Oil outlook and investment challenges

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Executive Summary

This background paper, based upon the OPEC World Oil Outlook 2007,[1] has been prepared for the first session of the Ministerial Symposium on "Providing Petroleum, Promoting Prosperity, Protecting the Planet", organized on the occasion of the Third Summit of OPEC Heads of State and Government, to be held in Riyadh, Kingdom of Saudi Arabia, on 17th and 18th November 2007. The paper provides a description of the medium-to-long-term reference case outlook for oil supply and demand to 2030, as well as alternative scenarios. It also looks at investment requirements, the associated challenges, and the resulting implications for the oil industry in general and OPEC Member Countries in particular.

Energy is crucial for sustainable development and its use has continuously increased in response to demand for heat, light and mobility from a growing and more urban population. Access to modern energy services is a key contributor to poverty eradication and to the achievement of the United Nations Millennium Development Goals. Petroleum continues to play a central role in satisfying the world's energy needs, with oil and gas accounting for over 60% of the energy mix. Oil, in particular, has been in the leading position for the past four decades. It also plays a fundamental role in the socio-economic development of OPEC Member Countries, accounting in 2006 for three-quarters of the total value of their exports.

Demand for energy is set to continue to grow, under all scenarios. In the reference case, fossil fuels continue to provide more than 90% of the world's total commercial energy needs, accounting for 93% of the demand growth in the reference case to 2030. Oil is expected to remain the leading supplier of the world's energy needs, with its current energy demand share of 39% declining only slightly to 36% by 2030. Gas is expected to grow at a faster rate, steadily approaching coal in its importance in the energy mix, although coal has recently seen impressive growth, particularly in China. The total contribution of hydropower, nuclear and new renewables is presumed to flatten out, despite the high growth rates for some renewables.

Turning specifically to oil demand, the reference case, based on the assumption that no particular departure in trends for energy policies and technologies takes place, sees demand rise by 34 mb/d from 2005 to 2030, reaching 118 mb/d by 2030. Developing countries are set to account for most of this rise, with consumption doubling from 29 mb/d to 58 mb/d. Asian developing countries account for an increase of 20 mb/d, which represents more than two-thirds of the growth in all developing countries. Nevertheless, to 2030, OECD and transition economy countries will continue to consume more oil than developing nations. On a per capita basis, the contrast is even sharper: by 2030, developing countries will consume, on average, approximately five times less oil per person than OECD countries. The transportation sector accounts for more than half the future oil demand growth, given the expected continued expansion in mobility across the world and with oil being this sector's fuel of choice. Additional oil

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1 Available at www.opec.org.

demand by 2030 is overwhelmingly for light and medium products, with, in addition, an expected marked shift from gasoline to diesel and a move towards more stringent product specifications.

From the supply side, the remaining conventional oil resources are sufficient to satisfy demand over the projection period. Moreover, supply will also come from other sources: non-conventional oil, natural gas liquids, gas-to-liquids, coal-to-liquids and biofuels. In the reference case, non-OPEC crude oil supply initially rises to a plateau of around 48 mb/d, before beginning a gradual decline from around 2020, while non-conventional oil supply, including biofuels, is expected to reach more than 10 mb/d by 2030, an increase of 8 mb/d during this projection period. Over the medium term, increases in non-OPEC supply, both crude and non-crude, leave little room for additional OPEC crude. Looking further ahead, the amount of crude oil that OPEC would be relied upon to supply in the reference case rises to 49 mb/d by 2030, or 42% of total oil supply, a share not markedly different from today's figure.

As part of this supply picture, the future indications for biofuels appear to be mixed. On the one hand, the biofuels industry in some countries has been given impetus from large fiscal incentives and strong political backing, including through the setting up of binding quantitative targets and timetables. On the other hand, the sustainability of large production and biofuel use is now being seriously questioned. First, competition for land and scarce water resources will lead to food price increases, impacting mainly the poorest. Second, the value of biofuels in reducing greenhouse gas emissions and fossil fuel energy use varies widely and, overall, biofuels, having relatively higher mitigation costs, appear to have at best only a minor role in comparison with other options. Finally, the impact of large-scale biofuel use on the functioning of the downstream could lead to energy systems risks being compounded with agricultural ones.

For the downstream sector, with changes in the crude production slate quality expected to be only moderate, the real challenge will come from the demand side, where the growth and shift toward lighter products and much tighter fuel quality specifications will have more substantial consequences. In the reference case, a total of 13 mb/d of additional distillation capacity, combined de-bottlenecking and major new units will be required over the period 2006–20, mostly in the Asia-Pacific region. In addition, the global downstream sector is estimated to require more than 7.5 mb/d of combined upgrading capacity, more than 18 mb/d of desulphurisation capacity and around 2 mb/d of capacity for other supporting processes. A comparison of scenarios for refining needs and distillation capacity additions in the coming years indicate a continuing tightness in the refining sector, at least up to 2010, with a mixed picture developing further in the future. Moreover, it is expected that there will be persistent tightness in conversion and hydro-treating.

The future supply-demand picture clearly indicates that the volumes of traded oil and the corresponding inter-regional movements are set to increase, accompanied by a progressive shift towards Asia. Crude exports are projected to reach the level of 44 mb/d in 2020, compared to around 38 mb/d in 2005, while the trade of refined products and

intermediates reaches a level of 18.5 mb/d, which is 6.5 mb/d higher than in 2005. Consequently, fleet requirements will increase by more than 25%.

In addition to the reference case, alternative scenarios have been developed to explore two contrasting plausible futures and, in particular, the demand for OPEC oil. In the *lower growth* scenario, by 2015 world oil demand is already almost 5 mb/d lower than in the reference case. By 2020, the difference reaches 8 mb/d, and the gap continues to widen in the longer term. Average demand growth over the entire projection period is just 0.8 mb/d annually. In the *higher growth* scenario, world oil demand by 2015 is more than 2 mb/d higher than in the reference case, and almost 4 mb/d higher by 2020. Average annual demand growth over the period to 2030 is 1.7 mb/d. It is worth noting that there is a range of important drivers, in particular energy and environmental policies in consuming countries, as well as technological developments, that tend to push in one direction, namely towards a reduction in demand and, consequently, risks over possible future demand patterns are skewed towards the downside.

OPEC supplies the residual barrel and offers spare capacity for the benefit of the world at large, thus supporting market stability. As a result, the uncertainties in these scenarios, in terms of demand and non-OPEC supply, translate into a wide range of possible levels of future demand for OPEC crude oil. With a *higher* and *lower growth* case, a range of 1.7 mb/d opens up for the possible amount of oil that OPEC might have to supply by 2010, but this gap widens to close to 5 mb/d by 2015 and 9 mb/d by 2020. This has an impact on OPEC upstream investment requirements. For example, by 2020 an estimated uncertainty of $270 billion for required OPEC investment can be envisaged, with the *lower growth* scenario suggesting a cumulative requirement of just under $230 billion, instead of the $500 billion in the *higher growth* case. Even over the period to 2015, there is an estimated range of $160 billion. These ranges are even more dramatic should estimates include corresponding investments in refining and infrastructure such as pipelines, storage, terminals and ports.

Despite these uncertainties, OPEC Member Countries are undertaking large investments to expand their production and refining capacity. Upstream capital expenditure to 2012 is estimated today to exceed $150 billion, and result in a 5 mb/d capacity increase. Member Countries are also investing heavily in refining and delivery infrastructure, both domestically and abroad. Crude distillation refinery projects in Member Countries are expected to add over 3 mb/d of additional capacity by 2012, an investment of around $50 billion.

The oil outlook and investment requirements paint a picture of various challenges and opportunities.

Probably the foremost challenge facing the oil industry, and OPEC in particular, stems from the uncertainty over how much future production capacity will be required to satisfy demand for oil while making available sufficient levels of spare capacity. Obviously, there is always the risk associated with the world economy, with its cycles of high growth being followed by periods of lower expansion, a risk which the industry manages and copes with, much as it does with geological and other quantifiable risks. But

the uncertainty over demand stems mainly from large consuming country policies that are unpredictable, unclear, and in some cases may have unanticipated consequences. Often, consuming country policies discriminate against oil through taxation, subsidies for competing fuels and other measures. For producers, there is a real prospect of wasting precious resources on capacity that may not be needed. In addition, the emergence of large levels of unused capacity would lead to downward pressures upon oil prices, as it has in the past, with the compounded effect of sharply lowering oil-export revenues.

It must be stressed that this main investment challenge, usually referred to when the concept of security of demand is invoked, is intrinsically linked to the issue of security of supply. Without the confidence that additional demand for oil will emerge and the market signals that long-run prices are supportive, the incentive for OPEC – and the industry in general – to undertake investment can be reduced. This, in turn, can lead to underinvestment and exacerbate concerns over eventual sufficiency of capacity, and thereby hamper the drive towards long-term oil market stability. Moreover, lower oil-export revenues would negatively affect available resources for future investment, with further subsequent market instability a distinct possibility.

Given the industry's past history and the magnitude of the monetary needs when compared to capital markets, the financing of required global oil investments does not appear to constitute a significant challenge. However, as in any industry, access to capital is conditioned mainly by sound project economics, adequate financial strengths of investors and acceptable overall risks below- and above-ground. In this regard, a central element is the expectation for the future oil price. A key challenge is to understand industry fundamentals, as well as market signals, which are mostly of a short-run nature and could be influenced by speculative activity.

One important factor which today hampers the economics of upstream and downstream projects is cost. The oil industry is facing a huge increase in the cost of raw materials and in all segments of petroleum services.

Furthermore, the industry faces increased difficulties in finding and hiring skilled labour and experienced professionals. This situation deserves due attention and co-ordinated action, as the supply and demand for energy discipline graduates has become unbalanced in recent years. In this regard, one necessary element is to look at redeveloping and redefining the industry's image to make it appeal to young people contemplating their career choice.

Another challenge is to adapt to globalisation, competition, changing trade patterns and the increasing influence of capital markets. Recent years have seen the emergence of national oil companies (NOCs) from producing countries, as well as large net importing countries, as key global players in both the upstream and downstream, as they seek to expand their presence outside their home country and look to more vertical integration. This is a welcome development as it creates more competition and diversity, and makes available more financial resources to fund the necessary investments along the entire supply chain. On the other hand, services and construction companies need to expand

their capacities to cope with the increasing demand for their services and avoid creating bottlenecks.

Technological progress and innovation have in the past benefited both oil supply and resource additions. However, following the oil price collapse in the late 1990s, industry research and development spending was reduced significantly. This trend needs to be reversed.

Further issues relate to defining efficient legal, regulatory and fiscal regimes, as well as the need to address local content and social impacts of oil-related activities.

Finally, with the protection of the environment increasingly the focus of attention of all stakeholders, the petroleum industry has to adapt to the evolution towards a carbon-constrained world. This needs to be done in a proactive manner, turning the challenge into an opportunity, by promoting cleaner fossil fuel technologies, and, in particular, the technology of carbon dioxide capture and storage in deep geologic formations. The oil industry needs to play a more active role in research, development and demonstration, in defining industry standards for site selection, monitoring and verification, and contributing to improved public acceptance. Having said this, developed countries should take the lead in the development and deployment of this technology.

The overall picture that emerges is one of an interdependent, more global world. This highlights the importance of pragmatic and structured dialogue, such as recently embarked upon by OPEC. This also reiterates the importance of fora for energy dialogue, such as that offered by the Riyadh-based International Energy Forum.

