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Oil outlook to 2025

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Oil outlook to 2025

This paper was originally published in the September 2004 issue of the OPEC Review, under the authorship of Adnan Shihab-Eldin, Mohamed Hamel and Garry Brennand.

It presents the OPEC Secretariat's projections of world oil demand and supply to the year 2025, based upon analysis using the OPEC World Energy Model, OWEM.

OWEM was originally developed in the 1980s as an econometric model specialising in medium-to-long-term projections of oil and energy trends. Extracts from annual OWEM scenarios reports have been published in the OPEC Review since 1998.

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Contents

Abstract

This paper presents the OPEC Secretariat's latest outlook to 2025 for oil supply and demand. The results have been developed using the OPEC World Energy Model, OWEM.

The next two decades are expected to see increases in energy demand met predominantly by fossil fuels, with oil set to continue to maintain its major role. There is also a clear expectation that the oil resource base is sufficiently abundant to satisfy this demand growth. Global oil demand rises in the reference case by 12 million barrels per day to 89 mb/d from 2002 to 2010, an average annual growth rate of 1.5 mb/d, or 1.8 per cent per annum, over the period. In the following decade, demand grows by a further 17 mb/d to 106 mb/d by 2020, and then by another 9 mb/d to 115 mb/d by 2025. Almost three-quarters of the increase in demand over the period 2002–25 comes from developing countries.

In the short-to-medium term, overall non-OPEC supply is expected to continue to increase — rising to a plateau of 55–57 mb/d in the post-2010 period. The key sources for the increase in non-OPEC supply will be Latin America, Africa, Russia and the Caspian. In the longer term, OPEC will increasingly be called upon to supply the incremental barrel.

Uncertainties over future economic growth, government policies and the rate of development and diffusion of newer technologies raise questions over the future scale of investment that will be required. These uncertainties, coupled with long lead times, inevitably complicate the task of maintaining market stability. Medium-term prospects suggest that there is a need to ensure that spare capacity is not too high and that it is consistent with sustained market stability. There are genuine risks of downward pressure on oil prices, and this could sow the seeds of instability.

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THE NEXT TWO decades are expected to see fossil fuels continue to account predominantly for increases in energy demand, with oil set to maintain its major role as a source of energy. There is also a clear expectation that the oil resource base is sufficiently abundant to satisfy this demand growth. Moreover, although non-OPEC production is seen as continuing its recent expansion over the medium term, it is generally agreed that OPEC will increasingly be relied upon to supply the incremental barrel. The absolute size of investment required by the oil industry in this outlook is not necessarily different in magnitude to that observed in the past.

Nevertheless, uncertainties over future economic growth, government policies and the rate of development and diffusion of newer technologies raise questions over the future scale of investment that will be required. These uncertainties, coupled with long lead times, inevitably complicate the task of maintaining market stability. On top of this, medium-term prospects suggest there is a need to ensure that the level of spare capacity is consistent with such stability.

This paper presents the OPEC Secretariat's latest outlook to 2025 for oil supply and demand. The results have been developed using the OPEC World Energy Model (OWEM). The paper is organized in five sections. The first part deals with the key assumptions in the reference case, which represents a "dynamics-as-usual" scenario. The second section provides an overview of the prospects for oil demand growth by sector and region, and the expectations for supply growth. Section Three looks at oil demand growth by sector, and Section Four considers the regional prospects for non-OPEC supply. The fifth section looks at scenarios based upon this reference case, with emphasis on the uncertainties associated with oil demand growth prospects. And Section Six contains concluding remarks.

1. Reference case assumptions

The reference case price for the OPEC Reference Basket of seven crudes, in real terms, is assumed to gradually fall to a range of $20–25/b, at today's prices. While such a path does not preclude some short-term variability, this price assumption reflects a number of important long-term perceptions. The first is confidence that the resource base is sufficient to deal with strong upward pressures on oil prices. Secondly, this oil price assumption is not so high as to generate such large quantities of additional oil, both conventional and unconventional, that OPEC oil production would have to shrink at rates that would imply considerable idle capacity. Thirdly, the price is sufficient to mobilize the resources to supply the market with the necessary oil. And fourthly, the budget requirements of Member Countries are fulfilled.

A key driver for future levels of oil demand is the rate of economic growth that is expected to prevail. The assumptions for the reference case are shown in **table 1**. Perhaps the major uncertainty over longer-term economic growth in the OECD is the expansion of productivity, and the extent to which this will be influenced by technological advances and the further growth in trade. The reference case foresees average growth in the OECD economies of 2.5 per cent per annum over the period 2003–25.

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Table 1
Average annual real GDP growth rates
% p.a.

	2003–05	2006–10	2011–15	2016–20	2021–25	2003–25
North America	3.5	3.0	2.8	2.7	2.6	**2.9**
Western Europe	1.9	2.3	2.2	2.1	2.0	**2.1**
OECD Pacific	2.2	2.4	2.2	2.1	2.0	**2.2**
OECD	**2.6**	**2.6**	**2.5**	**2.4**	**2.3**	**2.5**
Oil-importing DCs						
Latin America	2.5	3.8	3.5	3.2	3.0	**3.3**
Middle East and Africa	3.6	3.4	3.4	3.4	3.4	**3.4**
South Asia	6.2	5.5	5.5	5.0	4.6	**5.3**
South-East Asia	4.4	4.3	4.0	3.6	3.2	**3.9**
China	8.0	6.8	6.4	6.0	5.5	**6.4**
Oil-exporting DCs						
OPEC	3.7	4.0	3.8	3.7	3.6	**3.8**
Other	3.8	3.8	3.7	3.6	3.5	**3.7**
DCs	**5.6**	**5.3**	**5.1**	**4.9**	**4.5**	**5.0**
FSU	5.2	3.8	3.4	3.2	3.0	**3.6**
Other Europe	4.4	4.4	3.9	3.6	3.4	**3.9**
World	**3.9**	**3.8**	**3.7**	**3.6**	**3.4**	**3.6**

For developing countries, with largely low capital stock bases and considerable technological catch-up potential, GDP growth rates are expected to be higher. Population expansion will also contribute to economic growth, although at decelerating levels, as birth rates are expected to fall. There is uncertainty, however, as to how fast the capital stock and productivity will grow. Both will be positively affected by the liberalisation of markets and the increasing importance of trade. A major question mark hangs over whether recent high growth rates can be sustained. In particular, the prospects for economic growth in China represent a significant point of uncertainty in the outlook. Over the forecast period, developing countries are assumed to grow at an average of five per cent p.a., with China and South Asia expanding at the fastest rates.

Economies in transition have considerable scope for productivity catch-up, while Russia's economy is also benefiting from the impact of high oil prices. Real GDP growth in the former Soviet Union (FSU) of four-to-five per cent p.a. is assumed for the medium term, falling towards three per cent in the longer term. Other growth in Europe is expected to be slightly higher, as, over the forecast period, countries in the region will be trading increasingly with the European Union (EU).

Beyond these key assumptions, the reference case has been constructed as a "dynamics-as-usual" scenario, with efficiency improvements brought about by the ongoing introduction of new technologies, but only as an extension of patterns that have been observed in the past. The reference case does not, however, reflect an especially strong policy drive towards reducing demand. Other than as a reflection of a continuation of past trends, oil demand growth is not limited by concerted policy efforts, either through new tax measures or through non-fiscal means.

2. Overview of the reference case

2.1 Oil demand

The prospects for oil demand growth are described at the sectoral level by world region in Section Three. The transportation sector is clearly key to the development of oil demand, accounting in 2001 for 47 per cent of total final oil consumption. This sector, therefore, plays a particularly important role in forming an oil outlook for the period to 2025. How vehicle ownership levels evolve will be determined by increases in wealth, demographic dynamics and principles of saturation, as well as potential constraints, such as available infrastructure, which will all be crucial drivers of growth in oil demand. But the future behaviour of efficiencies, driven by government policy and/or technological innovation and implementation, will also be central to the possible scale of demand expansion. Section Five focuses upon scenarios around the reference case and considers alternative developments to vehicle efficiencies, probably driven by both fiscal and non-fiscal measures, which must be considered as feasible alternatives to the figures arising from the reference case analysis.

It is also nevertheless important to pay close attention to the other sectors of demand. After transportation, the industry sector — and petrochemicals, in particular — is the next most important source of oil demand. Expected regional patterns for this sector, as well as for the residential/commercial/agricultural and electricity generation

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Table 2
World energy demand in the reference case

	Levels *mtoe*			Growth *% p.a.*				Fuel share *%*			
	2000	**2010**	**2020**	**2025**	**2000–10**	**2010–20**	**2020–25**	**2000**	**2010**	**2020**	**2025**
Oil	3,614	4,225	5,059	5,492	*1.6*	*1.8*	*1.7*	*40.1*	*38.7*	*37.6*	*36.9*
Solids	2,341	2,818	3,435	3,750	*1.9*	*2.0*	*1.8*	*26.0*	*25.8*	*25.5*	*25.2*
Gas	2,101	2,800	3,808	4,453	*2.9*	*3.1*	*3.2*	*23.3*	*25.7*	*28.3*	*29.9*
Hydro/nuclear/ renewables	953	1,065	1,153	1,195	*1.1*	*0.8*	*0.7*	*10.6*	*9.8*	*8.6*	*8.0*
Total	**9,008**	**10,908**	**13,455**	**14,890**	***1.9***	***2.1***	***2.0***	***100.0***	***100.0***	***100.0***	***100.0***

sectors, consider below not only the impact of assumed economic growth, but also the possible changes in energy efficiencies in the relevant sector, the changing importance of individual sectors to aggregate economies, and elements of inter-fuel competition.

World demand for primary energy over the period 2000–25 grows at an average of two per cent p.a. **(table 2**). Fossil fuels will continue to dominate the global energy mix, accounting for close to 90 per cent of primary demand. Natural gas, which enjoys the highest growth rate, due mainly to its advantages in electricity generation, sees its share in the reference case reach 30 per cent in 2025, six points more than in 2000. Its percentage share will exceed that of coal from around 2010. Although oil's share in the energy mix falls from 40 per cent in 2000 to 37 per cent by 2025, the volume of demand increases steadily from 77 million barrels per day in 2002 to 115 mb/d in 2025.

The results of the reference case for aggregate oil demand by region are shown in **table 3**. Global oil demand rises in the reference case by 12 mb/d to 89 mb/d from 2002 to 2010, an average annual rate of 1.5 mb/d, or 1.8 per cent p.a., over that period. In the following decade, demand grows by a further 17 mb/d to 106 mb/d by 2020,

Table 3
World oil demand outlook in the reference case
mb/d

	2002	**2005**	**2010**	**2015**	**2020**	**2025**
North America	24.2	25.0	26.1	27.2	28.3	29.4
Western Europe	15.1	15.4	15.9	16.3	16.6	16.8
OECD Pacific	8.5	8.8	9.2	9.4	9.5	9.6
OECD	**47.7**	**49.3**	**51.2**	**52.9**	**54.5**	**55.8**
Oil-importing DCs						
Latin America	3.2	3.3	3.8	4.4	5.1	5.7
Middle East and Africa	1.7	1.9	2.1	2.5	2.8	3.2
South Asia	2.6	3.1	4.1	5.5	7.1	9.1
South-East Asia	3.2	3.4	4.1	5.0	5.7	6.5
China	5.0	6.0	7.6	9.4	11.4	13.5
Oil-exporting DCs						
OPEC	6.2	6.5	7.3	8.1	9.0	9.9
Other	2.7	2.8	3.2	3.6	4.1	4.6
DCs	**24.7**	**26.9**	**32.3**	**38.5**	**45.3**	**52.5**
FSU	3.8	4.1	4.4	4.7	5.0	5.2
Other Europe	0.7	0.8	0.9	0.9	1.0	1.1
Transition economies	**4.5**	**4.8**	**5.3**	**5.7**	**6.0**	**6.3**
World	**77.0**	**81.0**	**88.7**	**97.1**	**105.8**	**114.6**

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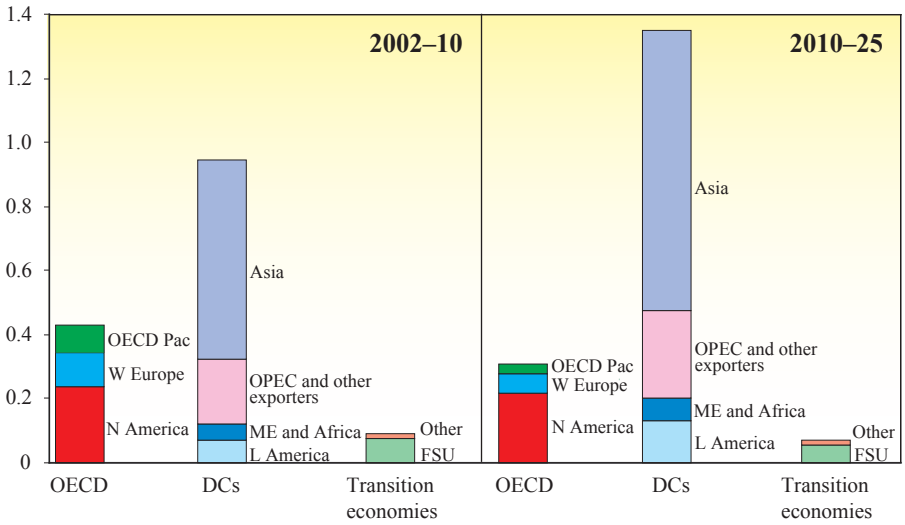
and then by another 9 mb/d to 115 mb/d by 2025 (averaging 1.7 per cent p.a. over the years 2010–25). Almost three-quarters of the increase in demand of 38 mb/d over the period 2002–25 comes from developing countries, whose demand doubles over that time. By 2025, the share of developing countries in world oil demand has risen to 46 per cent, up from 32 per cent in 2002. Nevertheless, the OECD remains the largest consumer of oil throughout the projection period.

Demand in North America increases faster than in other OECD regions, primarily because of greater economic growth. Additionally, despite signs of saturation in the road transportation sector, stronger population growth is keeping demand growth relatively buoyant. Within developing states, the Asian countries continue to be the key source of demand increase, accounting for a rise of 18 mb/d, or 65 per cent of the total increase for developing countries, over the years 2002–25, which is almost half the global increase in that period (**figure 1**). China and India are central to this growth, with the expansion in the transportation sector a particularly important component. The huge potential for growth is clear from the very low intensity of vehicles in these two countries — at only just over ten vehicles per 1,000 inhabitants, in contrast with values higher than 500 in some OECD countries. Indeed, historically, growth rates in vehicle ownership averaging more than ten per cent p.a. have been observed in several countries. However, despite this obvious huge potential, there are many factors that may constrain the rise in demand in the future, in particular the availability of necessary infrastructure, as well as the possible development of policies aimed at limiting growth. The future behaviour of efficiencies, driven by policy and/or technological

Figure 1
Annual growth in oil demand, 2000–25
mb/d p.a.



innovation and diffusion, will also be central to the possible scale of demand expansion. These ambiguities, coupled with uncertainty over the sustainability of the strong economic growth rates assumed to occur in these countries, point to the need for an awareness of substantial downside risks to oil demand.

Figures 2–4 portray the growth in demand by sector. The transportation sector accounts for 78 per cent of the increase in oil demand over the period 2000–25 in the OECD, and almost all the increase in the transition economies. The electricity generation sector is not expected to be a source of growth in the OECD, while oil use in both industry and other sectors is expected to rise only modestly, with growth limited by structural changes in economies, saturation effects, slow population growth and the increasing importance of natural gas and electricity in these sectors.

