemical plants, as well as the surplus propane and butane from NGLs, will be exported. Ethane could also be exported to Europe or Asia, but there are several obstacles to overcome: the ethane would have to be liquefied, with costs similar to those of LNG liquefaction (moreover, most of the steam crackers in Europe run on naphtha and very few on ethane). It is far more economical to transport plastics.

The shift from heavier feedstocks, such as naphtha, towards ethane has put other petrochemical streams, including propylene and aromatics, at a disadvantage. This has resulted in lower propylene production from steam crackers in the United States (by some 2 Mt per year, a fall of around 25%), leading to higher and more volatile propylene prices and encouraging investment in on-purpose production of propylene, based on LPG. Over the longer term, post-2020, growth in petrochemical production in the United States is expected to level off and then fall, as a consequence of increasing feedstock prices and a tighter ethane balance.

In contrast to the outlook for the United States, Europe sees a 25% drop in demand for oil-based feedstock in our projections and Japan a fall by 20%, driven by weak domestic demand and relatively high feedstock prices. Production in Europe and Japan is mainly based on expensive naphtha from refineries, which makes these regions the highest cost producers in the world. Refinery runs in these regions are expected to decline, reducing the availability of naphtha, entailing the closure of several steam crackers. The petrochemical industry in the far east and Europe is suffering from a significant disadvantage in terms of feedstock costs and can limit the negative effects only by further increasing efficiency, considering refinery integration and moving to higher value products (see Chapter 8).

South American petrochemical production, dominated by Brazil, sees a production increase though the region remains a minor producer. A substantial portion of the increase in petrochemical capacity is projected to be built after 2020 when Brazilian oil and gas production is expected to increase. Brazil is a pioneer in the commercial production of ethylene and plastics from biomass, with a first plant built in 2010 and a second expected to come onstream in 2015. Production costs are still high, compared with conventional technologies, which accounts for its limited growth in our projections.

### Box 15.4 ▷ Is cheap coal the Chinese answer to cheap gas in the United States?

The United States has enjoyed an impressive surge in natural gas production from unconventional sources over the past five years, making it the world's leading gas producer (see Chapter 3). As a consequence of rising NGLs production, ethane output surged to around 1 mb/d and its price dropped to below $5 per million British thermal units (MBtu) at the start of 2013, from as high as $20/MBtu in 2008. With feedstock costs accounting for roughly 75% of total petrochemical production costs, the availability of ethane at these prices has made the United States the world's second lowest-cost producer of ethylene, after the Middle East. The improved outlook for such an important industrial sector has prompted many governments around the world to examine whether and how they might replicate, at least in part, the experience of the United States.

In our projections, unconventional gas does not play a major role in the Chinese energy balance until well into the 2020s. But China has another feedstock that is both cheap and readily available: coal. Given oil prices in the range of $120 to $130/barrel in the longer term, and domestic coal prices in China of less than $100/tonne in the New Policies Scenario, coal-to-olefins (CTO) plants have a distinct cost advantage in China compared to oil-based petrochemicals. This represents a potential source of industrial advantage that China is expected increasingly to develop, as well as a way to slow the rise in oil imports.

China already has large coal-to-methanol facilities and the expansion of CTO plants is well underway: the first propylene plant to use coal opened in 2010 and three CTO plants have been added since, resulting in total capacity for olefins production of 2 Mt per year. Another 2 Mt of olefin capacity is under construction and we see 10 Mt coming online within the next five years, by then accounting for more than one-fifth of China's total ethylene production and curbing the increase in oil demand by about 300 kb/d. Unlike ethane-based production in the United States, coal-based production can be adjusted to yield the required ethylene-to-propylene ratio. There are limits, however, to the scope for expansion: after 2020, difficulties over access to water and concerns about the environmental impact of such projects – they are both water and carbon-intensive – are likely to constrain further investment.