1. Introduction

This background paper, based upon the OPEC World Oil Outlook 2007, has been prepared for first session of the Ministerial Symposium on "Providing Petroleum, Promoting Prosperity, Protecting the Planet", organised on the occasion of the Third Summit of OPEC Heads of State and Government, to be held in Riyadh, Kingdom of Saudi Arabia, on 17th and 18th November 2007.

The two previous Summits, held in Algiers in March 1975 and in Caracas in September 2000, adopted Solemn Declarations that addressed a wide range of political, economic, financial and energy-related issues, recognising the strategic importance of petroleum, and focusing upon socio-economic development needs, both in OPEC Member Countries and in the world at large. This was most clearly reflected in the founding of the OPEC Fund for International Development (OFID), as a direct consequence of the issues discussed and laid out at the First Summit.

Petroleum continues to play a central role in satisfying the world's energy needs, with oil and gas accounting for over 60% of the energy mix. Oil has been in the leading position for supplying the world's energy for the past four decades, and there is a clear expectation that this will continue. But oil also plays a fundamental role in the socio-economic development of OPEC Member Countries, accounting in 2006 for three-quarters of the total value of their exports.

Looking forward, many features appear, some new, some familiar, that are likely to shape the energy scene and represent challenges for the future. From the demand perspective, a geographic shift in both economic and demand growth has been occurring, with the more evident importance of the Asian region to world growth. Nevertheless, energy poverty is expected to remain a serious issue for many developing countries. The challenge of anticipating the scale of increases in demand was amply demonstrated by the high rate of growth in 2004, which has been followed by only modest rises since. While lower oil intensities, accommodating monetary policies and rising wealth support robust demand, even in times of high oil prices, there are also some signs of a decoupling of economic and energy growth, at least in OECD countries. Policies continue to be implemented that are geared to reducing oil demand, as witnessed by high taxation levels on oil products. In short, demand patterns are changing, and are as uncertain as ever.

On the supply side, investment in additional capacity, rising costs, and a shortage of skilled human resources – partly as a result of the low price environment prevailing less than 10 years ago – have all come to the fore as pressing issues. This follows a period since the 1980s characterised by large levels of idle capacity. OPEC has continued to undertake large investments in capacity, reflecting its continued commitment to oil market stability. However, the task has become increasingly hampered by the uncertainties around the amount of oil that might be required from Member Countries.

For some, the idea that oil supply could be peaking is offered as one of the explanations for recent oil price behaviour. OPEC believes that remaining oil resources are plentiful. Better knowledge and technology have played a fundamental role in raising estimates of

recoverable reserves, and increasingly large amounts of non-conventional oil are expected to contribute to future supplies. The downstream sector has, in recent years, justifiably been receiving increased attention and the increased tightness in this sector has been seen as a source of potential market instability. Other supply constraints have also come to the fore, in particular the lack of skilled labour.

Prices, moreover, are formed differently, at least compared to around the time of the first Summit. There are now no administered oil prices: prices for commodities are set by global markets, with different layers, physical, forward, futures and options. Market participants have different interests, expectations and perceptions, and, in addition to supply-demand fundamentals, markets are also being influenced to some extent by speculative activity.

Technology, policies and environmental concerns are among other important drivers that are shaping the new energy landscape. This paper tries to explore how the energy system will evolve, and what this signifies for oil; it explores the nature of challenges that might lie ahead for the oil industry; it looks, in particular, at the implications of some of these issues for OPEC Member Countries; and it explores how the industry might rise to the challenges ahead.

The paper is organised into three core sections. We begin by providing a description of the medium-to-long-term reference case outlook for oil supply and demand to 2030. This considers the prospects for demand by region, sector and then by product, before turning to how oil will be supplied, from both conventional and non-conventional sources. The important downstream sector is also addressed in detail. The subsequent section looks at the likely scale of investment requirements and, more specifically, into OPEC Member Countries' capacity expansion efforts. The following section contains a specific treatment of the investment challenges and opportunities that arise from this outlook. The paper finishes with some concluding remarks.

2. World oil outlook to 2030

Key assumptions

When the II Summit of OPEC Heads of State and Government opened on 27th September 2000, the OPEC Reference Basket (ORB) price stood at just over $29/b. In the weeks approaching the III Summit, it reached levels above $75/b. It is worth noting, however, that these prices were still well below those that prevailed for much of the early 1980s, when corrected for inflation and relative exchange rates, which also affect the real value of crude; in particular, the softening of the US dollar against the euro over the past six years has meant that the real growth of prices in the Euro-region has been far more modest. Indeed, since June 2001, the percentage rise in the ORB price in euro terms has been well under half the increase when measured in dollars.

The recent period of higher oil prices has led much of the oil industry to revise up both short- and long-run reference case equilibrium price assumptions, and it has also been observed that in the present market climate both economic growth and oil demand are more resilient to higher oil prices than had previously been thought. In addition, there is a growing awareness of the impacts of rising procurement, construction and services costs, as well as the cost and availability of skilled human resources.

Despite the inherent cyclical nature of many upstream costs, such as steel prices, an emerging dominant impression is that, in order to finance the necessary investments, there appears to be a need for higher prices than previously thought. Indeed, this has become the understanding, tacit or otherwise, of both producing and consuming countries.

Bearing these developments in mind, it is assumed the reference case OPEC benchmark crude price remains in the $50–60/b range in nominal terms for much of the projection period, rising further in the longer term with inflation. These price levels are, of course, no more than assumptions, and do not reflect or imply a projection of most likely price paths, or of the desirability of any given price.

Turning to economic growth, demographic dynamics constitute an important element in the potential long-term expansion of the global economy. World population is expected to grow by an average of 1% per annum (p.a.) over the years to 2030, reaching more than 8.2 billion, an increase of more than 1.7 billion from 2005. More than 90% of this growth comes from developing countries. Behind these aggregate movements, however, there are declines expected in growth rates for all regions. It is also important to note that the age structure of these populations will change, with a fall in growth for the working age population much more pronounced.

Productivity growth potential is the other key driver of economic growth rates. The growth of capital stock, world trade patterns, and the impacts of economic reforms will all contribute to total factor productivity. The output of the working age population has been assumed, in the reference case, to follow paths that are broadly consistent with longer-term trends.

The earlier years of the reference case projection reflect the current momentum of the global economy, growing at average rates in the range of 4–5% p.a.. We have witnessed, since 2004, a period of synchronised expansion of the world economy at unprecedented rates. This year sees the fifth consecutive year of above-average expansion. However, there are doubts as to how long the recent surge in global growth can be maintained and there are already signs of a tightening of monetary policies in many countries to avoid overheating. Moreover, in terms of the current outlook, there are growing concerns regarding the possible impacts of the sub-prime loan crisis in the US.

For the longer term, the reference case sees robust global economic growth averaging 3.5% p.a. at purchasing power parity (PPP) to 2030 (Table 1).

Table 1
Average annual real GDP growth rates in the reference case (PPP basis) *% p.a.*

	2006-10	2011-15	2016-20	2021-25	2026-30	2006-30
OECD	2.5	2.2	2.1	2.0	1.9	2.1
DCs	6.3	5.0	4.7	4.5	4.4	5.0
Transition economies	5.2	3.2	2.7	2.5	2.5	3.2
World	**4.2**	**3.5**	**3.4**	**3.3**	**3.3**	**3.5**

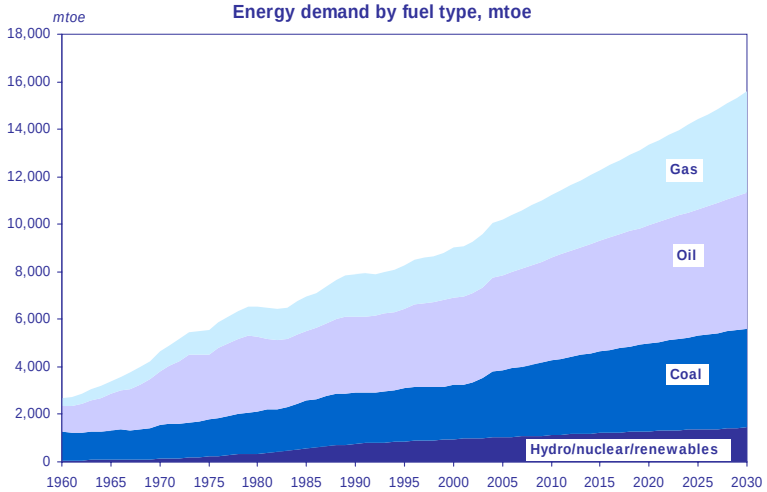
Beyond these economic growth assumptions, another important issue regarding the development of the reference case outlook concerns policies and technologies. No significant departure from current trends is assumed.

Energy and oil demand

Overview

Demand for energy is set to continue to grow. Fossil fuels will continue to provide more than 90% of the world's total commercial energy needs, accounting for 93% of the demand growth in the reference case to 2030. Oil has been the leading supplier of the world's energy needs for the past four decades, and there is a clear expectation that this will continue, with its current share in energy demand of 39% declining only slightly over the next two decades, reaching 36.5% by 2030 (Figure 1 and Table 2). Gas is expected to grow at fast rates, steadily approaching coal in its importance in the energy mix, although coal has recently seen impressive growth, particularly in China. The total contribution of hydropower, nuclear and new

Figure 1
Energy demand by fuel type, mtoe



renewables is presumed to flatten out, despite the extremely high growth rates for some renewables. The climate change issue combined with concerns about security of supply are currently renewing interest in nuclear in many parts of the world. However, nuclear expansion is likely to continue to be hampered by many impeding factors, such as high upfront capital costs, safety concerns and waste-disposal environmental hazards. Overall, some growth in nuclear power in developing countries is assumed to be accompanied by mixed trends in industrialised regions.

Table 2
World energy demand in the reference case

	levels *mtoe*				growth *% p.a.*	fuel shares *%*			
	2005	**2010**	**2020**	**2030**	**2005-30**	**2005**	**2010**	**2020**	**2030**
Oil	4,002	4,319	4,996	5,689	1.4	39.2	38.4	37.5	36.5
Solids	2,822	3,144	3,703	4,181	1.6	27.6	28.0	27.8	26.8
Gas	2,346	2,655	3,352	4,276	2.4	23.0	23.6	25.1	27.4
Hydro/Nuclear/ Renewables	1,041	1,117	1,283	1,434	1.3	10.2	9.9	9.6	9.2
Total	**10,212**	**11,236**	**13,335**	**15,580**	**1.7**	**100.0**	**100.0**	**100.0**	**100.0**

In the electricity sector, hydropower is the largest renewable contributor. Large dams often trigger complex social and ecological side effects, and increasing focus on such issues has led to significant debate over whether large hydroelectric power plants are among acceptable definitions of renewable energy. Instead, attention is turning to refining the technology and reducing the costs of small hydropower, generally of capacities less than 10MW: the so-called 'micro hydro'. Nevertheless, with hydro potential largely tapped in developed countries, the scope for hydropower increases is likely to be limited to developing countries.

Currently, new renewable energy sources, such as wind, solar, geothermal, modern biomass and small hydro, constitute less than 1% of the total global primary energy supply. The small initial shares of new renewables imply that high rates of growth sustained over many years will be necessary for these shares to be raised to significant levels. It is indeed true that recent growth rates for renewables have outpaced all other fuels. However, whether these phenomenal growth rates can be sustained is questionable. Policy support is required for most renewables, due to their high costs.