In developing countries, the transportation sector is the single most important source of increase, and represents close to half the expected rise in oil demand. Historically, the industrial and household/commercial/agriculture sectors have been important sources of demand growth, and this is expected to continue over the projection period. The driving forces behind these increases are primarily the expected strong economic growth, the continued expansion of the petrochemical industry, the increasing importance of industrial activity, strong population growth rates and the continued switch away from traditional fuels. The only significant growth in oil demand in the electricity generation sector will come in developing countries, although the size of the rise will be modest. However, aggressive development of clean oil technologies,

Figure 2
Annual growth in oil demand by sector in OECD countries
mboe/d

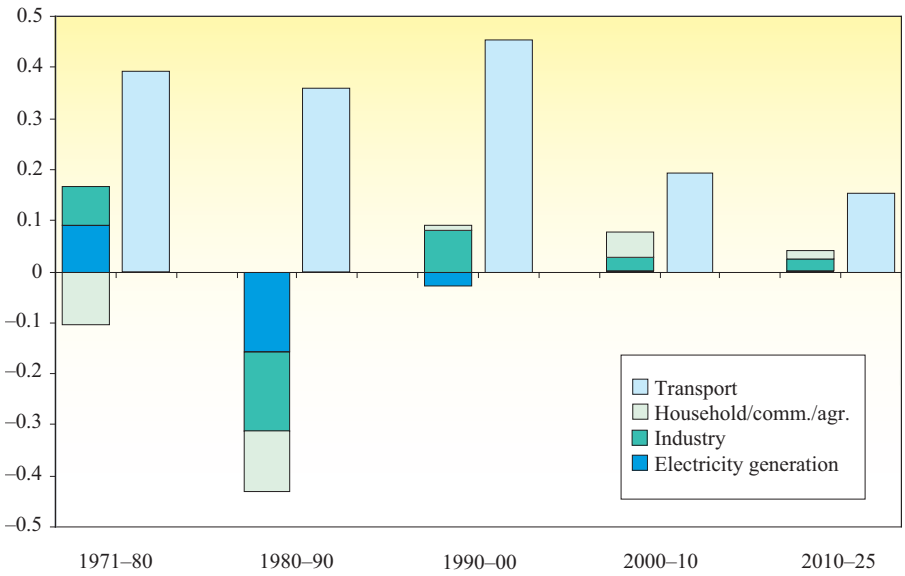


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Figure 3
Annual growth in oil demand by sector in developing countries
mboe/d

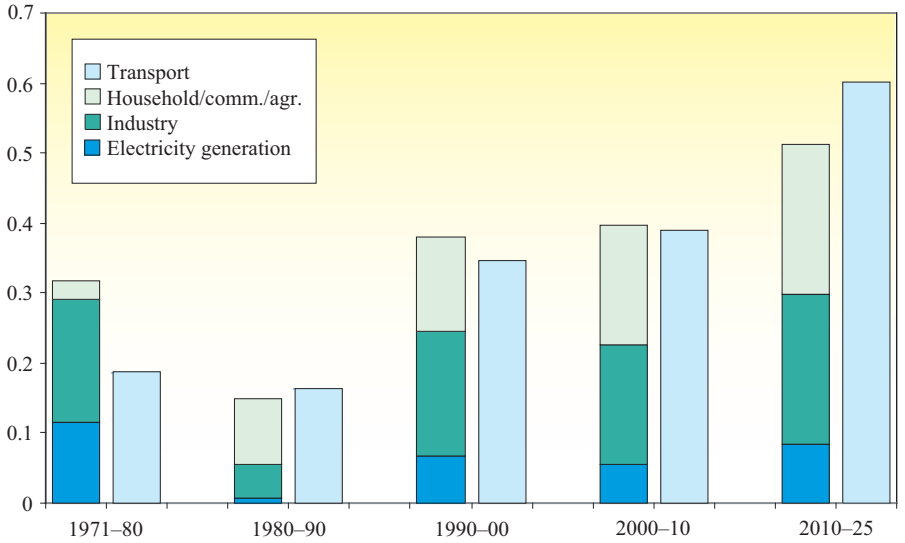
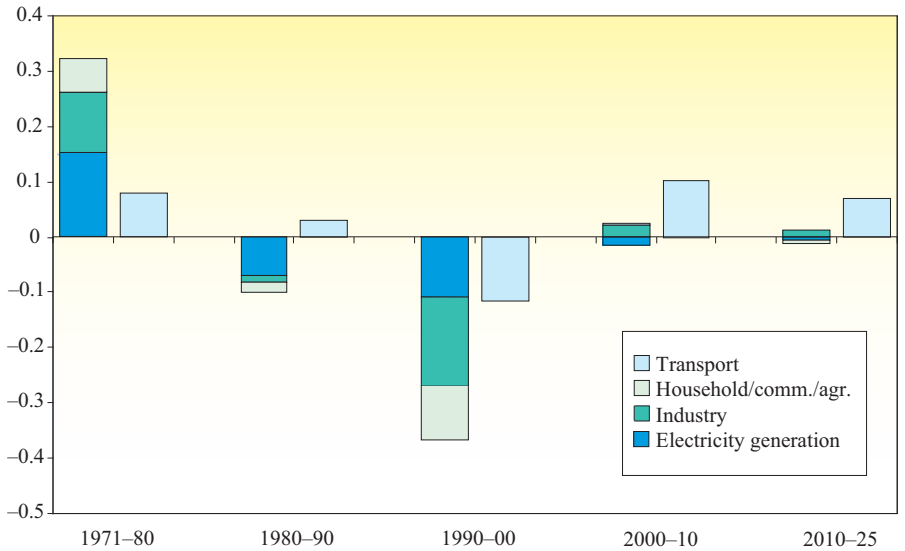


Figure 4
Annual growth in oil demand by sector in transition economies
mboe/d



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such as integrated oil gasification combined cycle and CO_2 sequestration, has the potential to enhance the use of oil in this sector.

2.2 Oil production

Concern over an impending oil crisis because of a shortage of resources, even over the coming decade, continues to be voiced in some quarters. Indeed, conventional global oil production is projected by some analysts to peak as soon as 2010. Such messages, that the world is "running out of oil", continue, however, to be strongly criticized by energy economists. The estimates of the ultimately recoverable reserves (URR) have been increasing over time, for example, from just 0.6 trillion barrels throughout the 1940s, rising to 2 tr b in the 1960s and 1970s, up to the most recent mean assessment by the US Geological Survey (USGS) of 3.3 tr b. These increased estimates are due to the availability of improved data, as well as technological improvements. The last four estimates of the URR by the USGS have seen consecutive rises. At each point in time of those estimates, since the mid-1980s, the cumulative production, as a percentage of the estimated resource base, has been relatively stable, at just under 30 per cent.

This debate concerns the interplay between geology, technology and economics. The "peakers" point to the turning point for production being reached when around 50 per cent of the URR has been produced, assuming symmetric growth and a decline in production; the repeated revision of the size of the resource base has made this point recede further and further into the future. Technology also continues to blur the distinction between what is considered 'conventional' and 'non-conventional' oil. It is in this sense that the very concept of a resource limit is regarded as misleading. Although the figures that are estimated for the resource base need to be interpreted with caution, due to the existence of many associated uncertainties, it is nevertheless considered a sound conclusion that the oil reserves are sufficient to satisfy world oil demand growth over the projection period.

Before turning to the reference case outlook for oil supply, it is worth reflecting on some of the most important contributions made by technological developments. Advances in technology, in areas such as sub-surface imaging (3D and 4D), drilling and offshore production, have had a dramatic effect on upstream activity, leading to large discoveries, particularly in deepwater. The application of these breakthrough upstream technologies over the past two decades has contributed to significant additions to hydrocarbons resources, increased exploration successes, reduced costs and expanded access to new frontier areas.

Technological progress could also allow the development of large amounts of unconventional oil at lower cost, and would, therefore, enable the extension of the availability of oil supply, and support its role in the long run. Another technology that may impact on the supply of liquids is that related to gas-to-liquids.

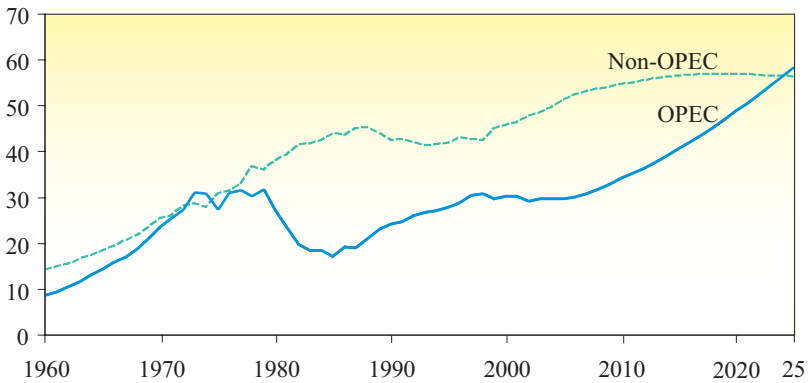
Turning to the outlook in the reference case, in the short-to-medium term, on the basis of detailed bottom-up data on development plans, overall non-OPEC supply is expected to continue to increase, rising to a plateau of 55–57 mb/d in the post-2010 period (**table 4** and **figure 5**). This represents an increase of 7–9 mb/d from 2002,

Table 4
World oil production outlook in the reference case
mb/d

	2002	2005	2010	2015	2020	2025
USA and Canada	10.9	11.1	10.9	10.9	10.8	10.7
Mexico	3.6	3.8	3.9	4.0	4.0	3.8
Western Europe	6.6	6.5	5.8	5.0	4.3	3.7
OECD Pacific	0.8	0.7	0.8	1.0	1.0	1.0
OECD	**21.9**	**22.1**	**21.4**	**20.8**	**20.1**	**19.2**
Latin America	3.9	4.2	5.1	5.6	6.0	6.2
Middle East and Africa	5.1	5.8	6.5	6.9	6.8	6.5
Asia	2.3	2.5	2.5	2.4	2.2	2.0
China	3.4	3.4	3.6	3.8	3.8	3.6
DCs, excl. OPEC	**14.6**	**15.9**	**17.7**	**18.6**	**18.8**	**18.3**
Russia	7.6	9.3	10.4	10.9	11.1	11.1
Caspian*	1.7	2.0	2.9	3.7	4.1	4.5
Other Europe	0.2	0.2	0.2	0.2	0.1	0.1
Processing gains	1.7	1.8	2.1	2.4	2.7	3.0
Non-OPEC	**47.8**	**51.3**	**54.6**	**56.5**	**56.9**	**56.3**
OPEC (incl. NGLs)	**29.2**	**29.7**	**34.1**	**40.6**	**48.9**	**58.3**
World	**77.0**	**81.0**	**88.7**	**97.1**	**105.8**	**114.6**
OPEC market share %	***37.9***	***36.7***	***38.4***	***41.8***	***46.2***	***50.9***

** All FSU states, except Russia.*

Figure 5
OPEC and non-OPEC oil production, 1960–2025
mb/d



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although the eventual scale of this future expansion is subject to considerable uncertainty. The key sources for this increase in non-OPEC supply will be Latin America, Africa, Russia and the Caspian.

Of this non-OPEC expansion (**figures 6–8**), Russia deserves a special mention. Russian oil production surged by 30 per cent over the period 2000–03, increasing by 2 mb/d, the highest increase of any country at that time. By 2003, Russia had overtaken the United States of America to become the largest non-OPEC oil producer, and the second-largest producer in the world. The recent exceptional growth in oil production in Russia may not, however, be sustainable. In the medium-to-longer term, attention continues to be focused on the available export infrastructure in the country. Nevertheless, in recent years, the upward revisions to non-OPEC supply projections, which have been observed for forecasts from all institutions, have been largely driven by increases in expected Russian oil output. Reference case figures place Russian output eventually at a plateau of around 11 mb/d within the next decade.

OECD countries are expected to witness a gradual decline in aggregate production levels over the forecast period. In North America, it is expected that the decline in onshore 'lower-48' US production and Canadian conventional oil output will continue to be offset by increases in the Gulf of Mexico and non-conventional oil output in Canada. Nevertheless, despite the large non-conventional resource base, supply may be limited, due to such factors as the highly capital-intensive nature of oil

Figure 6
Non-OPEC production, transition country regions
mb/d

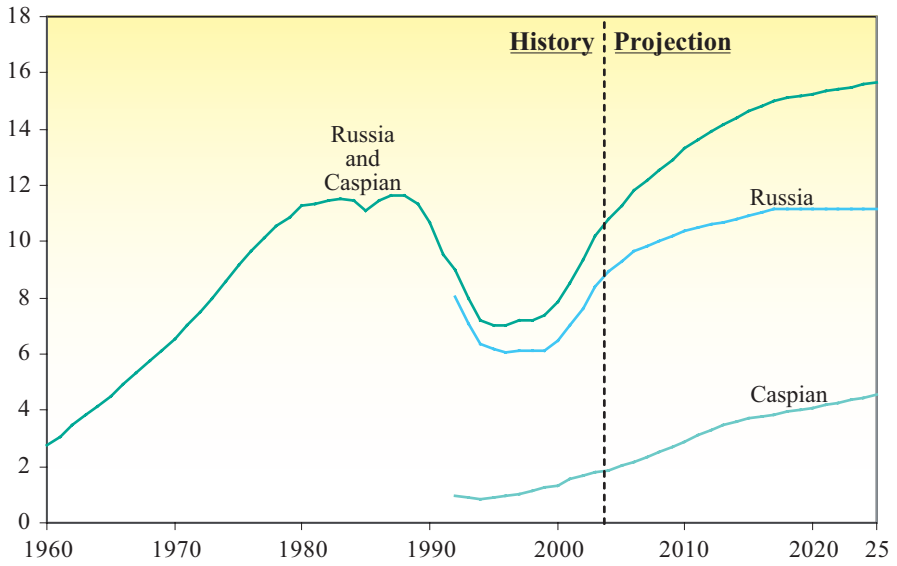

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Figure 7
Non-OPEC production, OECD regions
mb/d

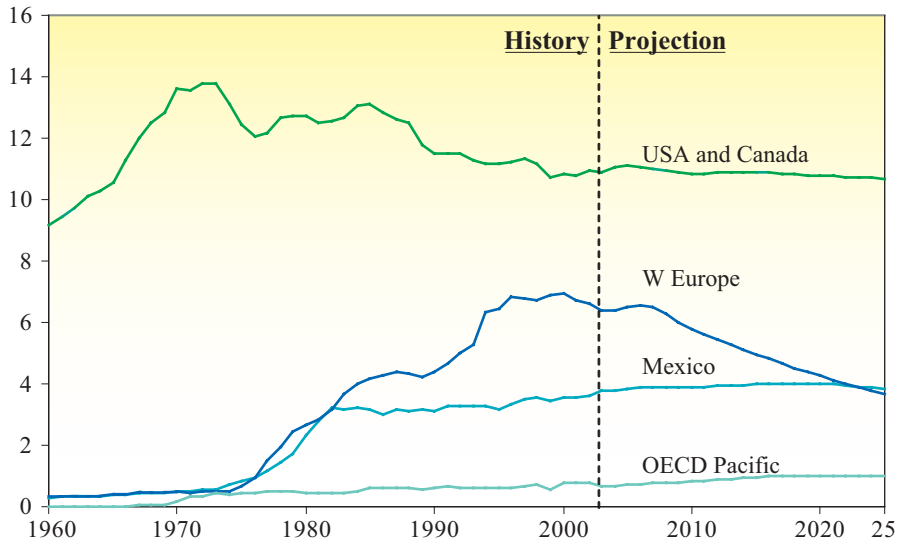
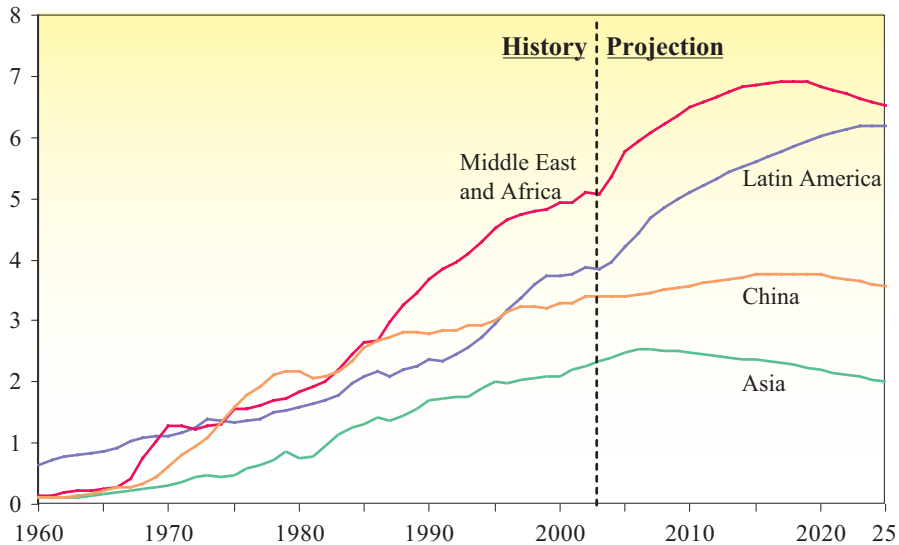


Figure 8
Non-OPEC production, developing country regions
mb/d



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sands projects and the long lead-times involved. Enhanced oil recovery is expected to continue to elongate the plateau of oil production in the North Sea. The quest for rapid returns on investment is leading to increased recovery rates, but this is also likely to mean that, when the fall in production occurs, it will be relatively sharp.