### *Other sectors*

*Power generation*

Oil has been largely displaced by other fossil fuels, nuclear power and/or renewables in the power generation sector in most countries. Where it is used, it often serves to provide back-up power in the event of a shortfall in capacity or to meet peak load. Globally, the use of oil to generate electricity in steam and gas turbines dropped by one-fifth between 1990 and 2012, to just 5.5 mb/d, and it is projected to fall by half to 2.7 mb/d by 2035 in the New Policies Scenario. Diesel is expected to account for a growing share of the oil that is still used for power generation, as old baseload steam-boiler plants that burn heavy fuel oil are retired over the projection period. As noted previously, a few countries do burn significant volumes of oil in power stations at present, notably Saudi Arabia, where shortages of gas have forced power generators to turn to burning heavy fuel oil or crude oil directly. Other oil-producing countries, mainly in the Middle East, at present burn significant volumes of oil for power, often in stations with very low thermal efficiency, because it is heavily subsidised. In 2035, just under half of projected oil-fired production is in the Middle East.

*Buildings*

Energy is used in residential, commercial and public buildings in a variety of ways, including for space and water heating, air conditioning, lighting, electrical appliances and equipment. Oil products are used almost exclusively for heating and cooking, for which alternatives are often available – notably natural gas and electricity. In most instances, piped natural gas is preferred to oil in areas served by a distribution network, for reasons of convenience and cost. For this reason, the share of oil in energy use in the buildings sector worldwide has been falling steadily since the 1970s, it was 15% in 1990 and just 11% in 2012. In the New Policies Scenario, the share falls further to 7% in 2035, with consumption in absolute terms falling slowly through the projection period. This entire decline is in OECD countries; consumption continues to rise marginally in non-OECD countries, due mainly to growing demand for LPG in the residential sector, especially in rural and peri-urban areas that cannot be served economically by natural gas networks.

## Oil demand by product

The different trends in energy and oil demand across transformation and final end-use sectors naturally determine the outlook for the different types of oil products that make up overall oil supply. For this year's *Outlook*, we have expanded our modelling to include eight product groups: ethane, LPG, naphtha, gasoline, kerosene, diesel (gasoil), fuel oil and other products.[8] The current split of oil demand by product (and main sectors of use) shows how diesel is the leading product by volume and the most versatile, being used in all the main sectors. It is followed by gasoline, which is used almost exclusively as a road-transport fuel (Table 15.5). Together, these two fuels currently make up almost 54% of total oil product consumption.

8. These include refinery gases, asphalt, wax, solvents, petroleum coke, etc.

### Table 15.5 ▷ Main sources and uses of oil products, 2012

| Product | Main sources | Main sectors | World demand | |
|---|---|---|---|---|
| | | | mb/d | % of total |
| Ethane | NGL fractionation | Petrochemical feedstock | 2.4 | 2.8 |
| LPG | NGL fractionation, condensate splitters, petroleum refineries | Petrochemical feedstock, buildings, road transport | 7.6 | 8.7 |
| Naphtha | Condensate splitters, Petroleum refineries | Petrochemical feedstock, gasoline blending | 5.7 | 6.5 |
| Gasoline | Petroleum refineries | Road transport | 20.8 | 23.8 |
| Kerosene | Petroleum refineries | Aviation fuel, buildings | 6.3 | 7.3 |
| Diesel | Petroleum refineries | Road transport, bunkers, buildings, industry, power generation | 26.0 | 29.7 |
| Fuel oil | Petroleum refineries | Bunkers, industry, power generation | 8.3 | 9.5 |
| Other products | Petroleum refineries | Non-energy use, refinery own use, power generation | 10.2 | 11.7 |
| **Total** | | | **87.4** | **100.0** |

Notes: Diesel excludes biodiesel (made from biomass feedstocks), but includes coal- and gas-to-liquids (CTL and GTL) diesel. Gasoline excludes ethanol, but includes additives and CTL/GTL gasoline.

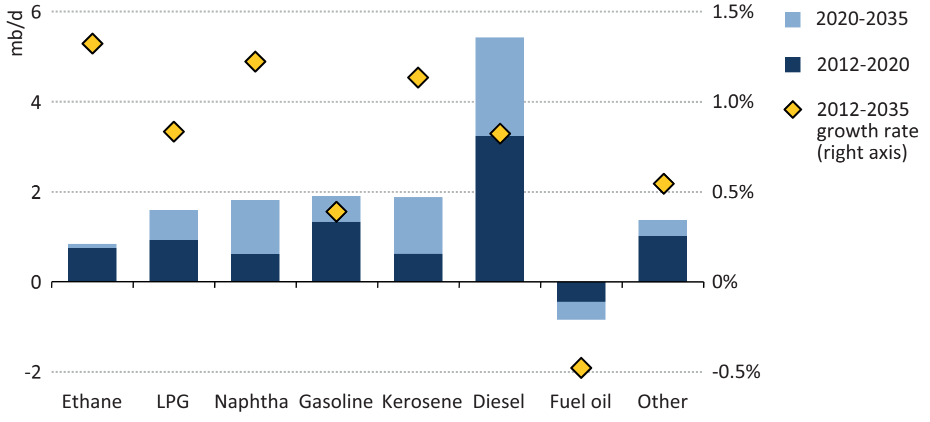
### Table 15.6 ▷ World primary oil demand by product in the New Policies Scenario (mb/d)