Moreover, practical and economic limitations of renewables arise from two important characteristics: low energy density, implying a large environmental footprint on the Earth, with current technologies; and the intermittent nature of renewables. Additionally, biofuel production has problems related to competition with land for food production, and the consequent implications for food prices. This is on top of problems associated with, for example, biodiversity and water availability, questionable energy and greenhouse gas emission balances, and soil depletion.

Oil Demand

Turning specifically to oil demand, the reference case sees demand rise by 34 mb/d from 2005 to 2030, reaching 118 mb/d by 2030 (Table 3). As mentioned previously, it should be emphasised that this is under the assumption that no particular departure in trends for energy policies and technologies takes place. Developing countries are set to account for most of this rise, with consumption doubling from 29 mb/d to 58 mb/d. Asian developing countries account for an increase of 20 mb/d, which represents more than two-thirds of the growth in all developing countries. Nevertheless, throughout the years to 2030, OECD and transition economy countries will continue to consume more oil than developing nations (Figure 2), and oil consumption on a per capita basis continues to throw up sharp contrasts. By 2030, North America will be consuming close to 20 barrels per person annually, Western Europe over 10 barrels and China just 4 barrels per head, while other Asian countries will be at even lower levels, below two barrels per capita (Figure 3). By 2030, developing countries will consume, on average, approximately five times less oil per person than OECD countries.

Figure 2
Oil demand, 2005 and 2030

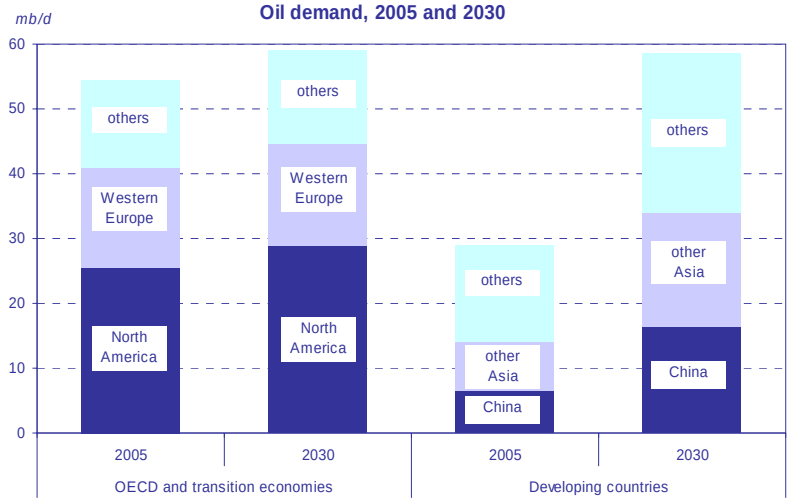


Figure 3
Oil use per capita in 2030

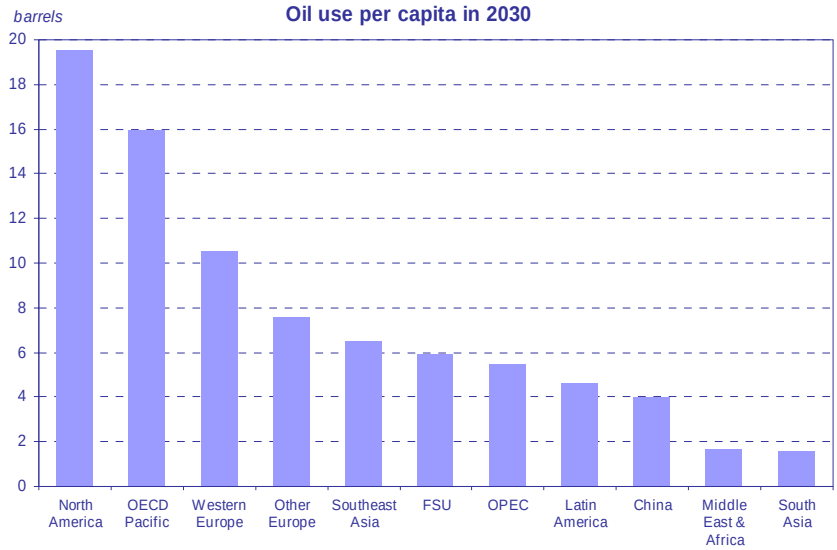


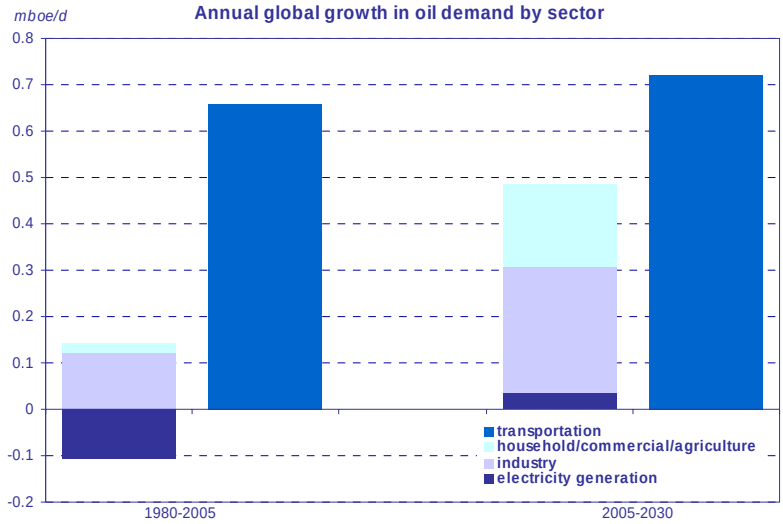
Table 3
World oil demand outlook in the reference case *mb/d*

	2005	2010	2015	2020	2025	2030
North America	25.5	26.1	26.9	27.7	28.4	29.0
Western Europe	15.5	15.6	15.8	15.9	15.9	15.8
OECD Pacific	8.6	8.6	8.6	8.6	8.6	8.5
OECD	**49.6**	**50.3**	**51.3**	**52.2**	**52.9**	**53.4**
Latin America	4.6	5.0	5.5	5.9	6.4	6.8
Middle East & Africa	3.0	3.4	4.0	4.6	5.2	5.9
South Asia	3.1	3.9	5.0	6.1	7.3	8.6
Southeast Asia	4.4	5.2	6.1	7.1	8.0	9.0
China	6.5	8.7	10.4	12.3	14.3	16.4
OPEC	7.4	8.2	9.1	9.9	10.8	11.7
DCs	**29.0**	**34.5**	**40.0**	**45.9**	**52.0**	**58.5**
FSU	3.8	4.0	4.2	4.3	4.5	4.6
Other Europe	0.9	0.9	1.0	1.0	1.0	1.1
Transition economies	**4.7**	**4.9**	**5.2**	**5.4**	**5.5**	**5.7**
World	**83.3**	**89.7**	**96.5**	**103.5**	**110.4**	**117.6**

Demand by sector

Looking closer at demand prospects at the sectoral level, the transportation sector will remain the main source of oil demand growth, given the expected continued expansion in mobility across the world (Figure 4) and with oil being the fuel of choice in this sector.

Figure 4
Annual global growth in oil demand by sector

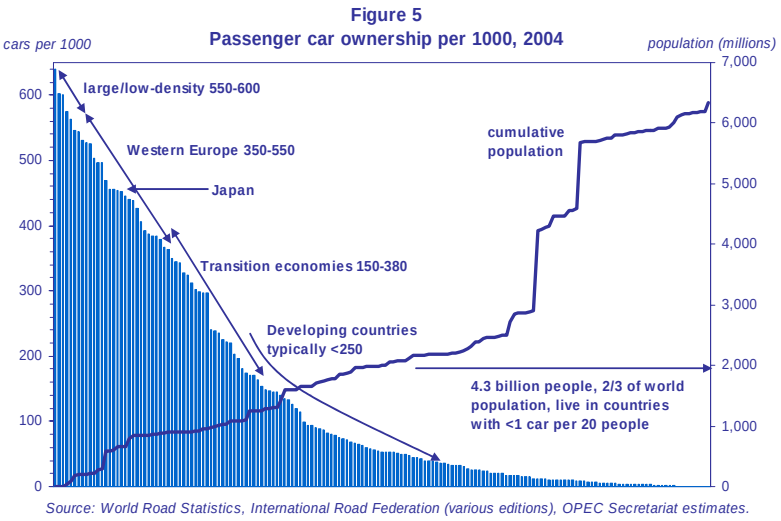


Total transportation demand projections for the reference case (Table 4) show that, over the period 2005–30, demand is expected to increase by 18 million barrels of oil equivalent a day (mboe/d). This is more than half the total demand increase, with 72% of that rise accounted for by developing countries. Nevertheless, OECD countries still account for more than half of the demand in this sector by 2030.

Table 4
Total transportation in the reference case *mboe/d*

	2005	2010	2020	2030	growth 2005-30
OECD	25.6	26.6	28.4	29.7	4.1
DCs	11.1	13.9	18.9	24.1	12.9
Transition economies	1.8	1.9	2.3	2.6	0.9
World	**38.6**	**42.5**	**49.6**	**56.4**	**17.8**

The main source of demand growth in the transportation sector is road transport, while other transportation oil demand (mainly aviation) is projected to increase at a global average annual rate of 3.3% p.a.



There is a vast discrepancy in passenger car ownership levels between countries. Figure 5 ranks the ownership per capita. Around 4.3 billion people, or two-thirds of the world's population, currently live in countries with an average of less than 50 cars per 1,000.

Over two-thirds of the increase in car ownership to 2030 is in developing countries (Table 5). By 2030, however, there is still an average of seven times more cars per 1,000 in the OECD than in developing countries.

The use of commercial vehicles in North America and Western Europe expands at a greater rate than for passenger cars. Saturation effects limit car ownership expansion in these regions, while continued economic growth gives rise to a need for a steady increase in the number of commercial vehicles. The expansion of commercial vehicles is, however, considerably stronger in developing countries.

Table 5
Projections of passenger car ownership rates to 2030

	cars per 1000				millions of cars				growth *% p.a.*
	2005	2010	2020	2030	2005	2010	2020	2030	2005-30
OECD	435	454	480	497	511	546	600	638	1.0
DCs	30	38	52	72	147	200	314	477	5.0
Transition economies	162	182	214	247	55	62	73	83	1.8
World	**110**	**118**	**130**	**146**	**714**	**808**	**987**	**1,198**	**2.1**

The average use of oil per vehicle is affected by conventional engine efficiencies, gasoline/diesel mixes, and the rate of development and diffusion of new technologies.

The highest efficiency improvements are assumed to take place in China, South Asia and OPEC Member Countries, reflecting, in part, the scope for these changes.

The main expected source of increase for non-transportation oil use will be in the industrial and residential sectors of developing countries. Although very little net industry growth in oil demand in OECD or transition economies is expected over the coming decades, demand in developing countries is set to increase by over 6 mboe/d by 2030, more than 90% of the total industry demand rise. Once more, growth in Asian developing countries is the strongest, accounting for 4.7 mboe/d.