Increases in output from non-OPEC Middle East and Africa will be primarily from the African region. Angola will probably be the main country in this region from which increases in oil production can be expected over the medium term, followed by Chad, Sudan, Congo and Equatorial Guinea. The key to expected increases over the short-to-medium term in Latin America lies with Brazil, still a net importer of oil, with a number of new fields due to come on-stream.

In the longer term, the balance of the global oil reserve base and the gradual depletion of non-OPEC reserves means that OPEC will increasingly be called upon to supply the incremental barrel, with its market share eventually set to rise. By 2020, with production levels, including natural gas liquids (NGLs), rising to 49 mb/d, OPEC's share is 46 per cent of the market, and is set to increase further in the reference case. By 2025, the share exceeds 50 per cent.

These supply projections underline the need for substantial investment to be made along the entire hydrocarbons chain. The scale of investment that this reference case outlook implies is, however, probably not greater in magnitude to that already witnessed. There is nevertheless a large degree of uncertainty over the demand and supply outlook and, hence, the required additional OPEC oil. These uncertainties are explored in the section on alternative scenarios. Despite the uncertainties, in the longer term, a key challenge will be to anticipate, in a timely and effective manner, the appropriate scale of investment needed to maintain and expand upstream capacity, as well as the corresponding downstream infrastructure.

However, over the medium term, a rather different challenge could arise. While, in the reference case, demand is predicted to grow at robust rates, it is expected to be accompanied, over the medium term, by strong increases in non-OPEC production, leaving little room for increases in OPEC output. OPEC capacity is, meanwhile, expected to increase gradually over the medium term. This, in turn, suggests that OPEC capacity utilisation rates are very sensitive over the medium term to, among other things, the pace of global economic growth; should the robust rates of the reference case not be sustained, significant increases in idle capacity could appear in OPEC Member Countries. Concern over medium-term oil market stability can become even more alarming if some of the other downside risks to oil demand growth are considered.

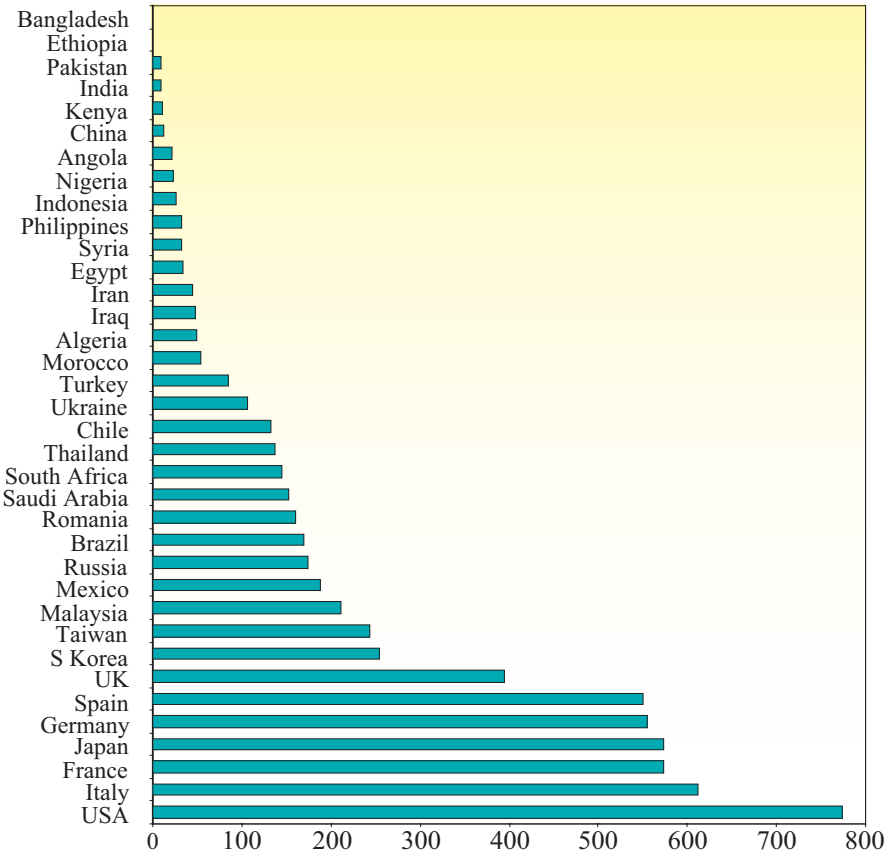
Oil downstream will also continue to be under pressure to adapt itself to the backdrop of many uncertainties (demand, pace of implementation of new specifications), resulting in a transitional phase with limited flexibility. The risk is that the downstream industry, in terms of both refining and distribution capacity, becomes a prime source of international volatility for oil prices during this transitional period. The impact of current downstream bottlenecks is an example of such lack of flexibility. In this regard, the future of this industry should be an important focus of attention for the international community.

3. Oil demand by sector

3.1 Transportation sector

Road and air transportation is by far the most important sector for oil demand, at 34.5 million barrels of oil equivalent per day, accounting for 47 per cent of world oil demand in 2001. This dominance is particularly marked in OECD countries, where the share averages almost 55 per cent, while, in non-OECD, it lies below 40 per cent. Moreover, this share has been rising strongly over the past two decades, either as the only source of growth in demand (in the OECD, increasing by more than 8 mboe/d in 1980–2001) or as a result of stronger growth than in other sectors (in the developing countries, increasing by more than 5 mboe/d in 1980–2001). Within this sector, road transportation is the most important source of demand, accounting for over

Figure 9
Vehicle ownership in 2000
per 1,000



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80 per cent of total transportation oil use in both OECD and developing countries. Close attention must, therefore, be paid to the driving forces behind oil demand growth in this sub-sector.

The key to the expansion of oil demand in this sector is the increase in vehicle use. Over the last two decades, world vehicle ownership has almost doubled, to reach over 800 million vehicles by 2000. By far the strongest percentage growth has been in developing countries, where current low levels of vehicle ownership (measured as the number of vehicles per 1,000 of population) provide obvious scope for increases. Most pointedly, vehicle ownership levels in 2000 in China and India were only 10–12 per 1,000 inhabitants, while the penetration in OECD countries was about 50 times as high, with, for example, the highest ownership level being in the USA, at 774 vehicles per 1,000 population, while Western Europe averaged 444 vehicles per 1,000. Total vehicle ownership in developing countries has increased from 45 million in 1980 to over 160 million in 2000. **Table 5** documents these vehicle ownership rates and levels for the year 2000 for the OWEM regions, together with some of the individual countries.

At over 770 vehicles per 1,000, the USA has the highest vehicle intensity in the world (**figure 9**). Ownership rates in other OECD countries are largely between 400 and 600 cars per 1,000, although Mexico, South Korea and Turkey are well below these levels. Several middle-income developing countries, such as Brazil, Thailand, Taiwan and Malaysia, are in the range of 100–300 vehicles per 1,000. However, almost 4 billion of the world's population are in countries where the vehicle penetration rate is below 100 per 1,000 inhabitants.

Historically, growth rates in vehicle ownership averaging more than ten per cent p.a. have been observed in several countries. Indeed, even in some OECD countries, such rapid increases have been observed over the past three decades (e.g. Spain, Turkey, South Korea and Mexico). However, it is predominantly in countries with very low intensities where growth of this order of magnitude continues to be observed, notably in India and China. How these vehicle penetration rates evolve is clearly a fundamental factor in determining the future growth of oil demand.

The evolution of vehicle intensities is linked to the growth in income per capita, but not in a linear fashion. Typically, vehicle ownership rates grow faster in middle-income countries than in lower-income ones, for example, as infrastructure expands, then slows at higher income levels, as saturation effects become more pronounced. The relationship between vehicle intensities and income per capita is, therefore, modelled using a non-linear sigmoid formulation, together with estimates of impacts of oil price movements. The saturation points in these equations are assumed, rather than estimated, since, especially for lower-income countries, the historical evidence provides little insight as to the characteristics of the curve. Assumed saturation levels, in line with similar work in the literature,[1] are 850 vehicles per 1,000 in North America, 700 per 1,000 in Western Europe and OECD Pacific, 600 per 1,000 in transition economies and 425 vehicles per 1,000 in developing countries. The differences between the regions reflect a number of factors, such as demography, geography and cultural differences. The evolution of intensities, both historically and in the projection, is shown in **figure 10**, with the projections detailed in **table 6**.

Table 5
Vehicle ownership in 2000

	Vehicles	Cars	Pop.	Vehicles	Cars	Vehicle growth % p.a.		
	/1,000	/1,000	*mill.*	*mill.*	*mill.*	70–80	80–90	90–00
North America	620	384	415	257	159	*4.0*	*2.1*	*1.7*
USA	774	472	282	218	133	*3.7*	*1.9*	*1.4*
Mexico	189	107	98	18	10	*12.0*	*5.8*	*6.4*
Western Europe	444	395	515	229	203	*5.1*	*3.5*	*2.6*
France	574	476	59	34	28	*4.2*	*2.7*	*1.8*
Germany	555	523	82	46	43	*4.7*	*2.7*	*3.6*
Italy	612	545	58	35	31	*5.6*	*4.5*	*1.7*
UK	445	393	60	27	23	*2.5*	*2.9*	*1.6*
Spain	550	452	39	22	18	*11.1*	*4.9*	*4.2*
Turkey	85	63	65	6	4	*13.1*	*10.6*	*7.2*
OECD Pacific	487	421	197	96	83	*7.1*	*4.3*	*2.9*
Japan	573	492	127	73	62	*7.8*	*4.3*	*2.3*
South Korea	255	171	47	12	8	*23.0*	*20.7*	*13.5*
OECD	**516**	**395**	**1,126**	**582**	**445**	***4.8***	***2.9***	***2.2***
Oil-importing DCs								
Latin America	152	120	262	40	31	*12.3*	*5.6*	*5.1*
Brazil	170	136	170	29	23	*13.8*	*6.0*	*4.8*
Chile	133	87	15	2	1	*7.4*	*4.5*	*6.8*
Middle East and Africa	33	23	509	17	12	*6.0*	*4.4*	*4.6*
Ethiopia	2	1	64	0	0	*1.4*	*2.2*	*4.5*
Kenya	11	8	30	0	0	*2.3*	*7.4*	*1.6*
Morocco	54	42	29	2	1	*7.7*	*3.6*	*5.6*
South Africa	145	92	43	6	4	*5.3*	*4.1*	*2.4*
South Asia	10	6	1,344	13	8	*3.0*	*10.3*	*9.9*
Bangladesh	1	0	131	0	0	*1.2*	*3.5*	*3.7*
India	10	6	1,016	10	6	*2.9*	*10.7*	*10.3*
Pakistan	9	5	138	1	1	*3.4*	*11.0*	*8.1*
South-East Asia	106	57	300	32	17	*7.4*	*10.1*	*9.8*
Philippines	32	10	76	2	1	*0.4*	*0.7*	*15.0*
Taiwan	243	213	22	5	5	*19.3*	*16.7*	*6.3*
Thailand	138	48	61	8	3	*9.8*	*10.5*	*12.4*
China	12	7	1,275	16	9	*15.9*	*19.6*	*15.7*
Oil-exporting DCs								
OPEC	39	24	510	20	12	*11.7*	*7.0*	*3.8*
Algeria	50	24	30	2	1	*12.6*	*1.2*	*5.9*
Indonesia	26	15	210	5	3	12.8	8.9	6.8
Iran	45	34	64	3	2	*7.9*	*7.1*	*5.3*
Iraq	48	34	23	1	1	*10.7*	*11.2*	*2.5*
Nigeria	24	9	127	3	1	*13.5*	*14.3*	*8.7*
Saudi Arabia	152	91	21	3	2	*31.7*	*9.7*	*0.3*
Other	70	52	375	26	20	*7.2*	*5.7*	*4.5*
Angola	21	19	13	0	0	*–0.1*	*2.6*	*7.2*
Egypt	34	26	64	2	2	*12.6*	*12.8*	*3.7*
Malaysia	212	181	23	5	4	*11.4*	*9.8*	*8.1*
Syria	33	9	16	1	0	*7.7*	*8.8*	*7.7*
Total DCs	**36**	**24**	**4,574**	**164**	**109**	***8.8***	***6.8***	***6.5***

Table 5
Vehicle ownership in 2000 (cont.)

	Vehicles /1,000	Cars /1,000	Pop. *mill.*	Vehicles *mill.*	Cars *mill.*	Vehicles growth *% p.a.* 70–80	80–90	90–00
FSU	150	126	288	43	36	*2.8*	*2.9*	*4.0*
Russia	174	140	146	25	20	*2.4*	*2.3*	*3.7*
Ukraine	106	106	50	5	5	*5.3*	*5.3*	*4.8*
Other Europe	222	194	63	14	12	*6.8*	*5.4*	*3.6*
Romania	160	139	22	4	3	*2.7*	*5.0*	*8.0*
Transition economies	**163**	**138**	**352**	**57**	**49**	***3.5***	***3.5***	***3.9***
World	**133**	**100**	**6,051**	**803**	**602**	***5.0***	***3.4***	***3.1***

Sources: International Road Federation, "World Road Statistics 2003", and other editions; OPEC Secretariat database; World Bank online database; estimations.