| | 2000 | 2012 | 2020 | 2035 | 2012-2035 | |
|---|---|---|---|---|---|---|
| | | | | | Delta | CAAGR* |
| Ethane | 1.7 | 2.4 | 3.2 | 3.3 | 0.9 | 1.3% |
| LPG | 5.9 | 7.6 | 8.6 | 9.2 | 1.6 | 0.8% |
| Naphtha | 4.3 | 5.7 | 6.3 | 7.5 | 1.8 | 1.2% |
| Gasoline | 18.7 | 20.8 | 22.1 | 22.7 | 1.9 | 0.4% |
| Kerosene | 6.5 | 6.3 | 7.0 | 8.2 | 1.9 | 1.1% |
| Diesel/gasoil | 20.2 | 26.0 | 29.2 | 31.4 | 5.4 | 0.8% |
| Heavy fuel oil | 8.7 | 8.3 | 7.8 | 7.4 | -0.9 | -0.5% |
| Other products | 10.2 | 10.2 | 11.3 | 11.6 | 1.4 | 0.5% |
| **Total** | **76.3** | **87.4** | **95.4** | **101.4** | **14.0** | **0.6%** |

* Compound average annual growth rate. Notes: Naphtha includes only petrochemical feedstock use. Naphtha used as a gasoline blending component is included in gasoline.

In the New Policies Scenario, demand growth is concentrated in the middle distillates: diesel sees by far the largest increase in volume terms, rising 5.4 mb/d to more than 31 mb/d between 2012 and 2035 (Table 15.6 and Figure 15.16). Some of the lighter products also see substantial demand growth, notably ethane for use as a petrochemical feedstock. Heavy fuel oil is the only product for which demand falls over the projection period. Refiners have some flexibility in the short term to adjust the mix of product output to meet seasonal or other fluctuations in demand, but, as discussed in Chapter 16, longer-term shifts require investment in secondary processing facilities. Levels of consumption can be determined by availability (notably for ethane and LPG), with the price adjusting to ensure that demand comes into balance with supply.

**Figure 15.16 ▷ Change in demand for oil by product in the New Policies Scenario, 2012-2035**



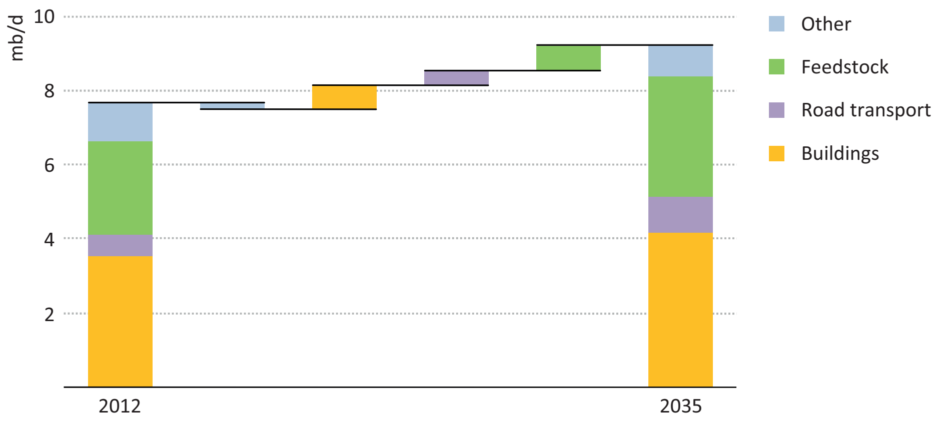

### *Ethane*

Worldwide, ethane is the second most important feedstock in steam crackers, after naphtha. Both types of feedstock can be substituted by diesel, LPG and methane (natural gas), but with a different yield of intermediate petrochemical products. The Middle East and the United States together account for almost three-quarters of world ethane use today. Of the projected 860 kb/d, or 35%, increase in ethane consumption between 2012 and 2035, 60% occurs in the Middle East and 12% in the United States, with ethane supplies in both regions boosted by rising natural gas production. Most of the increase occurs during the period 2012-2020, when a number of new crackers – many of them already under construction – are expected to come online.