Oil use in developing countries' households is closely associated with the gradual switch away from traditional fuels. This trend is expected to continue, especially in the poorer developing countries of Asia and Africa. The household sector will also experience a continued rise in the shares of natural gas and electricity, especially in middle-income regions. The urbanisation trend throughout the developing world is central to the continued move towards commercial energy. The reference case sees an increase in demand for developing countries of almost 5 mboe/d over the period 2005–30 for this sector.

Despite the expected continued expansion in electricity production and consumption across the world, the prospects for oil demand growth in this sector are limited. Coal continues to account for the largest share of electricity generated. Continued additions of coal-based generation capacity, particularly in the US and outside of the OECD, should mean that this fuel retains its strong position in this sector. This has significant implications for future CO_2 emissions and points to the need to focus efforts upon this sector in the context of any net emission reduction objectives. This may include the development and deployment of carbon capture and storage (CCS) technologies, something which is discussed later in this paper.

The global share of natural gas has also risen steeply over the past two decades. Throughout the world, gas-fired plants benefit from the efficiency of combined-cycle technology, as well helping meet environmental concerns over the effect of emissions at both a local and global level. However, additional infrastructure such as LNG import terminals in large consuming countries is needed to cope with the rate of expansion of natural gas usage in the future.

With these developments in mind, it is not expected that oil demand will experience growth to any significant degree in the electricity generation sector. Some potential for future use could come from distributed generation in residential and commercial buildings. In developing countries, of note is the use of oil-based power in remote areas, where conventional electricity distribution is not affordable and diesel or gasoline transportation to such areas for use in generators constitutes the most economical means of providing access to modern energy services.

Finally, demand in marine bunkers is expected to grow by more than 2 mboe/d over the period from 2005 to 2030, almost entirely in developing countries. Upward pressures

from increased trade, including that of oil, will be tempered by ongoing efficiency improvements from the turnover of stock and the growing average size of ships.

Demand by product

The evolution of oil product demand in the reference case over the projection period to 2030 is presented in Table 6. The changing product slate resulting from the expected developments in the various sectors of consumption has important implications for downstream investment needs.

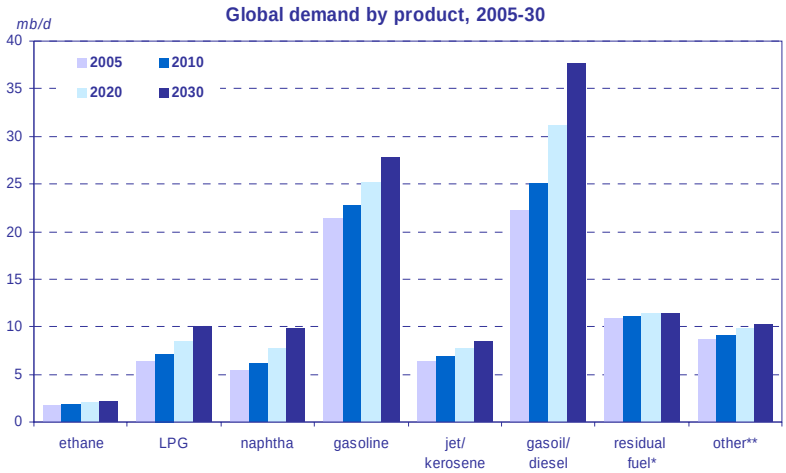
Table 6
Global demand by product, volumes and shares

	demand *mb/d*				share in demand %			
	2005	2010	2020	2030	2005	2010	2020	2030
Ethane	1.7	1.8	2.0	2.2	2.0	2.0	2.0	1.8
LPG	6.4	7.1	8.5	10.0	7.7	7.9	8.2	8.5
Naphtha	5.4	6.1	7.8	9.8	6.5	6.8	7.5	8.3
Gasoline	21.4	22.7	25.1	27.8	25.7	25.3	24.3	23.6
Jet/Kerosene	6.4	6.9	7.7	8.5	7.7	7.7	7.5	8.3
Gasoil/Diesel	22.2	25.0	31.1	37.8	26.7	27.9	30.1	32.1
Residual fuel*	10.9	11.1	11.3	11.4	13.1	12.4	11.0	9.7
Other**	8.7	9.0	9.8	10.3	10.4	10.1	9.5	8.8
Total	83.3	89.8	103.5	117.6	100.0	100.0	100.0	100.0

* *Includes refinery fuel oil.*
** *Includes bitumen, lubricants, waxes, still gas, coke, sulphur, direct use of crude oil, etc.*

Many of the recent trends in the refined product mix are expected to continue over the projection period. Of the 34 mb/d of additional oil demand by 2030, more than 32 mb/d will be for light and medium products, while only 2 mb/d is expected to be for the heavy end of the refined barrel. This will pose one of the biggest challenges for refiners in the coming years. Furthermore, as demonstrated earlier, the bulk of the increase is for transportation fuels, mainly diesel oil, gasoline and jet kerosene (Figure 6). The change in the product mix, along with overall product demand growth, will necessitate an expansion of refinery downstream distillation as well as conversion capacity to increase desired product yields.

Figure 6
Global demand by product, 2005-30



** Includes refinery fuel oil.*
*** Includes bitumen, lubricants, waxes, still gas, coke, sulphur, direct use of crude oil, etc.*

Starting at the light end of the barrel, relatively strong expansion of liquefied petroleum gas (LPG) usage is expected in developing countries, especially Africa, Latin America and some Asian countries, with growth rates varying

between 2.4% and 3.6% p.a. Significantly lower rates are projected for OECD countries, Russia and the Middle East, where natural gas has an advantage over LPG due to the competitive price and infrastructure availability.

Naphtha records the strongest forecast growth rate at 2.4% p.a., with global demand rising from 5.4 mb/d in 2005 to 7.8 mb/d by 2020 and 9.8 mb/d by 2030, driven mainly by high growth in the petrochemical sectors of Asia and the Middle East.

Gasoline demand rises globally in the reference case by 6.4 mb/d, reaching 27.8 mb/d by 2030. This translates into an average growth rate of 1% p.a. However, gasoline growth rates vary widely by region. In OECD Europe, demand for gasoline will decline, reflecting a continued drive toward 'dieselisation'. In the US and Canada, there is a projected average growth rate of just 0.7% p.a., moderately higher than the OECD Pacific. These low growth rates contrast with those for regions outside the OECD. Expanding demand for mobility in these regions leads to gasoline demand growth rates that generally fall in the range of 1.5–2.5% p.a., and higher in China (3.5% p.a.) and Southeast Asia (3.1% p.a.).

Total distillate demand is the main element of projected global product demand growth in the reference case to 2030. Due to fiscal measures favouring the expansion of diesel car fleets in many countries, automotive diesel demand is growing rapidly, whereas gasoil demand growth has slowed, mainly because of the shift towards the use of natural gas, electricity and renewable energy for heating. The net result is for demand for gasoil/diesel, plus jet kerosene, to rise to 46.3 mb/d by 2030 from 28.6 mb/d in 2005.

These growth rates indicate an expected shift from gasoline to diesel. In 2005, the difference in demand between these two products was less than 1 mb/d. By 2020, projected gasoil/diesel demand is 6 mb/d higher than that for gasoline, with the difference increasing to 10 mb/d by 2030.

Another significant component in the demand projection is that there will be essentially no growth in residual fuel demand, with an increase in bunker fuel demand offset by declines in the use of residual fuel oil in industry and power-generation through substitution for natural gas.

In addition to these increasing volumes of oil products, the reference case also sees major changes to product specifications, which will represent a major challenge for the downstream sector. The implications for refining capacity requirements are explored below in the supply section.

Oil supply

Overview

In satisfying the future demand for oil that has been described, liquid supply will come not only from crude oil, but also from other liquids, such as natural gas liquids (NGLs),

gas-to-liquids (GTLs), coal-to-liquids (CTLs) and biofuels, whose importance will grow over time.

Regarding crude oil supply, a central tenet of the OPEC long-term supply perspective assessment is that resources are sufficient to meet demand over the projection period and beyond. The resource base, as defined by estimates from the US Geological Survey of ultimately recoverable reserves (URR), does not constitute a constraint to supplying the rising levels of oil demanded in the reference case. Indeed, the methodologies developed and applied to derive the regional crude supply figures revolve around the assessment of remaining resources (resources minus cumulative production), so supply projections are, by definition, plausible from the resource perspective. Moreover, it is worth noting that these URR estimates have practically doubled since the early 1980s, from just 1,700 billion barrels to over 3,300 billion barrels, and it is probable that this upward revision process will continue. It should be noted that cumulative production during this period was less than one-third of the increase. In addition, these figures do not take into account the large resources of non-conventional oil.

One of the most critical elements in the resource base expansion has been technology. Though certain advances in technology may contribute to faster depletion, the more important effects of technology are to add reserves by identifying new accumulations, increasing recovery, extending the reach to frontier regions or resources, and making development of sub-commercial resources commercially attractive. Examples of new technologies that add resources, increase recovery, identify and access new accumulations include horizontal drilling, extended reach drilling, 3-D and 4-D seismic, in addition to the technologies that improve the recovery and the economics of very heavy oil, tar sands and shale oil.

In the reference case, non-OPEC crude oil supply initially rises to a plateau of around 48 mb/d, before beginning a gradual decline from around 2020 (Table 7). This plateau is maintained as increases from Latin America, Russia and the Caspian compensate for decreases elsewhere, mainly in the North Sea.

The most significant growth in non-OPEC non-conventional oil supply is expected to come from the Canadian oil sands. Some increases are also expected from biofuels and coal- and gas-to-liquids. In total, more than 10 mb/d of non-conventional oil supply will come from non-OPEC by 2030, an increase of 8 mb/d during this projection period.

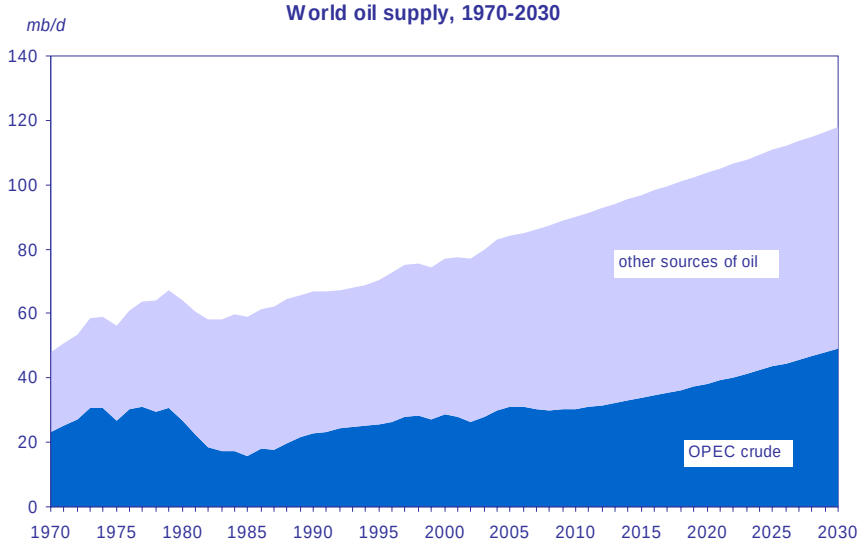
Up to 2010, increases in both crude and non-crude supply push total non-OPEC liquid supply up to 54 mb/d, an increase of 5 mb/d compared to 2005. With demand increasing by only a slightly higher rate, this leaves little room for additional OPEC oil over the medium term. Indeed, with OPEC non-crude supply, primarily NGLs, set to rise to just under 6 mb/d by 2010, the call on OPEC crude by 2010 is likely to not exceed 2005 levels.