Table 6
Projections of vehicle ownership rates to 2025

	Vehicles 2000	2010	2020	2025	Growth of vehicles 2000–10	2010–25
	per 1,000				*% p.a.*	
North America	620	648	675	687	*1.6*	*1.2*
Western Europe	444	523	583	604	*2.0*	*1.1*
OECD Pacific	487	528	544	554	*1.0*	*0.2*
OECD	**516**	**572**	**614**	**631**	***1.6***	***1.0***
Oil-importing DCs						
Latin America	152	168	237	269	*2.0*	*3.8*
Middle East & Africa	33	40	49	54	*4.1*	*3.7*
South Asia	10	21	46	63	*9.7*	*8.7*
South-East Asia	106	148	213	240	*4.7*	*4.3*
China	12	30	57	74	*10.0*	*6.8*
Oil-exporting DCs						
OPEC	39	53	67	75	*4.8*	*3.8*
Other	70	85	104	115	*3.6*	*3.2*
DCs	**36**	**51**	**77**	**92**	***5.0***	***5.1***
FSU	150	220	282	312	*3.7*	*2.2*
Other Europe	222	315	406	446	*3.5*	*2.0*
Transition economies	**163**	**237**	**304**	**336**	***3.7***	***2.1***
World	**133**	**152**	**178**	**191**	***2.6***	***2.4***

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Figure 10
Vehicle intensities, 1970–2025

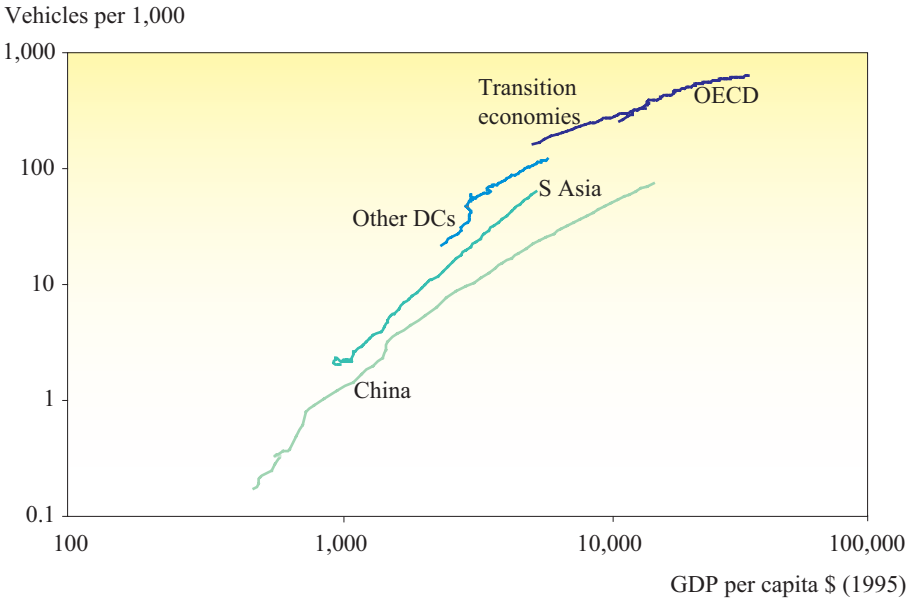
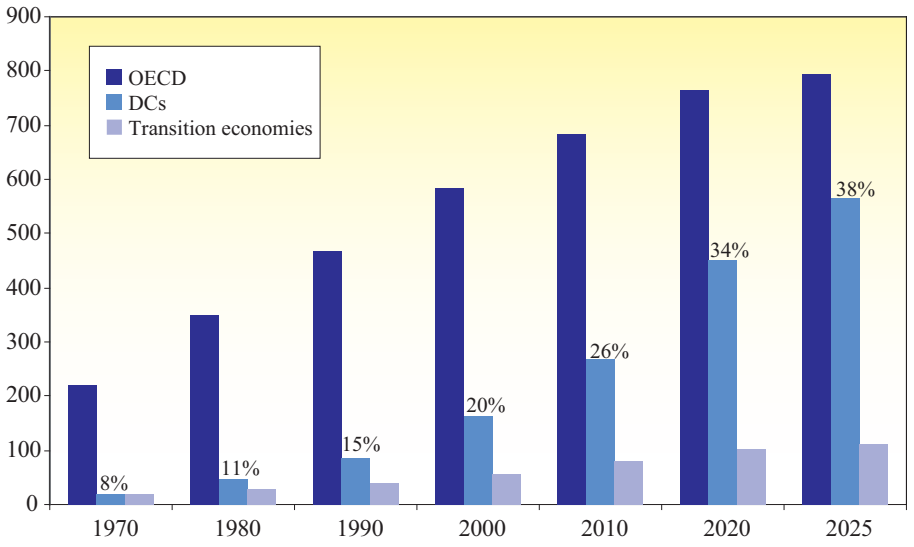


Figure 11
Number of vehicles, 1970–2025
million



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The choice of saturation level is an important factor in determining growth potential in countries that are already approaching saturation levels, in particular OECD regions. It is also an important factor in determining growth in developing countries which have already achieved substantial rates of penetration, such as in Latin America and parts of South-East Asia. However, for countries with currently very low rates, such as China and India, the choice of saturation assumption is not a major driver of demand growth, unless exceptionally low points of saturation are considered.

The growth in vehicles is such that the share of developing countries in global vehicle ownership increases from 20 per cent in 2000 to 38 per cent by 2025 (**figure 11**). Both Chinese and South Asian vehicle-ownership growth is close to ten per cent p.a. in the decade 2000–10, falling to lower average rates of seven-to-nine per cent in the long run. These are growth rates that are consistent with the expected continued "take-off" of ownership, given the huge scope for increases and the strong economic growth, as well as the observed behaviour of both these regions and other regions that have undergone a similar rapid expansion in ownership rates over the past three decades. Nevertheless, important potential limits to such growth rates must be borne in mind in the assessment of longer-term oil demand growth possibilities. In particular, the availability of the necessary infrastructure is normally identified as one of the most likely constraints to such swift ownership expansion, although India, for example, is already embarking on a major investment programme to expand the motorway network. Similarly, the evolution of domestic policies that may address rising import dependency, either through fiscal or non-fiscal means, as well as the speed of development of local vehicle manufacturing capabilities, will have important implications for the rate of expansion of vehicle ownership.

While the growth in vehicles outlined above provides a strong impetus for oil demand growth, this is accompanied by parallel improvements to the aggregate efficiency of the vehicle stock. A frequently identified factor that drives such gains in efficiency is improvements in the efficiency of new vehicles; these can come about either by the more rapid penetration of existing technologies, greater emphasis upon diesel growth as opposed to gasoline, or the development and implementation of newer technologies, in particular hybrids. Clearly, all these factors can be and are, to a large extent policy-driven. Aggregate oil efficiencies are also affected by the rate of growth of alternative fuels, such as compressed natural gas. Another factor that can influence the aggregate use of oil for any given vehicle stock is the relative growth of passenger cars to buses and lorries.

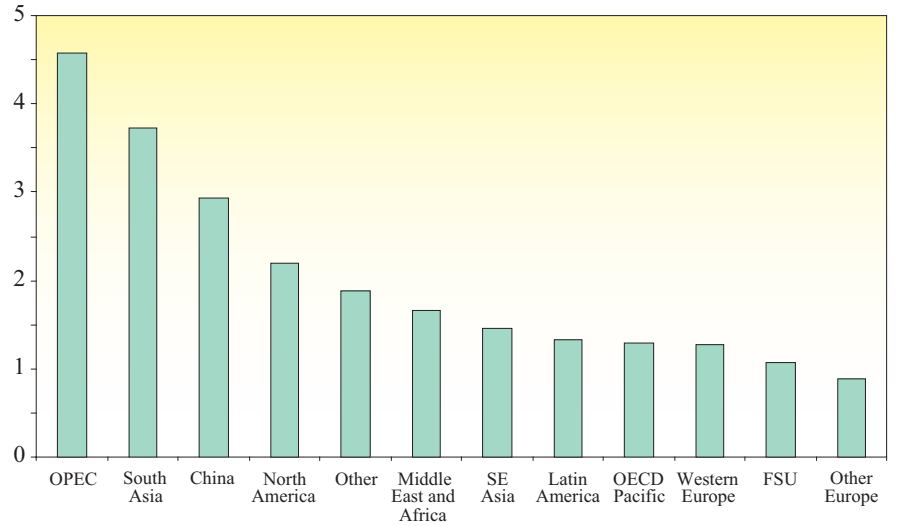
Thus, while historical patterns can provide some indication of the scope for further improvements, the uncertainties for this important element in the demand picture need to be emphasized. This is, therefore, the subject of a sensitivity test in the later section on scenarios. **Table 7** provides historical growth rates of the oil efficiency per vehicle (i.e. total road transportation oil demand, divided by the vehicle stock), together with the assumed average growth in the reference case.

China and South Asia have experienced strong improvements in efficiency, and this is expected to continue, as the introduction of new vehicles to the stock will have a strong impact upon average fleet efficiencies. Furthermore, these two regions still

Table 7
Average annual growth in oil use per vehicle
%

	1971–80	1980–90	1990–00	2000–25
North America	–1.6	–0.7	0.4	–0.5
Western Europe	–0.7	–0.4	–0.7	–0.6
OECD Pacific	–1.6	0.2	–0.2	–0.4
OECD	**–1.3**	**–0.5**	**–0.1**	**–0.5**
Oil-importing DCs				
Latin America	–7.8	–0.8	2.9	–0.7
Middle East and Africa	–1.6	–1.2	–1.7	–1.4
South Asia	4.9	–3.1	–2.6	–2.2
South-East Asia	0.6	–2.2	–3.0	–0.9
China	–5.6	–10.5	-6.4	–2.1
Oil-exporting DCs				
OPEC	2.1	–3.3	0.4	–1.8
Other	–1.5	–3.3	–0.4	–1.2
DCs	**–3.2**	**–2.1**	**–0.6**	**–1.5**
FSU	4.0	–0.1	–7.8	–0.1
Other Europe	–5.1	–3.3	–3.6	0.2
Transition economies	**2.3**	**–0.8**	**–6.7**	**–0.1**
World	**–1.3**	**–0.7**	**–0.3**	**–0.8**

Figure 12
Oil use per vehicle in 2000
toe



have among the highest oil use per vehicle (**figure 12**). In other developing countries, the improvement in efficiencies is at greater rates than in the OECD, leading towards a convergence pattern over the very long term. Within the OECD, Western Europe has slightly stronger downward trends than in the other two regions. In this way, aggregate efficiency improvements to the vehicle stock over the medium-to-long term are assumed to average 0.5 per cent p.a. in the OECD and 1.5 per cent p.a. in developing countries.

As a result of these projections and assumptions, the growth in road transportation demand is derived and presented in **table 8**. As expected, the strongest growth over the projection period is for developing countries, growing at an average of almost four per cent p.a. over the years 2000–25, while OECD growth averages just under one per cent p.a.. In line with the expectations for the strong growth in vehicle use, the increase in oil demand in road transportation is strongest in China and South Asia, averaging six-to-seven per cent p.a. over this period. With transition economies' road oil use expanding by just under three per cent p.a., the world average lies at 1.9 per cent p.a..

Table 8
Road transportation in the reference case
mboe/d

	Levels				Volume growth	
	2000	**2010**	**2020**	**2025**	**2000–10**	**2010–25**
North America	11.3	12.2	13.5	14.1	0.9	1.8
Western Europe	5.9	6.5	7.1	7.2	0.6	0.7
OECD Pacific	2.5	2.6	2.6	2.6	0.2	–0.1
OECD	**19.7**	**21.4**	**23.1**	**23.8**	**1.7**	**2.4**
Oil-importing DCs						
Latin America	1.1	1.2	1.7	1.9	0.1	0.7
Middle East and Africa	0.6	0.7	0.9	1.0	0.1	0.3
South Asia	1.0	1.9	3.7	5.0	0.9	3.1
South-East Asia	0.9	1.3	1.9	2.2	0.4	0.9
China	0.9	2.0	3.2	3.9	1.0	1.9
Oil-exporting DCs						
OPEC	1.8	2.4	3.0	3.3	0.5	0.9
Other	1.0	1.2	1.5	1.7	0.2	0.5
DCs	**7.3**	**10.6**	**16.0**	**18.9**	**3.2**	**8.3**
FSU	0.9	1.3	1.6	1.8	0.4	0.4
Other Europe	0.2	0.3	0.4	0.5	0.1	0.1
Transition economies	**1.2**	**1.7**	**2.1**	**2.3**	**0.5**	**0.6**
World	**28.2**	**33.6**	**41.2**	**45.0**	**5.4**	**11.3**

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To complete the assessment for the transportation sector, the non-road element, primarily air transportation, needs to be considered. Currently, the OECD countries are by far the major users of oil in this sector, accounting for over two-thirds of demand. With growth in air transport continuing to rise with income levels, and little sign of saturation, the OECD is expected to be an important source of increase in demand in the coming two decades. Even stronger increases are expected from developing countries, growing at an average of over three per cent p.a. in the projection, with income elasticities expecting to remain close to 0.7 in most regions. Although the key to this increase is, once more, Asia, it is not expected that the dramatic increases in China, averaging over 13 per cent p.a. in the 1990s, are sustainable.

Finally, the projections for road and non-road transpiration are combined for a total transportation outlook (**table 9**). Over the ten years 2000–10, an increase in demand of 7 mboe/d is expected, while a further 14 mboe/d increase appears over 2010–25. The annual growth rate averages 1.9 per cent p.a., with developing countries' demand expanding at almost twice that rate.

Table 9
Total transportation oil demand in the reference case
mboe/d

	Levels				Volume growth	
	2000	**2010**	**2020**	**2025**	**2000–10**	**2010–25**
North America	13.7	14.9	16.4	17.1	1.1	2.3
Western Europe	7.1	8.0	8.7	8.9	0.8	1.0
OECD Pacific	3.1	3.5	3.7	3.7	0.4	0.3
OECD	**24.0**	**26.3**	**28.8**	**29.8**	**2.3**	**3.5**
Oil-importing DCs						
Latin America	1.2	1.4	1.9	2.1	0.1	0.8
Middle East and Africa	0.7	0.8	1.1	1.2	0.1	0.4
South Asia	1.1	2.0	4.0	5.3	0.9	3.2
South-East Asia	1.2	1.5	2.2	2.5	0.4	1.0
China	1.3	2.7	4.4	5.3	1.4	2.6
Oil-exporting DCs						
OPEC	2.0	2.7	3.3	3.7	0.7	0.9
Other	1.1	1.3	1.7	1.9	0.2	0.6
DCs	**8.7**	**12.6**	**18.7**	**22.1**	**3.8**	**9.5**
FSU	1.3	1.9	2.4	2.6	0.6	0.7
Other Europe	0.3	0.4	0.5	0.6	0.1	0.2
Transition economies	**1.6**	**2.3**	**2.9**	**3.2**	**0.8**	**0.9**
World	**34.3**	**41.2**	**50.4**	**55.1**	**6.9**	**13.9**

3.2 Industry sector

Oil use in industry accounted for 21 per cent of total world oil demand in 2001, with consumption at 11.8 mboe/d, and is thereby the second most important sector for consumption, after transportation. Its relative importance varies considerably between regions: the Asian regions typically have the highest share, with China and OECD Pacific both approaching 30 per cent of oil demand and South Asia at 24 per cent, while the share is just 18–19 per cent for the other OECD regions. The importance of petrochemicals as the source of oil demand in industry has grown steadily over the past two decades, accounting, by 2001, for just under half the industrial oil use in North America and OECD Pacific, and as much as 58 per cent in OECD Pacific. Detailed sub-sector data for developing countries is less reliable, but similarly strong trends are identifiable: whereas the petrochemical sector typically accounted for just one-fifth of oil demand in most regions in the early 1980s, this has risen dramatically as the petrochemical sector has developed in many of these countries. In China, for example, by 2001, the contribution had risen to close to half the total industrial oil use.