### *LPG*

LPG is a mixture of hydrocarbons, mainly propane and butane that changes from a gaseous to liquid state when compressed at moderate pressure or chilled. It is a highly versatile fuel, used to provide a range of energy services in several different sectors. Some 40% of current consumption is for cooking and heating in the residential sector, while one-third is used as a petrochemical feedstock. Most of the remainder is used, in almost equal measure, in industry and as an alternative road-transport fuel. In the New Policies Scenario, the use of LPG grows in all the main sectors where it is currently used (Figure 15.17). The biggest increase is projected to come from the petrochemicals sector, which adds some 800 kb/d to 2035, on the back of strong underlying demand for the derivative products and an assumption that LPG will be competitively priced in the main producing regions that are geared up to using this type of feedstock, notably the Middle East and the United States.

**Figure 15.17 ▷ LPG demand in the New Policies Scenario**




All of the growth in LPG use in the buildings sector arises in the developing world, where rising incomes and population boost demand for clean cooking fuels (see Modern Energy for All in Chapter 2). LPG is particularly well-suited to domestic cooking and heating uses, because of its clean-burning attributes and practical advantages over both solid fuels and kerosene – the other main type of cooking fuel in developing countries. Increased use of LPG for cooking and heating in Africa, India and other developing regions more than offsets the projected decline in such uses in North America and Europe.

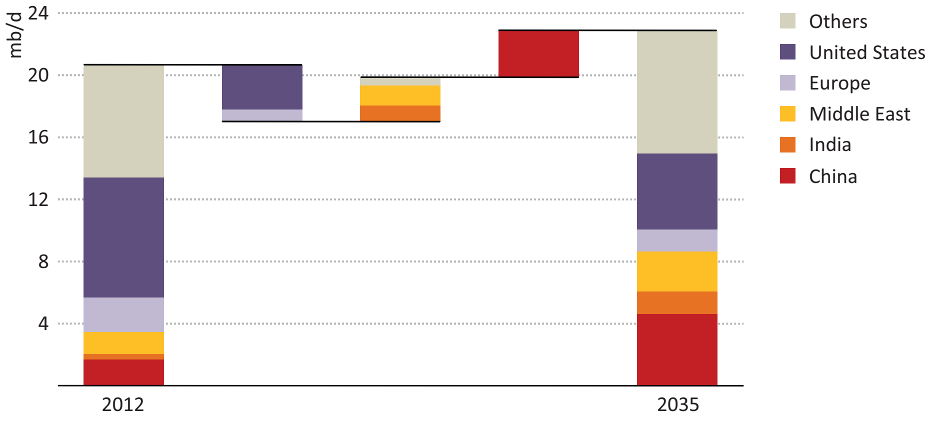
### *Naphtha*

Demand for the use of naphtha as a petrochemical feedstock is projected to climb from 5.5 mb/d in 2012 to more than 7 mb/d by 2035, driven by strong growth in China and, to a lesser extent, in ASEAN countries and the Middle East. By contrast, naphtha consumption declines in Europe, where petrochemical producers struggle to compete with lower cost producers in the United States and the Middle East, which rely mainly on cheaper ethane.

### *Gasoline*

The outlook for gasoline demand differs markedly across regions. The overall prospect is that strong demand in China and other emerging economies will compensate for weak demand in the OECD. In the New Policies Scenario, global demand rises slowly, from 20.8 mb/d in 2012 to 22.7 mb/d in 2035. Gasoline continues to be used almost exclusively for road transport, mainly in passenger and commercial LDVs. It remains the leading fuel for PLDVs in all regions outside Europe (where diesel use remains about even with gasoline) and Brazil (where biofuels continue to gain market share). Overall, diesel use for road transport (including freight) approaches that of gasoline by 2035. But these trends mask some very big differences between countries and regions. Gasoline consumption declines substantially in North America, Europe and OECD Asia Oceania, mainly as a result of major improvements in fuel economy and increased use of biofuels (largely blended into gasoline). In these countries, already high levels of vehicle ownership limit the scope for an expansion of the PLDV fleet to compensate for efficiency gains. By contrast, demand continues to soar in China and other emerging economies. Gasoline use in China alone jumps by almost 3 mb/d between 2012 and 2035 – almost equivalent to the projected fall in US gasoline use – with a projected five-fold increase in the PLDV fleet.