Table 7
World oil supply outlook in the reference case *mb/d*

	2005	2010	2015	2020	2025	2030
US & Canada	10.4	11.3	11.7	12.3	12.8	13.0
Mexico	3.8	3.8	3.8	3.5	3.2	2.9
Western Europe	5.8	5.0	4.3	3.9	3.5	3.2
OECD Pacific	0.6	0.7	0.7	0.8	0.8	0.8
OECD	**20.5**	**20.9**	**20.6**	**20.5**	**20.3**	**19.9**
Latin America	4.3	5.0	5.6	6.2	6.6	6.6
Middle East & Africa	4.4	5.0	5.1	5.3	5.1	5.0
Asia	2.6	2.9	2.8	2.5	2.3	2.1
China	3.6	4.2	4.5	4.8	5.0	5.3
DCs, excl. OPEC	**14.9**	**17.0**	**17.9**	**18.7**	**19.0**	**19.1**
Russia	9.4	10.3	11.0	11.2	11.2	11.2
Caspian and other FSU	2.1	3.5	4.1	4.5	4.9	5.2
Other Europe	0.2	0.2	0.2	0.1	0.1	0.1
Transition economies	**11.7**	**14.0**	**15.3**	**15.9**	**16.2**	**16.6**
Processing gains	1.9	2.2	2.4	2.8	3.0	3.2
Non-OPEC	**49.0**	**54.1**	**56.3**	**57.8**	**58.5**	**58.8**
of which: non-conventional	2.2	4.1	5.8	7.4	8.9	10.2
OPEC NGLs/non-conventional	**4.1**	**5.7**	**6.8**	**7.8**	**8.8**	**9.8**
OPEC crude	**31.1**	**30.2**	**33.8**	**38.2**	**43.5**	**49.3**
World	**83.3**	**89.7**	**96.5**	**103.5**	**110.4**	**117.6**

Looking beyond 2010, although non-OPEC crude reaches a plateau, strong growth of non-conventional oil and other liquids means that total non-OPEC supply actually continues to rise over the entire projection period. Moreover, OPEC supply of NGLs and non-conventional oil, mainly GTLs, is also expected to see a steady rise, in particular as domestic natural gas infrastructure expands and with it the availability of NGLs. As a result, the amount of crude oil that OPEC would be relied upon to supply in this reference case, rises to 38 mb/d by 2020 and 49 mb/d by 2030, representing 37% and 42% of total oil supply respectively, while other sources account for 63% and 58% for these two years. This distribution, while not markedly

Figure 7
World oil supply, 1970-2030



different from today's share, is rather different to that of the mid-1970s, when oil supplies outside of OPEC crude accounted for less than 50% of total supply (Figure 7).

Regional crude oil and NGL prospects

In the outlook assessment for crude and NGL supply, many factors influence the future growth potential. One key consideration is the investment in new fields and field expansions. There are numerous development projects in non-OPEC countries underway, or announced and expected to begin producing during the next five-to-six years. The figures for non-OPEC crude oil plus NGL supply in the initial years of the reference case are based upon a bottom-up approach, using a country-specific database of investment projects. Non-OPEC production growth is underpinned by over 300 greenfield and brownfield development projects, most of which are in the construction phase. As in the past two decades, offshore (shallow and deepwater) oil production will account for most of the cumulative increase.

The reference case outlook for crude supply plus NGLs is documented in Table 8.

Table 8
Non-OPEC crude oil + NGL supply outlook in the reference case *mb/d*

	2005	2010	2015	2020	2025	2030
US & Canada	8.9	8.7	8.1	7.5	7.0	6.5
Mexico	3.8	3.8	3.8	3.5	3.2	2.9
Western Europe	5.6	4.5	3.6	3.2	2.8	2.5
OECD Pacific	0.6	0.7	0.6	0.6	0.7	0.7
OECD	**18.9**	**17.7**	**16.1**	**14.8**	**13.6**	**12.5**
Latin America	4.0	4.5	5.0	5.6	5.8	5.8
Middle East & Africa	4.2	4.8	4.9	5.0	4.9	4.7
Asia	2.6	2.9	2.6	2.2	1.9	1.6
China	3.6	4.0	4.1	4.1	4.1	4.1
DCs, excl. OPEC	**14.4**	**16.2**	**16.7**	**16.9**	**16.8**	**16.3**
Russia	9.4	10.3	11.0	11.2	11.2	11.2
Caspian	2.1	3.5	4.1	4.5	4.9	5.2
Other Europe	0.2	0.2	0.2	0.1	0.1	0.1
Transition economies	**11.7**	**14.0**	**15.3**	**15.8**	**16.2**	**16.6**
Non-OPEC	**45.0**	**47.9**	**48.0**	**47.6**	**46.5**	**45.4**

Reference case figures see Russian output eventually reaching a plateau of around 11 mb/d within the next decade, an increase of almost 2 mb/d from 2005. In Russia, resource development is expected to shift from mature regions like Western Siberia and the Urals to Eastern Siberia and northern areas where, however, infrastructure is less developed. Caspian crude oil production is expected to account for an even greater rise, reaching over 5 mb/d by 2030, more than a 3 mb/d increase from 2005. Important export infrastructure is now in place that allows the continued expansion of large fields in the region. Increases from Kazakhstan and Azerbaijan will result in an improvement in the Caspian's crude quality that can be traced to the start-up of the light/sweet Kashagan field in Kazakhstan.

In Western Europe, improved oil recovery is expected to prolong the life of the North Sea, but the region will continue to decline. New discoveries are smaller and technically more challenging. Western Europe will see a decline in crude production from 5.5 mb/d in 2006 to below 4 mb/d in 2015 and to less than 3 mb/d by 2025, with the decline continuing thereafter as reserve levels steadily fall. The North Sea will remain a producer of generally light/sweet crude, although quality here is also on the decline.

In North America, conventional onshore crude oil production in the US Lower 48 states, as well as Alaskan crude, will continue its steady fall. However, this decline is to an extent offset by the production growth of medium sour crude oils from the deep offshore US Gulf of Mexico. Consequently, crude quality is steadily deteriorating. Total US and Canadian supply of conventional crude falls throughout the projection period, to below 7 mb/d within two decades. The other element of North American supply, Mexico, is expected to experience a long plateau up to around 2015, possibly declining thereafter.

Latin American non-OPEC crude supply increases by almost 2 mb/d over the forecast period, before reaching a plateau close to 6 mb/d around 2025. Growth is predominantly driven by offshore projects in Brazil. Here, API gravity will decrease across the region, with sulphur content rising as new projects increase production of lower quality crudes, such as heavy sour Brazilian deepwater.

In Asia, the reference case shows crude oil supply declining gradually over the forecast period from 2010. The decline in Asia is expected to occur outside of China, which experiences a long plateau near current levels, though some upside potential exists. The country's offshore resources remain largely undeveloped, located primarily in the Bohai and South China Seas, areas with water depths of less than 400m.

Output increases from non-OPEC Middle East and Africa will be primarily from offshore West Africa, but this will reach a plateau of around 5 mb/d within the next decade. Africa supplies mostly light sweet crudes to the world market and this is expected to continue.

Non-conventional oil

Beyond crude supply, it is important to remember that, currently, the world's endowment of non-conventional hydrocarbons outstrips resources of conventional oil. In the medium-to-long-term, significant increases are expected in the world's non-conventional oil supply, in the form of extra-heavy crude oil, synthetic oil from natural gas (GTLs) and from coal (CTLs), oil sands and oil shales. Biofuels are also expected to become increasingly important.

The contribution of non-OPEC non-conventional oil to supply increases in the reference case by close to 6 mb/d over the period 2005–30, reaching 7.3 mb/d by 2030 (Table 9). The single biggest contribution to this increase will be the Canadian oil sands, with the reference case seeing supply from this source growing from 1 mb/d in 2005 to almost 3 mb/d by 2015 and 3.8 mb/d by 2020. Further growth is expected in the following years, reaching 5 mb/d by 2030.

Table 9
Non-OPEC non-conventional oil supply outlook (excl. biofuels) in the reference case *mb/d*

	2005	2010	2015	2020	2025	2030
US & Canada	1.2	2.1	2.9	4.0	5.0	5.7
OECD	**1.3**	**2.3**	**3.2**	**4.4**	**5.3**	**6.1**
China	0.0	0.1	0.3	0.4	0.6	0.8
DCs, excl. OPEC	**0.2**	**0.2**	**0.5**	**0.8**	**1.0**	**1.3**
Non-OPEC	**1.5**	**2.5**	**3.7**	**5.1**	**6.3**	**7.3**

Increases in CTLs and GTLs, particularly in the US, China, South Africa and Australia, are also expected. GTL projects, however, are characterised by high capital intensity and cost overruns, with costs varying on the basis of location and site-specific conditions, size of the plant, the degree and scope of product upgrade facilities, availability of shared infrastructure and technology. In addition, the GTL process has low carbon and thermal efficiencies and high energy consumption compared with the liquefied natural gas (LNG) process. The CTL projects are even more capital-intensive and the process has even lower carbon and thermal efficiencies than GTLs. It also uses large quantities of water. All these factors will limit the rate of expansion of these non-conventional sources for the foreseeable future.

In the reference case, liquid production from GTLs in non-OPEC countries is forecast to be 0.5 mb/d by 2030. It is anticipated that liquid supply from CTLs will grow from about 150,000 b/d today to around 1.5 mb/d by 2030, mainly from China and the US.

Another source of non-conventional oil is in the form of oil from shales. Although world oil shale resources are large, it is unlikely, however, that there will be any significant commercial operations during the next 10–15 years. After this period, it is expected that technological advances would allow some projects to be commercial with a potential production level of around 0.4 mb/d by 2030.

Biofuels

Recent high oil prices, regulatory changes, fiscal incentives and various political statements favouring the use of biofuels, including through binding quantitative targets, have given impetus to the biofuel industry. At present, biofuels provide 1% of the world's liquid transport fuels, mainly in Europe, North America and Latin America. With world production standing at just under 700,000 b/d in 2006, bioethanol is the most widely used biofuel, more than doubling since 2000. With a world production of about 75,000 b/d in 2006, the share of biodiesel in transport fuel consumption is rather limited, except in Europe, where it constitutes the most used biofuel, having a share of 88% in total biofuel production.

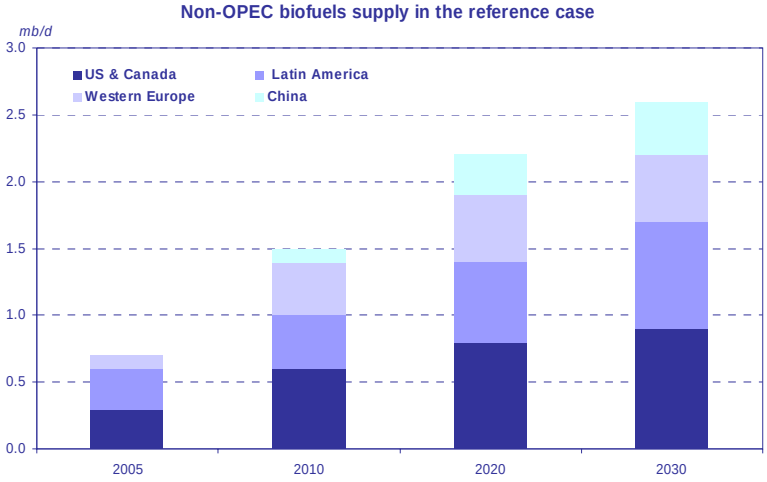
The costs of current biofuel production vary widely, depending upon feedstock, conversion processes, scale of production and region. In general, production costs of these conventional biofuels are higher than oil-based fuels and, with the production processes being well-established technologies, only minor improvements in the economics may be possible.