In absolute terms, oil demand in the industry sector is dominated by OECD countries, accounting for almost 60 per cent of worldwide consumption. Although this share has been approximately constant over the last decade, this has been due to the strong growth in developing countries' demand, particularly in China and India, being countered by the dramatic fall in consumption in the FSU in the early 1990s. Current trends, therefore, point to a continuing increase in the importance of developing countries for oil demand in this sector.

It is clearly important to understand the dynamics of growth in the industrial sector when assessing global oil demand prospects over the coming years. In making this assessment, intensity developments have been analysed, defined as fuel consumption per unit of industrial sector value-added to GDP.

3.2.1 Oil intensities

Historically, aggregate energy intensities have tended to fall in the industrial sector in the OECD regions. This has been partly precipitated by the rise of energy prices in the 1970s (the 1986 price fall to an extent stemmed this decline), but there is also an expectation that intensities will fall, even in the absence of such price signals. The assumption for these 'autonomous energy efficiency improvements' (AEEI) for the future development of intensities is between 0.6 per cent and one per cent p.a. for the projection period. These factors are derived from econometric evidence, but are important parameters in energy modelling that can be strongly influenced by policy, and, therefore, represent a key uncertainty in making projections. Such efficiency improvements are typically a result of technological innovation and the incentive to reduce costs by encouraging research and development activities. They also result from changes in the structure of industry, for example, away from high energy-intensive manufacturing towards lower-intensive areas, such as electronics. Some aggregate estimates for this variable include even more fundamental structural changes of an economy, reflecting general shifts from industrial activity to services; these additional efficiency improvements are reflected in the assumption for the share of industry in GDP, described below.

Following the increase in oil prices in the 1970s, the share of oil in this sector went into decline, particularly in Western Europe and OECD Pacific, although the price fall of 1986 halted this decline. In North America, natural gas is a competitor for oil in parts of the industry sector. The relative price of gas to oil can, therefore, affect the oil share in this sector. The reference case assumes that there will be no major pressure on this share over the projection period, but any change in the relevant price signals, resulting, for example, from either market pressure or fiscal measures, could have an impact upon the oil share.

In Western Europe, the petrochemical sector is not quite as dominant in industrial oil use, although it still accounts for over 60 per cent of consumption. As the share of oil declined historically, this was matched by a corresponding increase in the gas share. The commitment to deregulation is likely to have important impacts upon the regional gas market, and this, together with the obvious environmental credentials of the natural gas share, makes it likely that significant increases in gas imports will occur over the next two decades. Accordingly, the oil share in the industry sector in Western Europe is expected to fall slightly over this time. However, the gas/oil share in this region is extremely sensitive to relative price movements, so the impacts of the deregulation process on retail prices, government taxation policy, especially related to environmental protection, and the future cost of importing gas from increasingly distant sources are all important factors that will affect the development of oil demand in this sector.

In the OECD Pacific region, the industry sector is the second most important source of oil demand, and has a higher oil share than in the other two OECD regions. A similar long-term increase in the gas share is likely to affect the use of oil, although at a slower pace than is likely in Europe, with liquefied natural gas imports, in particular to Japan, expected to increase substantially.

The decline in aggregate energy intensities, together with the gradual fall in oil's share in this sector, leads to industrial oil intensity in the OECD falling by an average of 1.2 per cent over the forecast period.

Oil intensities in medium-income developing countries, defined here as Latin America and South-East Asia, fell in reaction to high oil prices in the early 1980s, but have risen gradually over the past two decades. This period, which has seen oil use in this sector growing faster than industrial GDP, reflects in part the expansion of the petrochemical industry in these regions, with the oil share rising swiftly in South-East Asia particularly. Recent behaviour suggests that these growth rates may be slowing, pointing to a likely future decline in oil intensities. The gas share is growing, in Latin America in particular, and this is likely to contribute to the expected decline in future oil intensities, although they will remain above average OECD levels.

The lower-income developing countries — South Asia, the Middle East and Africa — have seen a steady decline in the share of biomass (combustible renewables and waste) in the energy mix in the industry sector, falling in South Asia from 43 per cent in 1971 to 21 per cent by 2001, and from 30 per cent to 22 per cent in the Middle East and Africa, a shift which has seen a corresponding rise in the share of electricity and, to an extent, oil. Aggregate energy intensities have been falling at modest rates;

the impact upon oil demand has been for growth to have practically matched increases in industrial GDP, particularly in South Asia. Long-term developments in this sector foresee a continued strong link between the use of oil and growth in industry value-added, although intensities are expected to fall gradually, as the biomass substitution possibilities disappear and the use of gas in this sector continues to increase.

Oil and energy intensities in oil-exporting developing countries, in particular in OPEC, have, over the past two decades, been as high as in any other developing country region. Reasons for this include the low price that has been paid historically for fuels in industry and the importance of the petrochemical sector in many of the countries in these regions. Inevitably, natural gas is the key substitute for oil, particularly since domestic resources invariably make this an easily accessible option. Around 90 per cent of all fuel used in industry on average in OPEC is either oil or gas, the figure falling to just under 80 per cent for other exporters. The projections assume that a fall in oil's share occurs in both regions, leading to a steady decrease in oil intensity.

Chinese oil intensity in industry has fallen dramatically over the past two decades, even though the share of oil in this sector's energy demand has been increasing. This may partly reflect difficulties in interpreting Chinese GDP data. The longer term sees intensities continue to fall in this country, but not at such rapid rates as in the past. These improvements will come, for example, from the use of new industrial boilers and other improvements in technical efficiency, as well as a longer-term shift from heavy to light industry, as the communications and electronics industries grow.

While historical information for the FSU reveals little in terms of longer-term patterns, the large decline in oil intensities, following the collapse of the centrally planned economies, lasted only until 1994, since when a slight increase has occurred. It is assumed that the intensities remain stable around recent values.

For the industrial sector oil demand growth assessment, the aggregate GDP increases are combined with additional information and assumptions concerning the role of industry value-added in economic growth. The share of industry in GDP demonstrates very different characteristics across the world regions, in terms of both relative size and movement over time. OECD regions have all experienced declines in the share of industrial GDP, as the service sectors have taken increasing prominence. Over the period 1970–2000, the share fell by close to ten percentage points for all three regions, with North America now having the lowest industrial share of any world region. These declines are set to continue over the forecast period, with a further shift to the service sector.

In 2000, the highest share was for China, where 51 per cent of GDP was accounted for by industry, having risen from 42 per cent in 1990, reflecting an average growth of industrial GDP of over 12 per cent p.a. over the 1990s. The important role of industry in economic growth is expected to continue into the forecast period, partly as a result of the continued de-industrialisation in neighbouring Asian nations, in particular Japan. The attraction of investing in China lies with the low labour and operating costs, and also with the more lenient environmental and other regulations. South Asia, primarily accounted for by India and Pakistan, has also seen the share of industry rise, although not as swiftly as in China, and it is expected that this will continue in the forecast

period. The South-East Asian group of countries have experienced, throughout the 1970s, a classic rise in the share of industry as the major driver of economic growth. Since then, the share has steadily fallen, and this trend is expected to continue.

Latin America has experienced a similar pattern of development to South-East Asia, with the share of industrial GDP rising gradually over the 1970s and 1980s, followed by a general decline since then. A less pronounced pattern has been observable in the Middle East and Africa region, but recent growth patterns have seen the industry share fall steadily. The reference case assumes that these trends continue.

The oil-exporting countries, both in OPEC and elsewhere, have a higher share of industrial GDP than all other regions, with the exception of China, reflecting the importance of the petroleum sector for these countries. The fall in non-OPEC developing countries' share in the projection is a reflection not only of recent trends, but also of the expectation that the petroleum sector will play a progressively smaller role in these economies. For OPEC, the share has experienced strong fluctuations in the past,

Table 10
Oil demand in industry
mboe/d

	Levels				Volume growth	
	2000	**2010**	**2020**	**2025**	**2000–10**	**2010–25**
North America	3.7	4.2	4.4	4.5	0.5	0.3
Western Europe	2.9	2.9	2.9	2.9	0.0	0.0
OECD Pacific	2.5	2.4	2.5	2.5	–0.1	0.1
OECD	**9.0**	**9.4**	**9.8**	**9.9**	**0.4**	**0.5**
Oil-importing DCs						
Latin America	0.7	0.8	0.9	0.9	0.1	0.1
Middle East and Africa	0.2	0.3	0.3	0.4	0.1	0.1
South Asia	0.6	0.9	1.4	1.7	0.3	0.8
South-East Asia	0.6	0.9	1.1	1.3	0.3	0.4
China	1.4	1.9	2.5	2.8	0.5	0.9
Oil-exporting DCs						
OPEC	1.1	1.3	1.6	1.7	0.3	0.4
Other	0.6	0.7	0.9	1.1	0.1	0.4
DCs	**5.2**	**6.8**	**8.8**	**9.9**	**1.6**	**3.1**
FSU	0.8	0.8	0.9	1.0	0.1	0.1
Other Europe	0.2	0.2	0.2	0.3	0.0	0.0
Transition economies	**0.9**	**1.0**	**1.2**	**1.2**	**0.1**	**0.2**
World	**15.1**	**17.2**	**19.7**	**21.0**	**2.1**	**3.8**

reflecting the turbulence in oil markets from the 1970s' price rises and the 1986 price collapse. The reference case projection makes the neutral assumption that the industry share remains constant.

Finally, the share of industry in GDP in the FSU has been on a steady decline since the collapse of the command economy system: in 1990, the share was greater than for any other world region. It is expected that this downward trend will continue.

The above assessment gives rise to a reference case projection for oil demand in the industrial sector, presented in **table 10**. Total world demand in the industry sector over the period 2000–25 increases by close to 6 mboe/d. OECD oil demand in this sector increases by less than 1 mboe/d over this period, with North America the only appreciable source of growth. The developing country regions register stronger growth, with increases totalling almost 5 mboe/d by 2025. The largest increases are expected from the Asian developing countries, rising by over 3 mboe/d.

For both 2000–10 and 2010–25, China sees a larger growth in oil demand in the industry sector than any of the other world regions. North America registers significant growth in the first decade, but the post-2010 period is dominated by growth in developing countries, particularly in Asia (**figures 13** and **14**).

3.3 Residential/commercial/agricultural sector

Oil demand in this sector accounts for 14 per cent of the world total, and follows in size the transportation and industrial sectors. Around 55 per cent of world demand is in OECD countries, where the main use is for space- and water-heating, with Western Europe the largest consumer. The highest per capita use is in the OECD Pacific, having seen levels of use per head rise steadily over the past three decades, and further growth is likely. Aggregate energy use per head in this region is now at a comparable level to that of Western Europe, which has remained approximately constant over the last 20 years. Demand will also be limited by ongoing efforts in OECD regions to introduce more stringent efficiency codes, with regard, for example, to insulation in new buildings and such equipment as heat pumps and water heaters. The continued move towards gas and electricity for space-heating in all OECD regions will also limit the growth in oil demand in this sector.

Saturation considerations are, of course, not usually relevant for developing countries, where per capita demand is well below that of the OECD. The combination of increasing income and growing populations has driven demand in the past, with average income elasticities close to unity for some regions. While some switching behaviour to gas and electricity is evident in the middle-income regions of Latin America and South-East Asia, the poorer regions of South Asia and the Middle East and Africa will continue to move away from traditional fuels, and oil demand is likely to continue to benefit from this. In OPEC countries, on the other hand, a continued switch to natural gas could limit the potential for oil demand growth in this sector in the future, although recent behaviour suggests that income elasticities for oil demand remain high.

Table 11 documents the results for the reference case for this sector. As expected, the increases in demand come almost entirely from the developing coun-

Figure 13
Increase in oil demand in industry, 2000–10
mboe/d

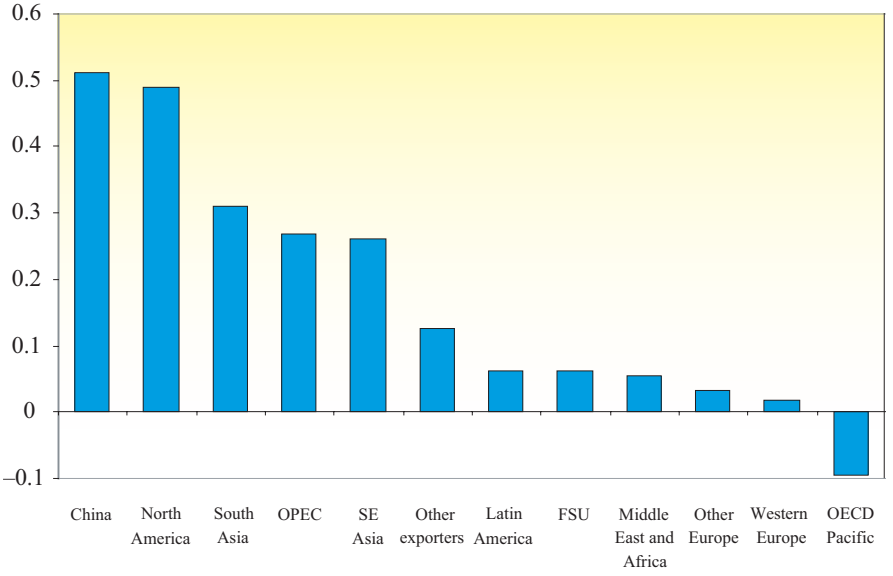

Figure 14
Increase in oil demand in industry, 2010–25
mboe/d

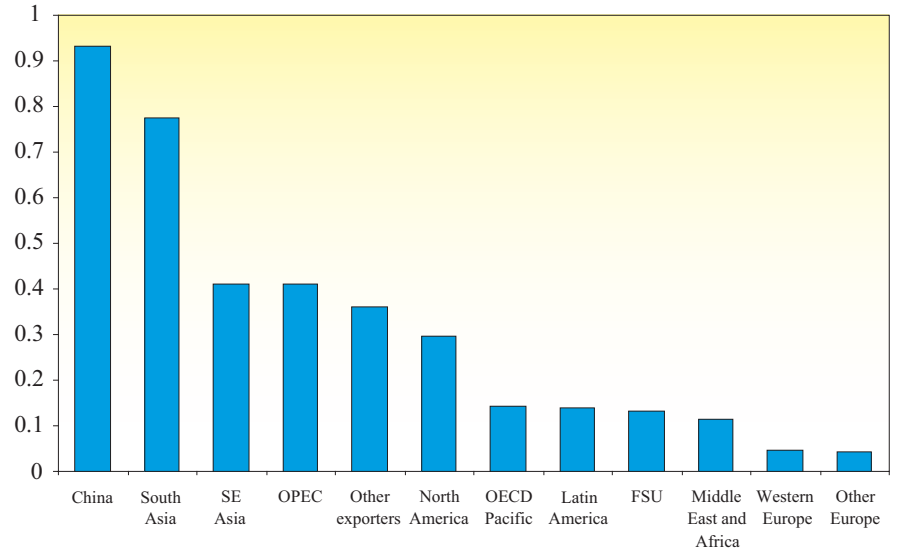

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Table 11
Oil demand in residential/commercial/agricultural sector
mboe/d

	Levels				Volume growth	
	2000	**2010**	**2020**	**2025**	**2000–10**	**2010–25**
North America	1.7	1.9	2.0	2.1	0.2	0.1
Western Europe	2.2	2.3	2.2	2.2	0.0	–0.1
OECD Pacific	1.3	1.7	1.8	1.8	0.3	0.1
OECD	**5.3**	**5.9**	**6.0**	**6.0**	**0.6**	**0.2**
Oil-importing DCs						
Latin America	0.4	0.6	0.8	0.9	0.2	0.4
Middle East and Africa	0.3	0.4	0.5	0.6	0.1	0.2
South Asia	0.5	0.7	1.0	1.2	0.2	0.5
South-East Asia	0.3	0.3	0.4	0.4	0.1	0.1
China	0.9	1.5	2.3	2.8	0.6	1.3
Oil-exporting DCs						
OPEC	1.0	1.5	2.0	2.3	0.5	0.8
DC exporters	0.5	0.6	0.8	0.9	0.1	0.3
DCs	**3.8**	**5.5**	**7.8**	**9.1**	**1.7**	**3.6**
FSU	0.6	0.6	0.5	0.5	0.0	–0.1
Other Europe	0.1	0.1	0.1	0.1	0.0	0.0
Transition economies	**0.6**	**0.6**	**0.6**	**0.6**	**0.0**	**–0.1**
World	**9.7**	**12.0**	**14.4**	**15.7**	**2.2**	**3.7**

tries, with rises in China the greatest, in terms of both volume and percentages. Switching away from coal towards both oil and electricity has been observed over recent years, while the main fuel for this sector is still biomass, at close to 60 per cent of total energy consumption, which should also provide additional scope for switching towards modern commercial fuels over the next two decades. Demand in the OECD Pacific increases initially, but the effects of saturation and lack of population growth see demand plateau, as in the other OECD regions. Demand in transition economies also stays approximately constant, where an expected recovery in energy use per capita will come about mainly through increases in electricity and gas use.