**Figure 15.18 ▷ Gasoline demand by region in the New Policies Scenario**



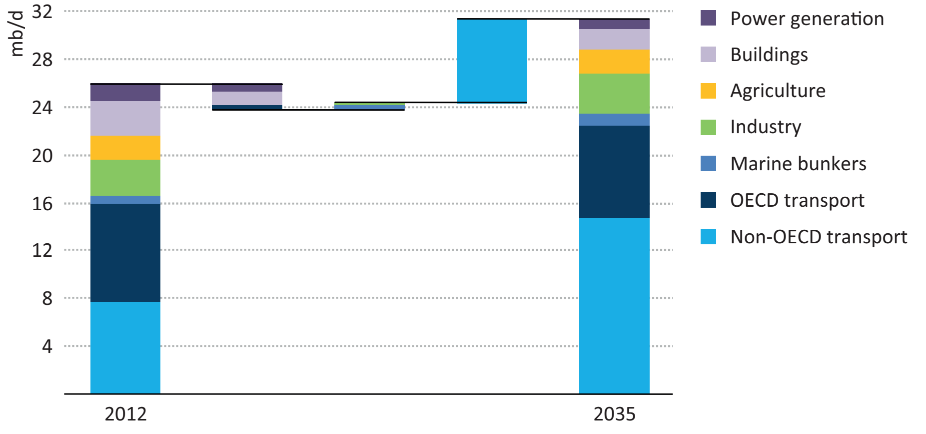

### *Kerosene*

Kerosene is used both as jet fuel in aviation and as a household cooking and heating fuel, mainly in developing countries. The prospects for kerosene use in these two segments are very different. Continuing strong growth in demand for domestic and international air travel is projected to more than compensate for improvements in the efficiency of jet engines, pushing demand for aviation kerosene up by around 45% between 2012 and 2035. Domestic aviation demand grows most in the United States, China, Brazil and Russia, while international aviation bunkers see most growth in hubs in ASEAN countries and the Middle East. Biofuels are the only viable substitute for jet kerosene, but they remain too costly in the *Outlook* to make major inroads into aviation fuel demand before 2035. By contrast, kerosene use in buildings decreases by almost 40% over the projection period. In OECD countries, households switch to natural gas and electricity for heating, while in Africa and south Asia, many households switch to less polluting and safer fuels for cooking, largely offsetting the effect of increased demand for fuels as incomes and populations rise.

### *Diesel*

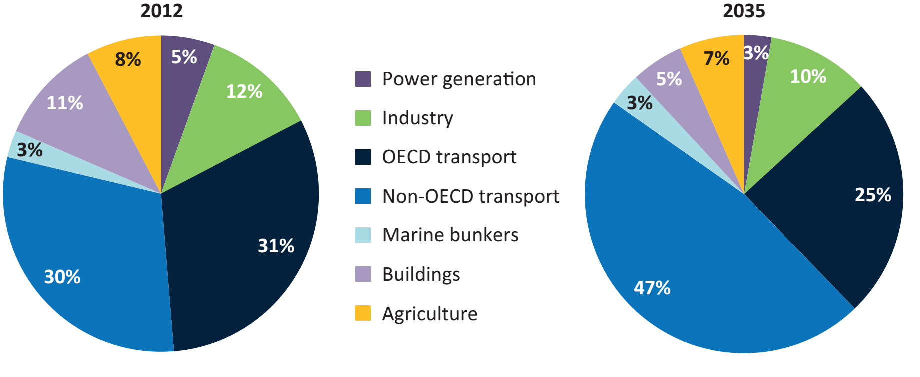
The confluence of technological and economic trends points to diesel consolidating its position as the leading oil product, while being used increasingly as a transport fuel. In the New Policies Scenario, diesel consumption increases from 26 mb/d in 2012 to more than 31 mb/d in 2035, its share of total primary oil demand edging up to 31%. All of the net increase in demand comes from the road-transport sector in non-OECD countries. Demand in most of the other sectors and in transport in the OECD falls – substantially in the case of buildings, where diesel in the form of light heating oil is replaced largely by natural gas and electricity (Figure 15.19). Non-OECD transport demand for diesel almost doubles from 7.8 mb/d to 14.7 mb/d between 2012 and 2035.