Beyond the issue of cost, the potential global impacts of large-scale biofuel production and trade are becoming subjects for serious debate. The drive to switch to biofuels could have a major impact on societies in terms of rising food prices, a phenomenon already occurring in many parts of the world, as well as generating competition with food crops for land and scarce water resources. With regard to the protection of the environment, the value of biofuels in reducing greenhouse gas emissions and fossil fuel energy use varies widely. Overall, biofuels appear to have only a minor role in reducing greenhouse gas emissions in comparison with other options, having relatively higher mitigation costs.

Second-generation biofuels are claimed to alleviate many of the concerns surrounding conventional biofuels. However, the associated technologies are still in the Research & Development (R&D) phase, and are assumed not to become commercially viable over the projection period.

In the reference case, incremental improvements in agricultural productivity and efficiency of conversion processes are assumed to reduce the costs of conventional bioethanol and biodiesel. Moreover, taxation- and agriculture-based policies in major consuming countries are expected to continue to provide support for biofuels, together with the introduction of mandatory biofuel targets. On the other hand, second-generation biofuels are assumed not to become commercially available in the reference case. Pressures emanating mainly from food and energy competition are assumed to continually slow growth after 2010. Total global biofuel production increases in the reference case by 2.2 mb/d to reach 2.8 mb/d by 2030. In absolute terms, the biggest increase in biofuel production occurs in the US. Ultimately, however, the amount of ethanol produced from corn will be limited due to the constraining factors of land availability, competition with food, and the corresponding effects on prices.

Figure 8
Non-OPEC biofuels supply in the reference case



Recent policy initiatives could perhaps change this outlook. In early 2007, the European Union (EU) adopted a 10% binding minimum target to be achieved by all its Member States for the share of biofuels in overall EU transport petrol and diesel consumption by 2020.[2] And in the US, the most recent proposal by the Administration – the 'Twenty In Ten Goal' – includes the mandatory Alternative Fuels Standard programme, which sets out targets for increasing the use of alternative fuels. It sees alternative transport fuel hitting 35 billion gallons in 2017 (almost 2.3 mb/d).

2 Energy Plan for Europe, adopted by the Council of the European Union, 15 February, 2007.

These recent policy announcements setting very ambitious targets for the large use of biofuels are already being contested as being unrealistic, particularly given that both the EU and the US targets critically depend upon second generation biofuels becoming commercially available. Many legitimate questions for OPEC and the oil industry arise: should they take seriously these policy targets and adjust, as it would have been expected from any industry, their investment plans accordingly? What would then be the consequences if these targets are not realised?

Oil downstream outlook

Distillation capacity

The downstream oil sector is an important part of the supply chain and in recent years has been characterised by tightness across all the basic refining functions, including key upgrading and quality improvement processes. Constraints in converting heavy and/or high sulphur streams into light and clean products are a primary factor contributing to the price differentials that exist today. The extent to which refining tightness remains or eases will depend on the evolution of what is currently a neck-and-neck race between refining capacity growth and product demand growth.

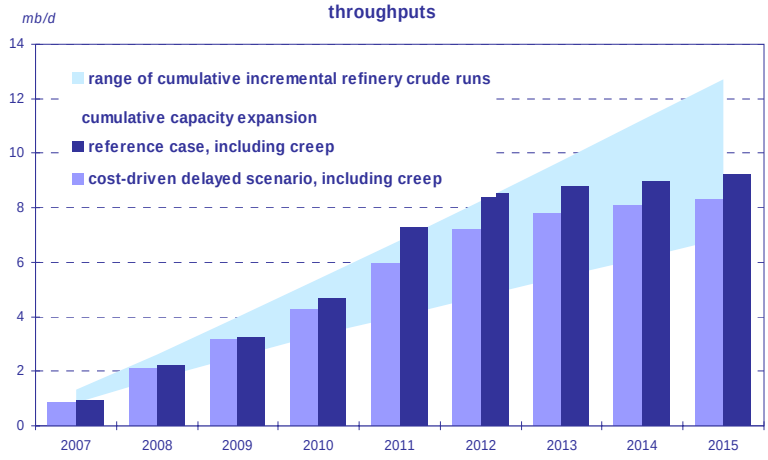
Several factors will shape developments in the downstream sector in the years to come. Growing demand for oil products clearly means there will be a rising volume of crude oil that needs to be refined. Moreover, the oil product demand structure will change, with the expected continued move towards lighter products. At the same time, and driven by environmental concerns, product specifications are moving towards significantly cleaner products that will necessitate substantial reductions in sulphur content, as well as improvements in other quality parameters. To meet these challenges, the downstream sector will require significant investment to ensure that sufficient distillation capacity is in place, supported by adequate conversion and desulphurisation, as well as other secondary processes and facilities.

In the reference case, additional refinery crude runs resulting from global demand increases should reach 4.7 mb/d by 2010 and more than 10.5 mb/d by 2015. This could be achieved either through the enhanced utilisation of existing capacity or by building new capacity. However, considering the current high refinery utilisation rates in key regions, such as China, US, Japan or Western Europe, and constraints on increasing it in other regions, there are mixed signals on the ability of distillation capacity expansion to keep pace with growing demand. The reference scenario for distillation capacity expansion in the medium term shows that a total of 8.5 mb/d of new capacity (including capacity creep), out of more than 14 mb/d of announced projects, will be added to the global refining system through to 2012 and 9.2 mb/d by 2015. Almost 70% of new capacity will be located in the Middle East and the Asia-Pacific.

An alternative scenario for capacity expansion, driven by possible termination of projects and further delays due to rising costs, limited availability of skilled human resources and administrative and environmental restrictions, foresees additions as low as 8.3 mb/d for the period to 2015. Consequently, a comparison of scenarios for refining needs, as

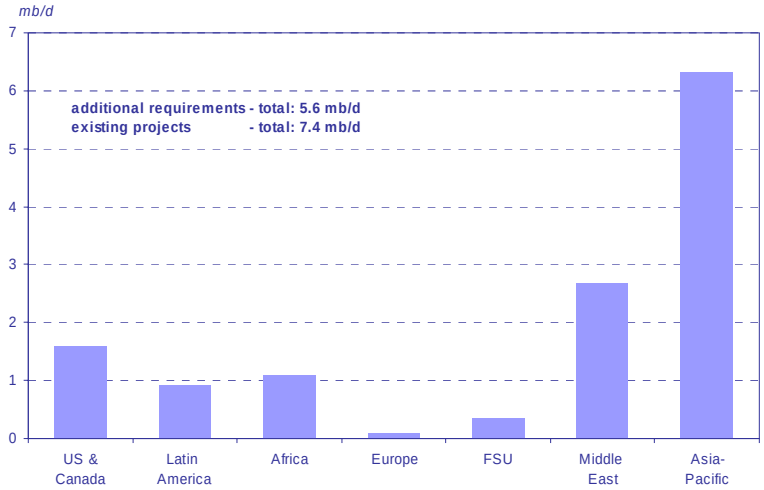
reflected by the light blue range in Figure 9, with scenarios for distillation capacity additions in the coming years represented by the columns, indicate continuing tightness in the refining sector, at least up to 2010. There is the possibility of easing tightness and potentially margins, in the period 2011–12. Under the cost-driven delayed scenario, the excess additions relative to the reference case are essentially eliminated even for this later period. Moreover, this is on top of expected persistent tightness in conversion and hydrotreating.

Figure 9
Cumulative distillation capacity additions vs incremental refinery throughputs



Based on the reference case scenario, by 2020 a total of 13.1 mb/d of additional distillation capacity, combined de-bottlenecking and major new units, will be required, compared to the refining base in 2006. The regional breakdown for additional distillation capacity, both existing projects and requirements beyond these projects, appears in Figure 10. Clearly, future capacity expansion should be predominantly placed in the Asia-Pacific, driven by the region's expected demand increase. Almost 4 mb/d of additional capacity, out of the 5.6 mb/d required globally, should be built in the Asia-Pacific. This is followed by the US and Canada, with 0.8 mb/d, and Latin America and Africa both requiring around 0.4 mb/d of additional distillation capacity by 2020.

Figure 10
Required regional distillation capacity additions between 2007 and 2020



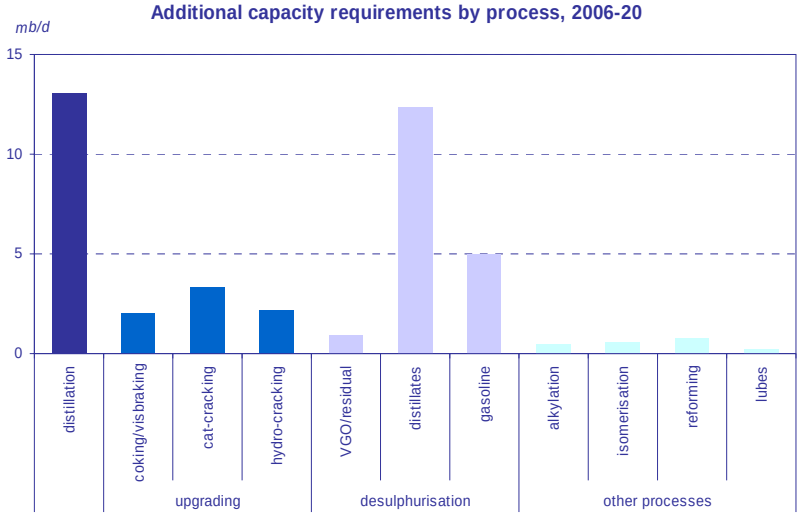
Other regions require no additional distillation capacity to meet their future demand. The current rapid expansion of the downstream sector in the Middle East will create sufficient capacity for the period to 2020. In the case of the former Soviet Union (FSU) countries, better utilisation of existing capacity will cover the need for refined products, and investments in the region should rather be geared toward product quality improvements. In Europe, the moderate increase in oil demand will be more than offset by increases in biofuel production, thus leaving distillation capacity requirements unchanged.

Conversion and desulphurisation capacity

In addition to crude distillation capacity, downstream conversion units and the associated support facilities will be required to meet future product demand, as well as changing product specifications. In this respect, crude oil quality will increasingly play an important role in determining future refining requirements. Heavier crude oil will require increased conversion capacity to produce a higher portion of light products and sulphur content increases will necessitate modifications to intermediate processes, notably hydro-treating, hydrogen and sulphur recovery.