3.4 Electricity generation sector

Electricity demand has grown over the last three decades at very strong rates in all world regions, with the amount generated in 2001 almost three times that of 1971. The developing countries have witnessed the fastest rates, but, in all regions, the expansion of electricity consumption has been very closely linked with GDP growth.

Figure 15
Electricity demand per capita
toe

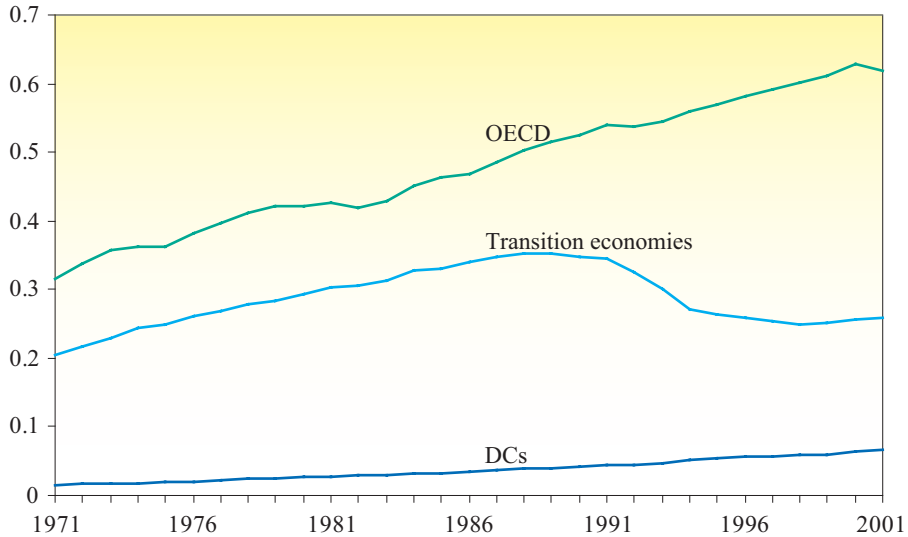
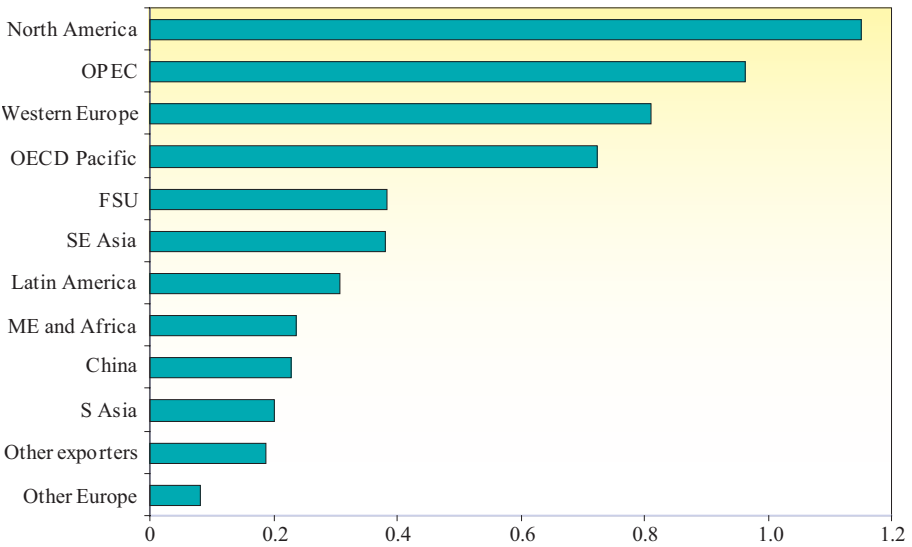


Figure 16
Oil consumption in electricity generation in 2001
mboe/d



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OECD consumption continues to expand in line with economic growth rates, while the rate of increase in developing countries has been considerably higher. The average consumption per capita in developing countries is just one-tenth of the OECD average (**figure 15**), demonstrating the clear need for further electrification.[2] While there are signs of decreasing elasticities in most regions, the growth in electricity demand over the projection period will be a major source of additional energy requirements.

The electricity generation sector is a smaller contributor to world oil demand than transportation, industry or the combined sector of residential, commercial and agricultural, accounting for just seven per cent of global consumption, representing less than 5 mboe/d. OECD regions account for almost half of global consumption (**figure 16**). OPEC Member Countries together consume more oil in electricity generation than any other OWEM region, apart from North America. Following strong growth in the 1970s, oil demand in this sector, in reaction to oil price rises, fell during the 1980s in both the OECD and transition economies, staying approximately flat in developing countries. The 1990s saw a revival of growth in developing countries, while demand remained flat elsewhere.

Coal continues to be the dominant fuel in this sector, with an average global figure of 46 per cent of the total energy input, although there are large regional variations, according to natural resource endowments. Thus, China and South Asia have coal accounting for 87 per cent and 75 per cent, respectively, of inputs, while Latin America lies below ten per cent, largely relying upon hydro power instead. Similarly, the share of coal in North America is close to 50 per cent, reflecting the large domestic coal resource base.

Natural gas, on the other hand, is the key input for electricity generation in oil-exporting countries, accounting for close to half, on average, of the mix in OPEC countries and the FSU, and as much as two-thirds in other exporting developing countries. Indeed, the gas share has been increasing over the past decade in most world regions, most notably Western Europe, South-East Asia and oil exporters.

In the reference case projections, the only significant growth in oil demand in the electricity generation sector will come in developing countries, although the size of this increase will be modest (**table 12**). However, the aggressive development of clean oil technologies, such as integrated gasification combined cycle power plants (IGCC) and CO_2 sequestration, has the potential to enhance the use of oil in this sector. A rapid expansion of the role of natural gas is expected to continue to constitute the major shift in patterns of energy use, with some increases in hydro, nuclear and other renewables also likely. In some regions, such as North America, expanded use of coal is also expected, although its share will gradually decline.

In contrast to the other sectors, China does not register a rise in oil demand in this sector in the reference case, with coal expected to continue to be the fuel of choice, while, at the same time, increases in hydro, nuclear and natural gas inputs are expected. Environmental concern, at both local and regional levels, over the impact of such expanded coal use could, however, lead to some fuel-switching, which may have some positive effect upon oil demand, since the possibilities for expanding gas use in this sector will be limited by the rate at which investments in transportation are

Table 12
Oil demand in electricity generation
mboe/d

	Levels				Volume growth	
	2000	**2010**	**2020**	**2025**	**2000–10**	**2010–25**
North America	1.2	1.2	1.3	1.3	0.1	0.1
Western Europe	0.8	0.8	0.8	0.8	0.0	0.0
OECD Pacific	0.7	0.8	0.7	0.6	0.1	–0.1
OECD	**2.7**	**2.8**	**2.8**	**2.8**	**0.2**	**0.0**
Oil-importing DCs						
Latin America	0.3	0.4	0.6	0.6	0.1	0.2
Middle East and Africa	0.2	0.3	0.4	0.5	0.1	0.2
South Asia	0.2	0.3	0.4	0.5	0.1	0.2
South-East Asia	0.4	0.5	0.6	0.6	0.1	0.2
China	0.2	0.2	0.2	0.2	0.0	0.0
Oil-exporting DCs						
OPEC	0.9	1.1	1.3	1.4	0.1	0.3
Other	0.2	0.2	0.2	0.2	0.0	0.0
DCs	**2.5**	**2.9**	**3.6**	**4.0**	**0.4**	**1.1**
FSU	0.4	0.3	0.2	0.2	–0.1	–0.1
Other Europe	0.1	0.1	0.1	0.0	0.0	0.0
Transition economies	**0.5**	**0.3**	**0.3**	**0.2**	**–0.2**	**–0.1**
World	**5.7**	**6.1**	**6.7**	**7.0**	**0.4**	**0.9**

made. Furthermore, concern over the available transportation infrastructure, to bring coal from the mined areas to the concentrations where it is to be burned, could also lead to further substitution.

Growth in oil-exporting countries, in particular in OPEC, is expected to continue to contribute to demand increases, but at much slower rates than have been observed over the past decade, as oil's share in the energy mix is steadily eroded by natural gas.

4. Non-OPEC oil production in the reference case: regional outlook

4.1 USA and Canada

As in earlier projections, it is expected that the declines in onshore lower-48 US production and Canadian conventional oil output will continue to be offset by increases in the Gulf of Mexico (GoM) and non-conventional oil output in Canada. Indeed, the GoM has become the region of most intense exploration and production activity in water depths of over 500 metres. It is expected that GoM deepwater production will peak some time before 2010. Improvements in the technology used to recover the Canadian oil sands has led to a dramatic fall in costs, resulting in at least one source

redefining these resources as proven reserves: the Oil and Gas Journal now reports Canada as having the second highest estimated proven reserves in the world, with only Saudi Arabia higher.[3] This revision increased the estimated reserves for Canada from five billion barrels to 180 bn b. Technological developments have continued to reduce costs, approximately halving operating costs in mining plants since 1990, with estimated future costs estimated in the range of US $6–11 a barrel.[4]

Nevertheless, despite the large non-conventional resource base, many factors are likely to limit supply, due to such factors as the highly capital-intensive nature of oil sand projects, long lead-times, uncertainty over future oil and natural gas prices,[5] the availability of condensate for blending bitumen, possible future environmental legislation, the speed and extent of the development of export infrastructure of this oil to the USA, the availability of suitable refining capacity and the availability of relevant skilled labour, all of which could affect costs substantially. The latest projections by the Canadian National Energy Board foresee oil sand production rising to 2.6–2.9 mb/d by 2025,[6] and these figures are incorporated into the reference case assessment.

Another major unknown for this region is the rate at which US deepwater production can increase, given the difficulties of developing reserves at depths below 3,000 metres. In the GoM, well-productivity is lower than initially expected, and the US Minerals Management Service, for example, has recently downgraded its forecast of medium-term potential from US deepwaters, expecting a peak in 2006. As a result of the foregoing, in the reference case, oil production in the USA and Canada stays approximately constant, at close to 11 mb/d over the medium-to-long term.

4.2 Mexico

Oil production in Mexico has increased gradually over the past decade, from 3 mb/d in 1990 to 3.8 mb/d in 2003. Further increases are, however, not likely, with investment to enhance production in existing fields probably balanced by declines elsewhere. Over the projection, Mexican production plateaus at around current levels, close to 4 mb/d.

4.3 Western Europe

Enhanced oil recovery is expected to continue to elongate the plateau of oil production in the North Sea.[7] The Ekofisk field in Norway is expected to sustain production levels for some considerable time, while Troll is now Norway's largest producing field. Water injection programmes are sustaining production elsewhere. Meanwhile, the Norwegian Government has announced a large planned increase in exploration activity and is considering a number of tax changes to encourage the development of small fields.

Similarly, although UK continental shelf production is past its peak, Government efforts are aimed at increasing exploration and encouraging the development of marginal discoveries, while the lives of mature fields are being extended. Royalty payments were abolished from the start of 2003, while petroleum revenue tax is to no longer apply for new tariffing business, which could unlock more than half a billion barrels of currently uneconomic oil.[8] The quest for rapid returns to investment is

leading to increased recovery rates, but is also likely to mean that, when the fall in production occurs, it will be relatively rapid. In the reference case, West European oil production plateaus at 6.5 mb/d, then begins to decrease from 2007. By 2010, production has fallen to 5.8 mb/d and continues to decline at around three per cent p.a., reaching 3.7 mb/d by 2025.

4.4 OECD Pacific

Australia has made some significant additions to its reserve base over recent years, but a significant rise in its production levels is not considered possible. The resource base is sufficient, however, to allow a sustained production level of 1 mb/d.

4.5 Middle East and Africa

Increases in output from this group will be primarily from the African region. Angola is expected to be the key country in this region from which increases in oil production can be expected over the medium term, followed by Chad, Sudan, Congo and Equatorial Guinea.

Angola's state-owned oil company, Sonangol, announced in May 2003 that oil output could increase to 1.6 mb/d by 2005, up from current levels of 0.9 mb/d, due largely to the expected expansion of deepwater production. Deepwater projects that are yet to be tendered could push output up even further in the medium term, with some analysts believing that as much as 2.5 mb/d could be produced by 2010.[9] Onshore fields also offer opportunities for expansion. The completion in 2003 of the Chad-Cameroon pipeline will lead to land-locked Chad becoming the latest oil exporter in the region. A sustainable production peak of over 0.2 mb/d is expected to be achieved. The potential for production increases in Sudan is considerable, but is particularly contingent on the development of further pipeline capacity, although the continuing civil war casts doubt upon how soon this might occur. Exploration and development efforts are proceeding for the Greater Nile Project and elsewhere, and domestic sources have suggested that output could double to 0.6 mb/d by 2005.[10] Production in Egypt peaked in 1995 at around 1 mb/d, and has been generally falling since. Although successful reservoir management programmes have stemmed declines in the large mature fields, the absence of any prospect of significant large new discoveries means that the future trend will likely be downwards.

In the Middle East, the three most important non-OPEC producing countries are Oman, Syria and Yemen. Production in Oman, according to the country's Minister of Oil and Gas, could rise until it reaches a plateau around 2007–08. Production in Syria and Yemen is constrained by the lack of any substantial new discoveries in recent years.