**Figure 15.19 ▷ Diesel demand by sector in the New Policies Scenario**




We project only a minor increase in the use of diesel in marine bunkers, despite the proposed initiative by the International Maritime Organisation to introduce lower sulphur limits on bunker emissions on the high seas, which could be expected to increase diesel use, at the expense of heavy fuel oil (bunker C). The increase in diesel demand required to replace bunker C fuel entirely would be around 3.5 mb/d by 2020, an amount that, in the *Outlook*, would be beyond the capacity of the world's refining system to deliver given that demand for diesel is, in any event, rising faster than that of any other product. To provide additional volumes for a switch to marine distillates, the premium for diesel over heavy fuel oil would need to rise to such an extent that other solutions to the lower sulphur limits would become financially viable, including sulphur scrubbers on board ships or the use of LNG as bunker fuel.

**Figure 15.20 ▷ World diesel demand by sector in the New Policies Scenario**

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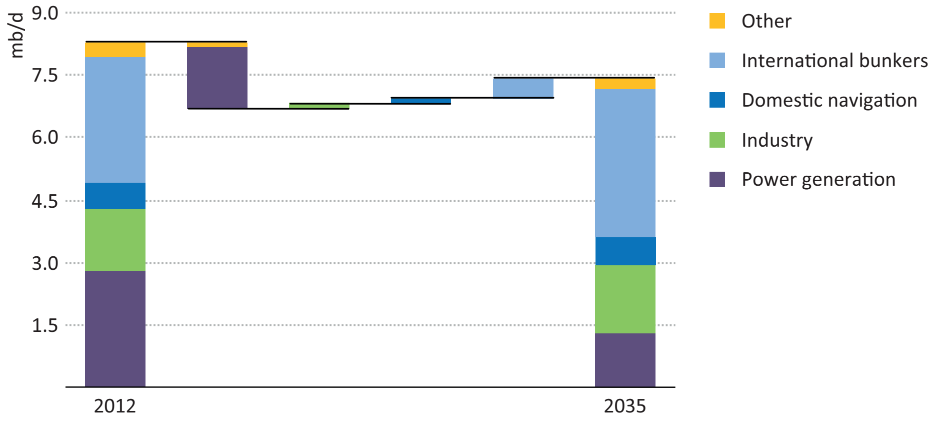
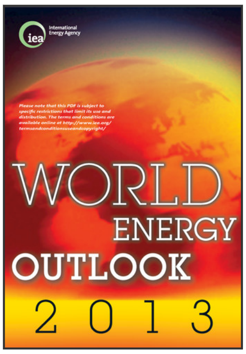
Overall, the New Policies Scenario sees a significant increase in the share of the transport sector (road and inland waterways navigation) in diesel demand, from 64% in 2012 to 75% in 2035. This is driven by increased consumption in non-OECD countries, where the transport sector alone accounts for half of world diesel consumption by 2035. Outside the non-OECD transport sector, diesel demand declines, but because of overall decline in consumption rather than because of switching to other oil products.

### *Heavy fuel oil*

Global demand for heavy fuel oil is expected to be replaced by other fuels in most end-use sectors, continuing its long-term decline. In the New Policies Scenario, demand drops by 10% between 2012 and 2035 to 7.4 mb/d (Figure 15.21). Switching to natural gas, nuclear power and renewables brings demand down in the power sector, while switching to gas and electricity is the main reason for falling demand in industry. Marine bunkers and domestic navigation are the only sectors where heavy fuel oil use increases – from a combined 3.6 mb/d to 4.2 mb/d. Most large ships use heavy fuel oil in diesel engines and this is not expected to change significantly over the projection period, although the use of LNG is starting to make inroads, driven by economics and stricter environmental regulations. Overall bunker fuel demand is driven by a continued expansion of international maritime shipping of manufactured goods, mainly from Asia, and of bulk commodities (including energy), though the rate of growth is expected to slow markedly, compared with that of the past two decades. The increased volume of shipping more than offsets further improvements in the efficiency of ship engines, since most of the potential for saving energy from large ships has already been exploited.

**Figure 15.21 ▷ Heavy fuel oil demand by sector in the New Policies Scenario**



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