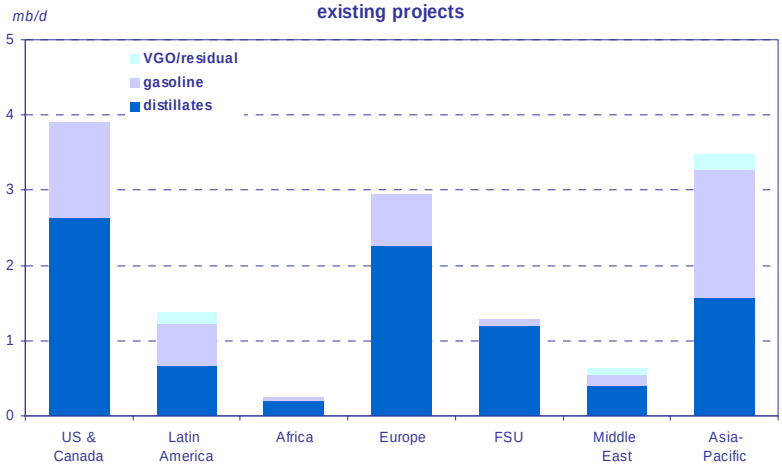
On the crude supply side, it is expected that the weighted average production slate will decline in its quality only moderately with respect to both average API gravity and sulphur content. The changing crude slate will not therefore create an additional problem for the refining sector. The real challenge, in this respect, will come from the demand side. The expected shift in the structure of demand toward lighter products and much tighter fuel quality specifications will be a greatly superior challenge to the one resulting from the change in quality of the global crude slate.

Figure 11
Additional capacity requirements by process, 2006-20



Taking into account the most likely changes in the future supply and demand structure and the corresponding quality specifications, the global downstream sector will require more than 7.5 mb/d of combined upgrading capacity, more than 18 mb/d of desulphurisation capacity and around 2 mb/d of capacity for other supporting processes, such as alkylation, isomerisation and reforming, over the period 2006–20, in addition to the 13.1 mb/d of distillation capacity (Figure 11). Requirements for all major refinery upgrading units – coking, cat-cracking and hydro-cracking – continue to be significant, but with hydro-cracking projected to take a progressively larger role. This is driven by the growth in distillate demand.

Figure 12
Additional desulphurisation capacity requirements, 2006-20, excluding existing projects



The impact of stricter product quality specifications is reflected in the projection that, by 2020, the global refining system will need more then 18 mb/d of additional desulphurisation capacity over the 2006 base (Figure 12). This is dominated by requirements to produce additional ultra-low sulphur gasoline and diesel. Desulphurisation requirements will be significant across all regions, but the bulk of these units is projected in OECD regions as these move towards ultra-low sulphur fuels by 2010–12, and essentially all gasoline and diesel streams have to be desulphurised. In other regions, due to the limited existing capacity, even modest sulphur reduction implies considerable capacity additions. This is particularly significant for countries like India and China that are on the path to follow the high European standards.

Crude and product trade

As a result of the growing gap between where oil is produced and where it is consumed, the volumes of traded oil and corresponding inter-regional movements are set to increase. Inter-regional oil trade increases by 13 mb/d from 2005, to almost 63 mb/d of oil exports in 2020. Both crude and product exports will increase appreciably, with product exports growing faster than crude exports. Thus, crude exports are projected to reach the level of 44.3 mb/d in 2020, compared to around 38 mb/d in 2005, while the trade of refined products and intermediates reaches a level of 18.5 mb/d, which is 6.5 mb/d higher than in 2005.

Figure 13
Major crude exports by destination, 2020

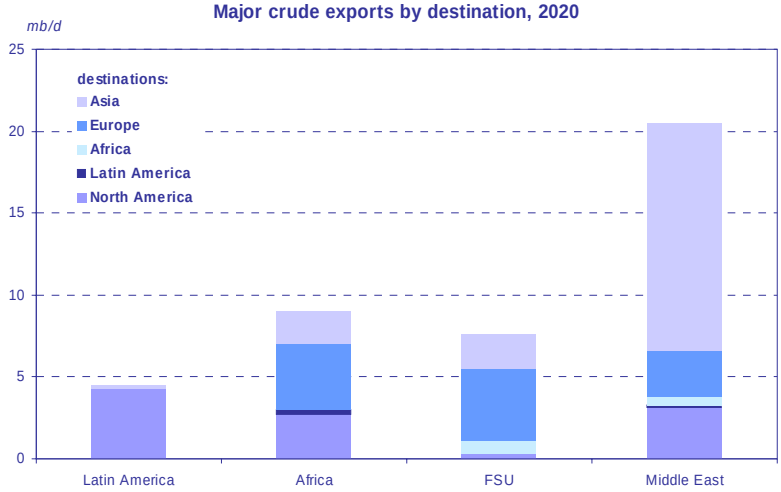


Figure 13 summarises the major flows of crude oil from the perspective of exporters. What initially jumps out is the future major role played by the Middle East in its exports to the Asia-Pacific region. Elsewhere, in comparison to the current situation, African exports to North America and Europe will rise and Russian and Caspian producers will increase their exports to Europe, as well as to the Asia-Pacific through newly developed routes. Another significant development is the rise in West African crude exports to several destinations, such as the US, the Asia-Pacific, Northern Europe, East and South Africa and Latin America. And finally, the current patterns of North African crude exports, primarily into Southern Europe and secondarily into the US, are maintained in the outlook.

In the reference case scenario, most of the Russian and Caspian crude exports move to the West and into the Atlantic basin. Total crude exports from Russia and the Caspian are projected to be around 7.7 mb/d in 2020. Of these, almost 4.5 mb/d are exports into Europe. The other major outlet for Russian and Caspian crude is the Asia-Pacific region. China will import around 1.2 mb/d through pipelines from Kazakhstan and Russia, as

well as through rail shipments. The remaining exports of Sakhalin crude and Siberian Light are projected to move into the Pacific region (0.9 mb/d), with marginal volumes to the US West Coast.

These projected patterns therefore point to the growing importance of oil trade between the Middle East and the Asia-Pacific region, with implications for the need for additional tankers to cope with the associated long-haul movements. Indeed, by 2020, total fleet requirements are expected to increase by 27% compared to 2006, to reach 460 million deadweight tonnes. This is a clear reflection of the increasing globality and interdependency of the oil industry.

Alternative scenarios: uncertain demand growth

In the reference case, the expectation is that, while demand for OPEC oil declines over the medium term, in the longer term OPEC will be increasingly relied upon to supply the incremental barrel. OPEC is making known well in advance its plans for production capacity expansion, not only to satisfy increased demand, but also to offer an adequate level of spare capacity. These measures will support security of supply and market stability, to the benefit of the world at large.

Nevertheless, the need for enhanced energy security must be seen from the mutually supportive supply and demand perspectives. Uncertainty over future demand – and, indeed, non-OPEC supply – translates into large uncertainties over the amount of oil that OPEC Member Countries, playing the role of residual suppliers, will eventually need to supply, signifying a heavy burden of risk. Investment requirements are very large, and subject to considerably long lead-times and pay-back periods. Security of demand is a major concern for producers.

Demand can, of course, be affected both positively and negatively by alternative rates of economic growth to those assumed in the reference case. However, there is a range of important drivers, in particular energy and environmental policies in consuming countries, as well as technological developments, that tend to push in one direction: a reduction in demand. It is to be expected, therefore, that uncertainties over possible future demand patterns are skewed towards the downside, with corresponding risks to the demand for OPEC oil.

With this asymmetry in mind, a scenario has been developed which depicts a possible future where the drivers of change give rise to relatively low growth in oil demand. In this *lower growth* scenario, the world economy is assumed to expand at a more modest rate, 0.5% lower p.a. than in the reference case. This could stem from a number of factors.

This *lower growth* scenario is both credible and realistic and reflects genuine and persistent concerns about the long-term health of the world economy, given the various economic and political uncertainties. On top of this, efforts to reduce oil demand growth are assumed to be made in both developing and developed countries. Specifically, it is assumed that vehicle efficiencies improve at faster rates than in the reference case. Besides, technological improvements in the efficiency of conventional internal

combustion engines and the introduction of alternative vehicles could reduce the potential increase in oil demand for transport in the longer term.

The specific assumption made is for an additional reduction of 0.5% p.a. in oil use per vehicle in all regions, compared to the reference case. This has been identified as representing a concerted effort to improve efficiencies.

Table 10 shows that, in this *lower growth* scenario, already by 2015 world oil demand is almost 5 mb/d lower than in the reference case. By 2020, the difference reaches 8 mb/d, and the gap continues to widen in the longer term. The only source of growth in this scenario is developing countries. Average growth in demand over the entire projection period is just 0.8 mb/d annually.

Table 10
Oil demand and OPEC crude supply in the *lower growth* scenario *mb/d*

	2010	2015	2020	2025	2030
World demand	88.0	92.0	95.6	98.8	102.1
OPEC crude	29.0	30.4	32.0	34.0	36.2

With this lower demand, there are downward pressures upon oil prices, as well as upon the amount of oil demanded from OPEC. Any resultant positive pressures upon demand are mitigated by the extent that, through taxation, a fall in crude prices is not necessarily observed in end-user prices. Lower prices have some negative impact upon non-OPEC supply, although this is modest. The impacts could be higher, however, should the prospects for non-conventional oil supply be substantially affected by lower prices. By far the largest impact is upon the amount of oil that would be supplied by OPEC in this scenario, falling by over 3 mb/d compared to the reference case by 2015, and of more than 6 mb/d by 2020. This clearly demonstrates the genuine concern over the amount of investment required to cover anticipated demand growth, as well as to maintain adequate levels of spare capacity.

As previously mentioned, uncertainties concerning demand exist in both directions, and even stronger growth than in the reference case can be readily conceived. Stronger economic growth could emerge if geopolitical and economic conditions give a robust impetus to world trade, as well as to capital flows and technology transfer.

The resulting increased growth in oil demand is assumed to eventually lead to some consumer reactions and energy policy responses that limit the pace of demand growth. It is also possible in such a scenario that environmental concerns, both local and global, would precipitate a wave of additional policy measures to limit oil demand growth.

It can be seen from Table 11 that this *higher growth* scenario gives rise to world oil demand that by 2015 is more than 2 mb/d higher than in the reference case, and almost 4 mb/d higher by 2020. Once again longer-term differences are even greater, although the assumed consuming policy measures limit the rate at which this gap widens. Most of this additional growth in demand is in developing countries. Average annual demand growth over the period to 2030 is 1.7 mb/d.

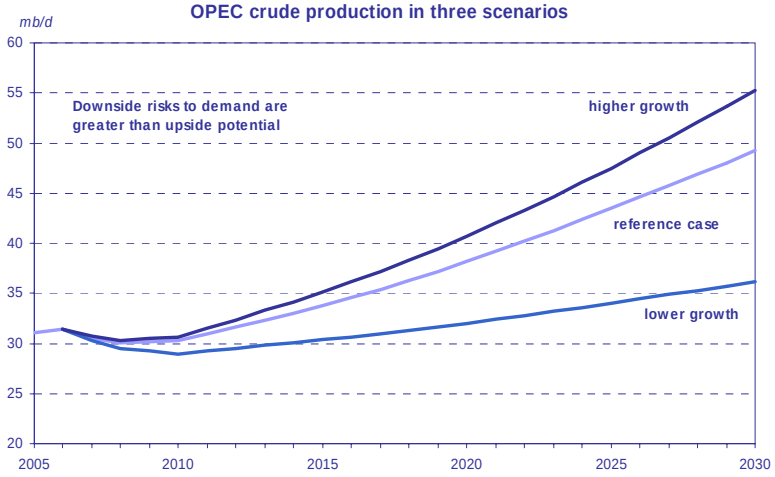
Table 11
Oil demand and OPEC crude supply in the *higher growth* scenario *mb/d*

	2010	2015	2020	2025	2030
World demand	90.5	98.9	107.4	116.3	125.8
OPEC crude	30.7	35.2	40.7	47.5	55.3

The higher demand increases the amount of oil that is required from OPEC. It is assumed that higher prices will need to emerge to support the necessary investments, and that these prices would give rise to some support for non-OPEC supply, although the impact is modest, with output only 1 mb/d higher by 2015 compared to the reference case, and only around 2 mb/d higher in the longer term (Table 11). The reaction to the higher oil price is partly limited by the higher finding, development and operating costs that are assumed for this scenario. On the other hand, higher prices may improve the potential for the increased supply of non-conventional oil. The amount of oil demanded from OPEC in this scenario, by 2030, is around 6 mb/d higher than the reference case.