Production in the Middle East and Africa region thereby increases in the reference case from 5.1 mb/d in 2002 to 6.5 mb/d in 2010, peaking at 6.9 mb/d in the following decade, before beginning its decline.

4.6 Latin America

The key to expected increases over the short-to-medium term in Latin America lies with Brazil, still a net importer of oil. The most important oil-producing basin is the

Campos Basin, which lies entirely offshore, mostly in deep water, and accounts for almost 85 per cent of Brazilian production. Brazil's state-owned oil company, Petrobras, has announced plans to expand oil production to 2.2 mb/d by 2007, although more than half the increase will come from operations in Argentina and Nigeria. A number of new fields are due to come onstream, although safety concerns have become an important issue, after the p36 platform exploded and sank in 2001, and this may lead to delays in some projects. Furthermore, financial problems and uncertainties over tax policies are contributing to delays for the planned p43 and p48 platforms. Both these large platforms are expected to be able to eventually produce 150–180,000 b/d, with production now expected to start in 2005. The medium-term expansion could slow down, once self-sufficiency is reached, in order to sustain that status for as long as possible.

Ecuador is also expected to be a source of growth, on the back of the completion of the OCP heavy oil pipeline. Declines are expected in the mature producing areas of Argentina and Colombia, although looser rules are being introduced in the latter for private companies to encourage extending production activity. Total production for the Latin American region is expected to continue to increase over the projection period, rising from just under 4 mb/d in 2002 to reach 5 mb/d by 2010 and exceed 6 mb/d by 2025.

4.7 Asia, excluding China

Only very slight growth is expected over the medium term in this region. New production in deepwater areas, in particular off Vietnam, Malaysia, India and Brunei, will help offset natural declines elsewhere in mature fields. Aggregate production for the region is expected to reach a plateau over the period 2005–10, beginning a gradual decline thereafter and attaining an output level of 2 mb/d by 2025.

4.8 China

China's current oil production is dominated by onshore fields, all of which are currently operated by state companies and many of which are now in decline. PetroChina has implemented various enhanced recovery projects in its larger fields to maintain production, and there is some evidence that declines have slowed or reversed over the last few years in a number of major onshore basins. Longer-term, the level of production will depend very much upon the success of exploration efforts in the frontier basins, mostly in the north-west of the country. In the reference case, output is expected to peak at around 3.8 mb/d, just 0.4 mb/d higher than current levels.

4.9 Caspian

Future available infrastructure remains the key constraint to the expansion of exports from the Caspian. The Caspian Pipeline Consortium (CPC) project represents the most recent major development for increasing exports from the region. Plans to expand the capacity of the CPC pipeline exist, which could see exports from Kazakhstan through this route rise to over 1.3 mb/d by 2015.[11] Other ambitious plans exist to develop new infrastructure, such as a trans-Caspian pipeline and a pipeline to Western China. Legal hurdles could continue to hinder progress with any line along the bed

of the Caspian, due to the unresolved status of ownership, while the profitability of the China project is questionable. Other large projects are also under consideration in countries of the region, such as exports through to the Gulf coast. The Baku-Ceyhan route is the key current project for expanding exports from Azerbaijan to international markets. In the reference case, production increases by more than 1 mb/d in the period 2002–10 and by another 1 mb/d in the next decade, rising to 4.5 mb/d by 2025.

4.10 Russia

Russian oil production surged by 30 per cent over the period 2000–03, increasing by 2 mb/d, the highest increase of any country over that period. By 2003, Russia had overtaken the USA, to become the largest non-OPEC oil producer and the second-largest producer in the world. In the near future, Russia is expected to become the world's largest producer. There have been incentives to expand production over this period, in particular due to the investment climate, together with a fiscal regime that applies a flat corporate tax rate. These observed increases in production continue to come primarily from Western Siberia, with the application of new technologies having improved operating efficiencies. Further increases in production from this region are still expected, despite the over-production in Soviet times that has affected well-productivity. The recent exceptional growth in oil production in Russia may not, however, be sustainable. In particular, planned higher taxation rates may curb growth, while uncertainty over the developments of international crude oil prices could have an important impact upon the likely scale of increase in output. There is also the possibility that investment activity will be affected by the impact upon the business climate of the tensions between Yukos and the Government. In the medium-to-longer term, attention continues to be focused upon the available export infrastructure and how production levels might be affected in the longer term by the need to replace projects in large fields with those in smaller ones.

When looking at future Russian oil output potential, the reserves picture tells us that there is enough oil to enable a swift and sustained growth in production. For example, current reserves are estimated at 60 bn b,[12] and undiscovered oil is also likely to be substantial. The resource base does not, therefore, represent a useful indicator of how oil output will grow. Longer-term problems in mature fields, where the water cut is as high as 80 per cent, is expected to lead to substantial rates of decline that will need to be offset by new capacity. Long-term sustainable production will, therefore, be affected by the balance between available investment and these rates of decline, so that an indefinite increase in production, although supportable by the resource base, is not considered possible. It is the speed at which this oil is developed and exported that is central to our concern.

The Russian Government's forecast of production growth, as contained in the "Energy Strategy to 2020" approved in September 2003, is rather pessimistic, ranging between 8.4 and 8.9 mb/d in 2005 and 8.9 and 9.8 mb/d by 2010; this contrasts with the more buoyant mood reflected by the projections of oil companies themselves, with aggregate expectations suggesting an increase to over 11 mb/d by 2010.[13] Of course, both these groups have their reasons for alternative portrayals of future potential:

private oil companies have an incentive to push up both current production, as well as the outlook for output levels, with the intention of increasing the valuation of their assets for future possible takeovers. Government forecasts emphasise the likelihood of insufficient infrastructure constraining exports, while also taking into account the potential bias in oil companies' declarations. It has even been suggested that the Government may control longer-term production levels, in order to protect reservoirs from being damaged by over-exploitation.[14] Furthermore, the extent to which the Russian Government can and will be willing to exert control over private companies will have extremely important implications for longer-term oil market fundamentals; possible policy instruments include licensing and the fiscal and legal upstream framework.

As with the Caspian, the export infrastructure is seen as a key potential constraint to export expansion. The recent surge in exports has been mainly made possible by an increased use of rail transportation, largely to ports or refineries, although exports to China are currently also mainly supplied by rail. However, capacity constraints for rail shipments are already being felt. Although some plans for expanding the rail export capacity are being developed, notably to China over the short-to-medium term, this is not likely to provide substantial additional increases in export capacity.

There are major efforts underway to expand the export pipeline infrastructure, in particular by expanding the Baltic Pipeline System, where plans have been brought forward for increasing capacity to over 0.8 mb/d by mid-2004, with further proposals to expand throughput capacity by 2005 to over 1.2 mb/d.[15] If this materializes, it is thereby expected that some of the more expensive rail transport will be replaced. Meanwhile, plans to make the Adria pipeline bi-directional have been delayed, partly because of environmental requirements which will add substantially to the cost, but it is still likely that this route will provide additional capacity from 2005 onwards.

Increasing congestion problems in the Bosporus[16] question the likelihood of expansion of capacity through Black Sea ports; for example, a proposed expansion by 0.3 mb/d through Novorossiysk is now considered uncertain to go ahead. Given this constraint, a number of projects are being considered that would bypass the Bosporus, such as the proposed Burgas-Alexandropoulis pipeline, which would have an initial capacity of 0.3 mb/d.

Earlier estimates of an expansion in capacity by building a pipeline to China from the Siberian city of Angarsk may also be in need of revision, at least concerning the timing, with delays likely to the start of construction. However, it is thought that this pipeline could become operational by 2006/07. Initial capacity is expected to be 0.4 mb/d, possibly rising to 0.6 mb/d. A second Far Eastern project being considered is the 1 mb/d Baikal-Pacific-Pipeline, which would run along the Trans-Siberian rail corridor to Nakhodka, by the Sea of Japan, and which would open up an export route to Japan and South Korea. However, it is thought that the Russian Government has made the connection to China a priority.[17] Meanwhile, the Sakhalin I and II projects in the Far East, currently the largest investment undertakings in Russia, are expected to increase exports by over 0.4 mb/d by 2010.

The largest proposed project for pipeline construction is for the route to Murmansk, on the Barents Sea. Medium-term expansion by 2010 to around 1 mb/d is

considered feasible, although the planned first phase already foresaw exports of 1.2–1.6 mb/d by 2007. Indeed, under the terms of a Memorandum of Understanding signed with the Government distribution monopoly, Transneft, and the Russian Ministry of Energy in June 2003, this project would aim for an ultimate capacity of 3 mb/d.[18] This oil would be destined mainly for US markets, and it is known that the US Government strongly supports this project. Tension with Transneft has been a key obstacle in the past, as it was originally proposed that oil companies should build and operate this pipeline privately. This would have meant that this project would not only compete with other pipelines that Transneft operates, but would also challenge the role of Government in the Russian oil sector. It now appears that Transneft will operate the pipeline, should it be built, with oil producers supplying finance (almost 60 per cent from Lukoil and Yukos, with a further 32 per cent from TNK and Sibneft) and receiving favourable treatment. A feasibility study by the Ministry of Energy should be completed by the end of 2004, with a view to building the pipeline by 2007, should approval be granted, although doubts are growing about the likelihood of this project materialising.

The export capacity projects that are under consideration, in terms of both their proposed volume and likely timing, suggest that medium-term export infrastructure expansion is consistent with a rapid expansion of production, although not at such high rates as observed in the recent past. The reference case figures for Russian production reflect very much the plans of the Russian oil companies up to 2006; indeed, output levels in 2003 and probably 2004 are likely to be even higher. As we look further ahead, however, the reference case reflects increasingly the more cautious view contained in Government forecasts, with the inherent emphasis upon likely constraints from the available export infrastructure. By 2010, the projected figure thereby lies between the Government and company projections, at 10.4 mb/d. Thereafter, production levels are expected to reach a plateau of close to 11 mb/d.

5. Scenarios

5.1 Low economic growth scenario

Despite the robust economic growth of the reference case, worries persist about the long-term health of the world economy, as a result of potential weaknesses, such as financial market instability, possible over-heating, geopolitical risks and structural problems.

It is, therefore, plausible that lower economic growth rates than those assumed for the reference case will emerge over the next two decades. Such downside risks are considered more likely than even stronger growth in the world economy. In order to explore the implications for oil demand with such lower growth, the assumption has been made that economic expansion in each global region is one percentage point lower than in the reference case. This lower assumption is meant to reflect the genuine concern for the potential for medium-to-long-term global economic expansion, rather than representing an extreme view.

With this lower growth, oil demand expands over the forecast period at an average of just one per cent p.a., compared with the 1.7 per cent p.a. growth of the

reference case, with the resulting increment amounting to less than 1 mb/d annually. If this lower oil demand is matched by a corresponding fall in OPEC production by 2010, OPEC output (including NGLs) is below 30 mb/d in that year, the same level as in 2003. It is only in the post-2010 years that OPEC production begins to rise (**table 13** and **figures 17** and **18**). Inevitably, the sustainability of such an outcome must be questioned.

Table 13
World oil supply and demand outlook in the low economic growth case
mb/d

	2005	**2010**	**2015**	**2020**	**2025**
World demand	79.9	84.2	88.8	93.2	97.4
Non-OPEC production	51.3	54.5	56.3	56.6	55.9
OPEC production	28.6	29.7	32.5	36.6	41.5

The pressure upon oil prices can be assessed by how the developments in OPEC production relate to planned expansion in capacity. It is the existence of large amounts of spare capacity that would question the sustainability of certain paths, rather than the developments of market share, *per se*.

There has been a steady decline in the OPEC capacity utilisation rate since the early 1990s, but it has generally stayed in the range of 80–90 per cent. In the reference case, the medium-term outlook suggests rates close to 80 per cent. Should we look at the situation with the lower economic growth assumption, capacity utilisation rates continue falling, reaching just 66 per cent by 2010, a level that has not been seen since 1986–87.

So-called "price-reaction functions" have sometimes been used for oil price projections, in particular to identify, on the basis of observed past behaviour, the point at which OPEC utilisation rates are sufficiently low to place downward pressure on prices. Although this approach is not normally used as an empirical tool, the essence of the function goes to the heart of the idea that there are rates of spare capacity associated with expected downward pressure on oil prices. The actual introduction of such spare capacity to the market would be necessary to affect fundamentals, but markets can be expected to react even to this potential. While there is no satisfactory and unambiguous level that can be identified as being a potential "threshold" for such price movements, it is assumed in this analysis that a level below 80 per cent is not sustainable. This figure is consistent with the range of intercepts estimated from available data.

The assumption of an 80 per cent minimum OPEC capacity utilisation rate in the face of reference case demand developments suggests little downward pressure on oil prices over the medium-to-long term. However, the lower economic growth assumption produces a more pessimistic picture for the future price path: short-to-medium-term equilibrium prices could lie in the $15–20/b range, while longer-term pressures suggest that the minimum 80 per cent capacity utilisation could keep prices below $20/b.

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Figure 17
Loss in oil demand by 2010 caused by a 1% fall in economic growth
mb/d

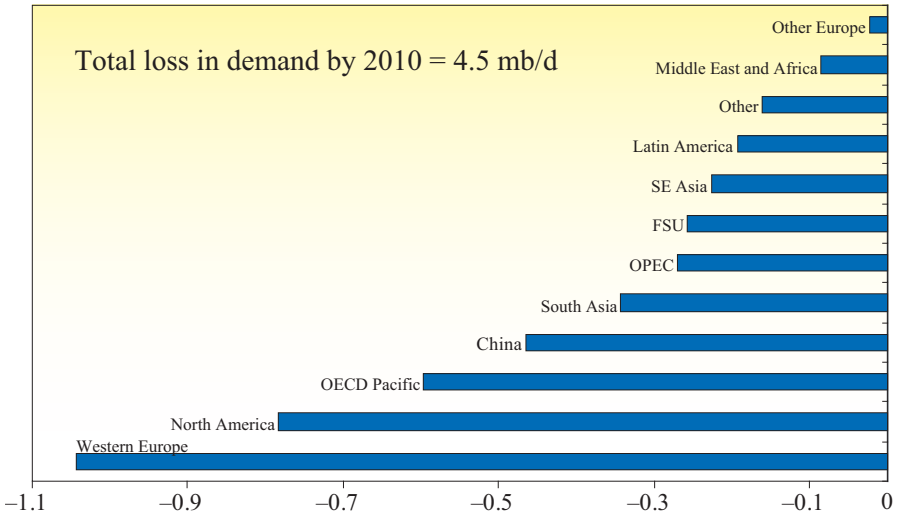
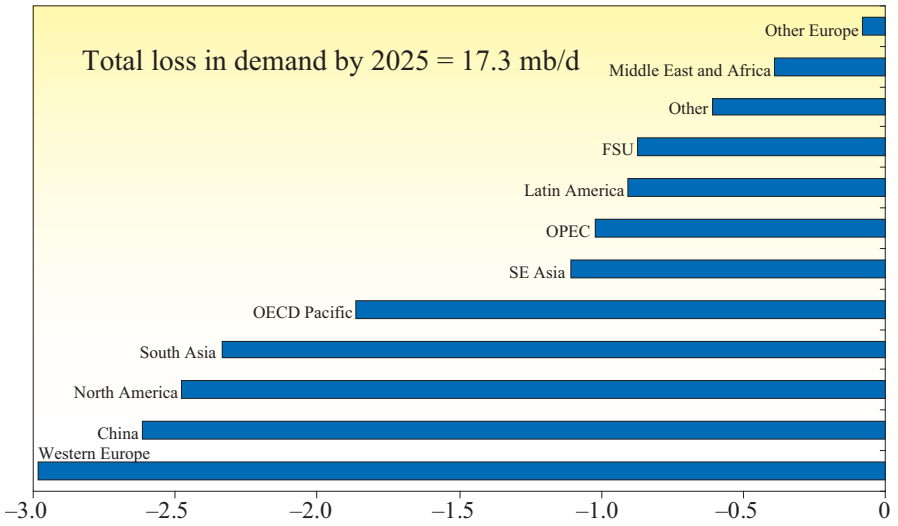


Figure 18
Loss in oil demand by 2025 caused by a 1% fall in economic growth
mb/d



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Although the response of oil producers in their exploration, development and production activities form a key foundation to these calculations, the possibility nevertheless exists that policy changes may occur in response to a lower oil price environment that would limit the volume response. Similarly, oil demand may not respond to lower oil prices, if both fiscal and non-fiscal measures are introduced to either limit the pass-through of the lower crude prices and/or to more explicitly limit demand responses. The upshot of these considerations is that, where downside risks to oil prices emerge, it is possible that the softening of prices could easily be compounded by other factors, which could mean that the above price responses are underestimated. Such a "snow-balling" effect could push prices considerably lower than this modelling exercise estimates. The implications of such low prices for medium-term stability are also a major unknown. In particular, while the fall in prices could initially be precipitated by excess capacity, a climate of soft prices will call into question the expected rate of expansion of production capacity, possibly leading to an eventual price spike. It is precisely the climate of stable oil prices assumed in the reference case that mobilises the resources to supply the market with the necessary oil in a timely manner.

One key component in this discussion is the consideration of how capacity expansion plans could adjust to evolving utilisation rates. It is unlikely, for example, that OPEC expansion plans would continue in the longer term, without a reaction to large amounts of spare capacity that become available. This raises the important question of the lead time that is applicable in capacity expansion plans, given the fact that the time-lags involved in production capacity are far from homogeneous. At one extreme, investment may generate a capacity impact within months. At the other, where, for example, a whole array of new infrastructure is required, the lag in capacity expansion, as a reaction to signals from the market, can amount to several years. This is, of course, the dilemma that faces OPEC, with large investment decisions being taken in a climate of such uncertainty. The downward impact upon oil prices would tend to be ameliorated by the adjustment of expansion plans, at least in the longer term. The medium-term picture, however, is likely to remain largely unaffected by these considerations, given the commitments in place of large amounts of capital in many Member Countries.

Thus, while the long-term picture points to inevitable increases in the need for investment in OPEC oil production capacity, the magnitude of the required increase is far from clear, even in the short and medium terms. The challenge of enhancing market stability and ensuring that sufficient capacity exists therefore involves anticipating, in a timely and effective manner, the investment required over the coming decades. The key to ensuring that sufficient investment takes place is oil market stability. For this, a reasonable level of price is needed to secure adequate sources of investment. This underlines the importance of the concept of the OPEC price band in the pursuit of this desired stability. However, it is becoming increasingly uncertain whether such stability can be maintained, in particular if it means OPEC producing at levels that are inconsistent with capacity expansion commitments. The challenge of maintaining market stability in the medium-to-long term is, therefore, far greater than most projections would suggest. This is a fundamental issue that is likely to increasingly confront the petroleum industry in the coming years.

5.2 Vehicle efficiency scenario

Other downside risks to demand and consequently to required investment in capacity expansion, relate to policies that may be introduced to reduce oil demand, in particular in the transportation sector. The taxation of oil products in the transportation sector has been a central policy measure to raise revenue, as well as to affect oil demand. However, the impact of additional taxation upon oil demand in the transportation sector may be limited, at least where taxation is already high. In order to have a better understanding of how oil demand might evolve in the future, and how this might be affected by policies in consuming countries, it is important to pay attention to measures beyond taxation that might affect oil demand, particularly in the transportation sector.

Future improvements in vehicle efficiencies will be largely driven by both the rate of penetration of existing technologies, as well as the rate of development and introduction of newer ones, which, in turn, will be affected not only by fuel prices, but also by more direct legislative efforts to bring such efficiencies about. The agreement between the EU and the European Automobile Manufacturers Association to improve average vehicle efficiency is an example of such a move.

There are, of course, a host of other potential policies that can and have been introduced to reduce oil use in the transportation sector. Such measures include public transport improvements, tax incentives to manufacturers of fuel-efficient vehicles, emission standards, vehicle taxation linked to emission characteristics and Government support for advanced technology research and development.

In an attempt to reflect alternative average efficiencies that might evolve following faster technological advances and concerted Government action in this area, a scenario has been developed that assumes, in line with work undertaken in other studies, that oil use per vehicle falls at an additional 0.5 per cent p.a., compared witho the reference case. This represents an additional strong and concerted effort, in terms of government policy over and above the improvements already considered in the reference case, to reduce oil demand in the transportation sector. This is driven by the effects of increasing concern over the local impact of road transportation (in particular, air pollution and congestion). It is worth recalling that the reference case already includes efficiency improvement policies and measures that are currently in existence, planned or expected on the basis of past trends.

Measures that could possibly be implemented include, for example, higher levels of government subsidies for new technologies, higher oil product tax levels, in particular in developing countries, and far higher efficiency standards. The lack of available infrastructure and the technological challenges suggest that the hydrogen-based fuel cells will not be a major part of these developments, with the most likely impact for oil demand linked to a strong growth of hybrids. Demand in developing countries, China and India in particular, may become strongly constrained by policies that limit demand growth, such as the introduction of minimum fuel economy standards on new cars and, possibly, import controls.

With an additional 0.5 per cent efficiency improvement p.a., OECD oil demand in 2020 is reduced by more than 2 mb/d from the reference case, or about 40 per cent

of the otherwise expected demand increase (**table 14**); however, higher impacts upon demand are conceivable, if a more aggressive set of measures are implemented. The impact on developing countries is to reduce demand by almost 2.5 mb/d by 2025. The combined effect upon both OECD and non-OECD countries of this scenario is to reduce world demand by 2025 by almost 6 mb/d, compared with the reference case. It is clear, therefore, how important the policy developments will be in developing countries, as well as in developed, and how they may have dramatic impacts upon the evolution of oil demand.

Table 14
Impact of additional 0.5 per cent efficiency improvement in OECD and DC road transportation
Change in demand from reference case
mb/d

	2005	**2010**	**2015**	**2020**	**2025**
OECD	–0.3	–1.0	–1.7	–2.3	–3.0
DCs	–0.1	–0.4	–0.9	–1.5	–2.3
Transition economies	0.0	–0.1	–0.1	–0.2	–0.3
World	**–0.4**	**–1.5**	**–2.7**	**–4.0**	**–5.6**

The policy framework for affecting oil demand developments in the future is therefore broad, complex and highly uncertain in both its composition and its impact. Quantification of the possible magnitude of oil demand growth must continue to take into account potential policies that may be introduced; and, in estimating the effects, it is essential to include all possible measures that will affect demand. The potential for such longer-term policy directions, in particular with increasing pressures to address environmental concerns of both a global and local nature, as well as efforts to limit the rise in oil imports, suggest that there are serious downside risks to the longer-term oil demand growth potential that are not reflected in benchmark reference cases.

These risks amplify the concern addressed in the previous scenario, reflecting the difficulties involved in investing in the various segments of the oil chain in an environment of uncertainty. The recent downward revisions of demand projections by other institutions are, to an extent, a reflection of the incorporation of the kind of policies and technological developments that are portrayed in the above scenario.

6. Concluding remarks

The long-term picture points to the need for increased investment in oil production capacity, but the magnitude of the required expansion is far from clear, even in the short and medium terms. This is partly due to the wide range of feasible demand growth scenarios, but it is also reinforced by contrasting views on the potential evolution of non-OPEC production. The challenge of enhancing market stability and ensuring that sufficient capacity exists therefore involves anticipating, in a timely and effective manner, the investment required over the coming decades.

The key to ensuring that sufficient investment takes place is oil market stability. For this, a reasonable level of price is needed to secure adequate sources of investment. The role that OPEC has played, and continues to play, in bringing about this stability is being recognized increasingly by industry analysts as an essential element of this quest for stability. In particular, the climate of deregulation in energy sectors in different parts of the world has already demonstrated the inherent dangers of becoming over-reliant on the basic concepts of unregulated markets, in particular where large investments and long lead times in a climate of uncertainty are involved.

However, there is concern that, in the pursuit of market stability, lower OPEC supply levels would be needed in the coming years that would result in substantial amounts of unused capacity. Over the medium term, in particular, there are risks of downward pressures on oil prices, which could sow the seeds of instability. It is important, then, to recognise the need for continued cooperation and dialogue among all players in the oil market, in the pursuit of the stability that is of interest to all parties.

Footnotes

1. *See, for example, Dargay, J., and Gately, D., "Vehicle ownership to 2015: implications for energy use and emissions", Energy Policy, Vol. 25, Numbers 14–15, December 1997, and Button, K., Ngoe, N., and Hine, J., "Modelling vehicle ownership and use in low income countries", Journal of Transport Economics and Policy, January 1993.*

2. *This issue is dealt with in detail in the International Energy Agency's World Investment Outlook, 2003.*

3. *Oil and Gas Journal, 23 December 2002, p. 113.*

4. *Canada's Energy Future: Scenarios for Supply and Demand to 2025, National Energy Board, 2003, available at: http://www.neb.gc.ca/energy/SupplyDemand/2003/English/SupplyDemand2003_e.pdf.*

5. *The extraction of* in situ *bitumen requires substantial amounts of natural gas and water.*

6. *ibid.*

7. *See presentation by Norwegian Ministry of Petroleum and Energy at the Oil Producer Meeting, Bergen, 28 February 2003.*

8. *Petroleum Review, May 2003, p. 10.*

9. *Oil and Gas Journal, 18 August 2003, pp. 29–31.*

10. *Arab Oil and Gas, 16 June 2003, pp.6–-8.*

11. *Oil Exports from the Caspian Region, RPI Inc, 2002.*

12. *BP Statistical Review of World Energy 2003, June 2003, BP.*

13. *"Post-Soviet oil exports: are the Russians really coming?", Khartukov, E., and Starostina, E., OPEC Bulletin, September/October 2003.*

14. *Russia's Energy Strategy to 2020: an Incomplete Roadmap; Cambridge Energy Research Associates, October 2003.*

15. *Russian Export Infrastructure Update, Merrill Lynch, 20 October 2003.*

16. *New restrictions on passage were introduced in 2002, related to waiting periods and maximum size and weight.*

17. *"Transneft: Russia's Preferred Oil Route", Troika Dialog, October 2003.*

18. *Khartukov and Starostina, OPEC Bulletin, op cit.*

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Appendix

Table A1
Energy demand in the reference case

OECD energy demand by fuel type, *mtoe*

	2000	2010	2020	2025
Oil	2,255.1	2,409.4	2,564.0	2,625.4
Solids	1,082.2	1,131.6	1,195.4	1,212.7
Gas	1,143.5	1,291.2	1,504.9	1,622.0
Hydro/nuclear	729.5	754.7	758.5	759.5
Total	**5,210.2**	**5,586.9**	**6,022.8**	**6,219.7**

OECD energy fuel share, *%*

	2000	2010	2020	2025
Oil	43.3	43.1	42.6	42.2
Solids	20.8	20.3	19.8	19.5
Gas	21.9	23.1	25.0	26.1
Hydro/nuclear	14.0	13.5	12.6	12.2
Total	**100.0**	**100.0**	**100.0**	**100.0**

DCs, including China, energy demand by fuel type, *mtoe*

	2000	2010	2020	2025
Oil	1,143.0	1,563.8	2,207.1	2,563.1
Solids	1,045.8	1,436.6	1,949.5	2,227.1
Gas	458.8	813.5	1,391.9	1,799.7
Hydro/nuclear	131.3	178.4	228.4	253.0
Total	**2,778.8**	**3,992.3**	**5,776.9**	**6,842.9**

DCs, including China, energy fuel share, *%*

	2000	2010	2020	2025
Oil	41.1	39.2	38.2	37.5
Solids	37.6	36.0	33.7	32.5
Gas	16.5	20.4	24.1	26.3
Hydro/nuclear	4.7	4.5	4.0	3.7
Total	**100.0**	**100.0**	**100.0**	**100.0**

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Table A1
Energy demand in the reference case (cont.)

Transition economies energy demand by fuel type, *mtoe*

	2000	**2010**	**2020**	**2025**
Oil	216.3	252.1	288.2	303.1
Solids	212.7	250.1	289.7	309.8
Gas	498.3	695.4	911.3	1031.3
Hydro/nuclear	92.1	131.5	166.3	182.8
Total	**1,019.3**	**1,329.1**	**1,655.6**	**1,826.9**

Transition economies energy fuel share, *%*

	2000	**2010**	**2020**	**2025**
Oil	21.2	19.0	17.4	16.6
Solids	20.9	18.8	17.5	17.0
Gas	48.9	52.3	55.0	56.4
Hydro/nuclear	9.0	9.9	10.0	10.0
Total	**100.0**	**100.0**	**100.0**	**100.0**

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Table 2A
World gas demand outlook
mtoe

					Average annual growth rates *% p.a.*		
	2000	**2010**	**2020**	**2025**	**2000–10**	**2010–20**	**2020–25**
OECD	1,143.5	1,291.2	1,504.9	1,622.0	1.2	1.5	1.5
North America	652.8	709.9	835.2	908.7	0.8	1.6	1.7
Western Europe	384.5	444.9	502.0	531.2	1.5	1.2	1.1
OECD Pacific	106.1	136.3	167.7	182.1	2.5	2.1	1.7
OPEC	234.1	385.0	609.5	766.1	5.1	4.7	4.7
Other DCs	196.5	380.6	710.4	947.3	6.8	6.4	5.9
FSU	28.1	47.9	72.0	86.3	5.5	4.2	3.7
China	471.0	663.1	873.7	990.9	3.5	2.8	2.6
Other Europe	27.4	32.3	37.6	40.3	1.7	1.5	1.4
World	**2,100.6**	**2,800.1**	**3,808.1**	**4,453.0**	**2.9**	**3.1**	**3.2**

Table 3A
World coal demand outlook
mtoe

					Average annual growth rates *% p.a.*		
	2000	**2010**	**2020**	**2025**	**2000–10**	**2010–20**	**2020–25**
OECD	1,082.2	1,131.6	1,195.4	1,212.7	0.4	0.6	0.3
North America	579.1	600.7	619.2	618.9	0.4	0.3	0.0
Western Europe	318.9	281.4	273.7	272.0	–1.2	–0.3	–0.1
OECD Pacific	184.1	249.4	302.5	321.8	3.1	1.9	1.2
OPEC	15.6	22.9	29.7	33.8	3.9	2.6	2.6
Other DCs	374.6	498.4	623.8	681.1	2.9	2.3	1.8
FSU	655.6	915.3	1,296.0	1,512.2	3.4	3.5	3.1
China	181.2	211.3	245.5	262.9	1.5	1.5	1.4
Other Europe	31.5	38.8	44.2	46.9	2.1	1.3	1.2
World	**2,340.6**	**2,818.3**	**3,434.6**	**3,749.6**	**1.9**	**2.0**	**1.8**

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Oil outlook to 2025

This paper presents the OPEC Secretariat's projections of world oil demand and supply to the year 2025, based upon analysis using the OPEC World Energy Model, OWEM.

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