Given the role that OPEC plays in supporting market stability by supplying the residual barrel, the uncertainties in these scenarios translate into a wide range of possible levels of future oil supply demanded from OPEC. With a *higher* and *lower growth* case, a range of 1.7 mb/d opens up for the possible amount of oil that OPEC might have to supply by 2010, but this gap widens to close to 5 mb/d by 2015 (Figure 14). Looking even further ahead, the uncertainties continue to accumulate. By 2020, the amount of crude oil OPEC might be expected to supply could lie in the range 32–41 mb/d, according to these scenarios.

Figure 14
OPEC crude production in three scenarios



The uncertainties described in this section have large consequences over the level of investments needed in the petroleum sector in general and in OPEC Member Countries in particular. This is explored in the next section.

3. Investment requirements and activities

Investments along the entire supply chain are needed for the provision of energy services. For oil, this includes both the upstream and downstream sectors, and covers exploration, development, production, land and marine transportation, refining and distribution. It is today a global, widely spread and complex infrastructure that delivers more than 85 mb/d of oil and products to end-users. This section tries to understand how this will evolve in the future, by providing estimates of the investment requirements over the coming years. It also looks specifically at investment activity in OPEC Member Countries. The next section then analyses the nature and significance of the investment challenges facing the oil industry.

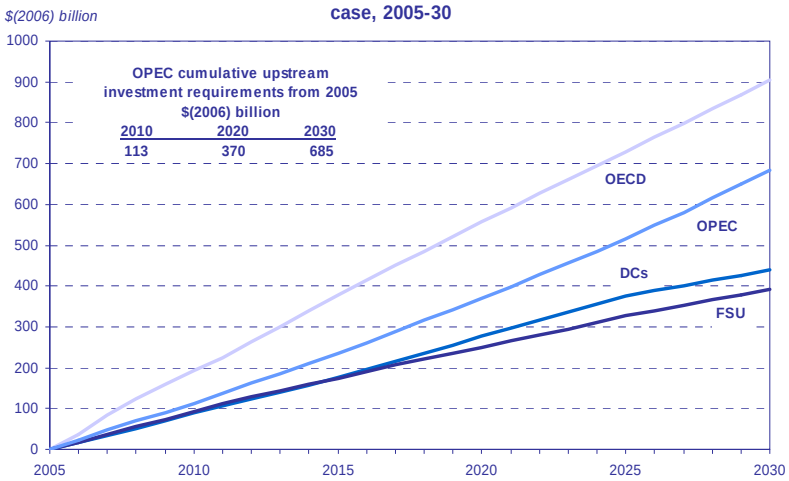
Upstream investment requirements

The estimate for upstream investment requirements accounts for not only the production capacity necessary to meet the additional crude oil demand, but also what will be required to compensate for natural declines in producing fields, such as workovers, in-field drilling, enhanced recovery schemes and even the development of new fields. The estimates cover only the upstream and do not include the development of new mid-stream infrastructure, such as pipelines, storage farms and ports.

Globally, expansion of non-OPEC capacity is, on average, two-to-three times more costly than for OPEC, with this gap widening over time, as costs in non-OPEC regions gradually rise faster than in OPEC. The highest-cost region is the OECD, which also experiences the highest decline rates.

From 2006, total crude oil upstream investment requirements to 2030 amount to $2.4 trillion (in 2006 US$). The OECD accounts for 38% of this figure. Over the first ten years of the projection, the requirements in OPEC, non-OPEC developing countries, as well as Russia and the Caspian states, are of a similar order of magnitude. All three of these non-OECD groups require around $100–110 billion of investment by 2010, and close to another $100 billion in the following five years (Figure 15).

Figure 15
Cumulative upstream oil investment requirements in the reference case, 2005-30



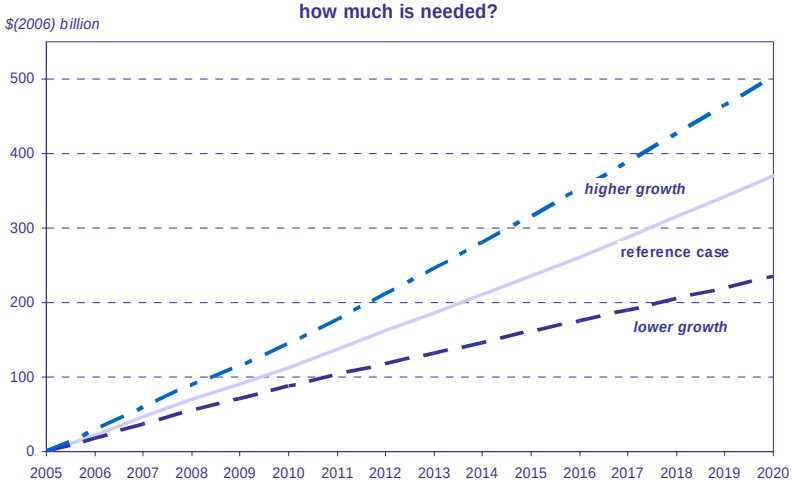
Nevertheless, the global scale of upstream investment implied by the reference case outlook is not expected to be significantly greater in magnitude than that witnessed previously. This is the result of the gradual shift from higher-cost non-OPEC to lower-cost OPEC supply.

It is important, however, to recognise the large degree of uncertainty over future demand and non-OPEC supply and, hence, the required additional OPEC oil, as outlined in the scenarios described in the previous chapter. Given these uncertainties, a key challenge will be to anticipate the appropriate level of demand to make the necessary investments to maintain and expand oil capacity, as well as the corresponding downstream infrastructure, without over- or under-investing.

The *lower growth* and *higher growth* scenarios result in a wide range of demand for OPEC oil and imply a corresponding range of required upstream investment in Member Countries over the coming years. Moreover, these investment needs have to include requirements resulting from OPEC's objective of maintaining an adequate level of spare capacity.

Figure 16 shows the wide range in OPEC upstream investment requirements resulting from demand uncertainties. For example, by 2020, an estimated uncertainty range of $270 billion for required OPEC investment can be envisaged, with the *lower growth* scenario suggesting a cumulative requirement of just under $230 billion, instead of the $500 billion in the *higher growth* case. Of course, the timeframe to 2020 could be considered as sufficiently long to adjust expansion plans in accordance with evolving demand patterns. In reality, the types of investment that are required vary substantially, and lead-times and pay-back periods can be long, particularly if the necessary infrastructure is not in place. Even over the period to 2010, there is an estimated range of investment uncertainty of $50 billion, increasing to $160 billion by 2015. These ranges are even more dramatic, should estimates include corresponding investments in infrastructure, such as pipelines, storage, terminals and ports.

Figure 16
Cumulative OPEC upstream investment requirements: how much is needed?



These figures clearly demonstrate the scale and reality of the main investment challenge faced by the oil industry in general and OPEC in particular.

Similar challenges exist in the downstream, to which attention is now turned.

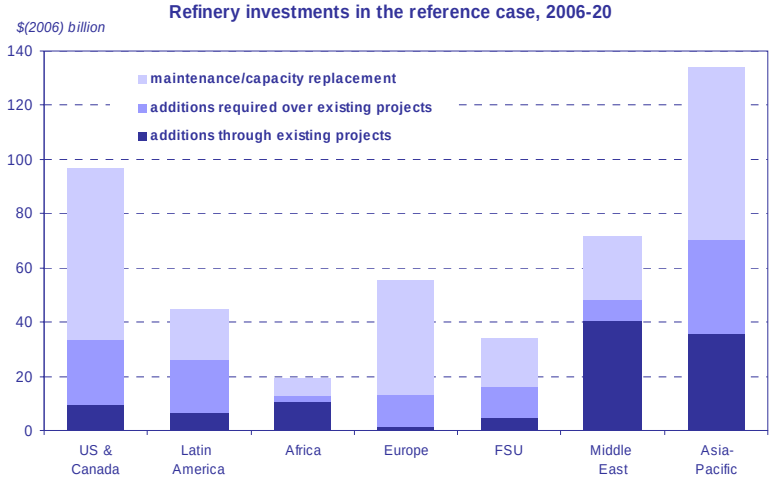
Downstream investment requirements

The total required investment in refinery processing to 2020 is projected at $455 billion in the reference case. Of this, $108 billion comprises the cost of known projects, $112 billion encompasses further required process unit additions, such as revamps and de-

bottlenecking/creep, as well as major new units, and $235 billion covers ongoing replacement. Investment in replacement is highest in those regions, such as the US and Europe, that have the largest installed base of primary and secondary processing units. As Figure 17 underlines, the Asia-Pacific is projected to require the highest level of investment in new units to 2020. China accounts for around 75% of the Asia-Pacific total.

Moreover, when considering required downstream investments, it is important to emphasise that these estimates are based upon refinery process requirements and do not include the infrastructure required beyond the refinery gate. In addition to refinery expansion, substantial investment in product transportation infrastructure, such as rail lines, pipelines and terminals to move products to demand centres, will be required.

Figure 17
Refinery investments in the reference case, 2006-20



However, uncertainty exists in this outlook. In addition to alternative demand scenarios, several factors are at play impacting project implementation. This is especially prevalent in industrialised countries, where many companies are reluctant to expedite the implementation of projects, in light of rapidly changing policies that place strong emphasis on developing alternative fuels that compete directly with refined products. This concerns particularly ethanol and biodiesel programmes in the US and Europe, and this raises serious considerations for stakeholders about the long-term prospects for additional investments in refining capacity expansion.

The issue of biofuels also raises questions over the future configuration of a complex downstream sector that includes both energy types. The question is how the sector should be structured in order to withstand major disruptions. In the past, incidents such as refinery fires or hurricanes affected only a few refineries concurrently, so that capacity loss was reasonably well compensated for by spare capacity elsewhere. However, with an increasing number of biofuel producers, the chances of losing this capacity for longer periods and over a larger area, for example, because of drought, could easily cause a significant shortage of required fuels. Under these circumstances, the question arises whether refiners should hold sufficient spare capacity to cover potential loss of capacity and who should bear the associated cost. All of this hints at a rather different future design and functioning for the downstream, compared to that of today, since energy-system and agricultural risks will be compounded.

Moreover, increasingly tighter environmental regulations are a further major barrier for refining investments, especially in OECD countries. The public resistance to major new refining projects (the NIMBY – 'not in my backyard' phenomenon), and often

complicated and cumbersome procedures to obtain the construction permit for new refineries, will extend the timeframes for these projects and add to the costs.

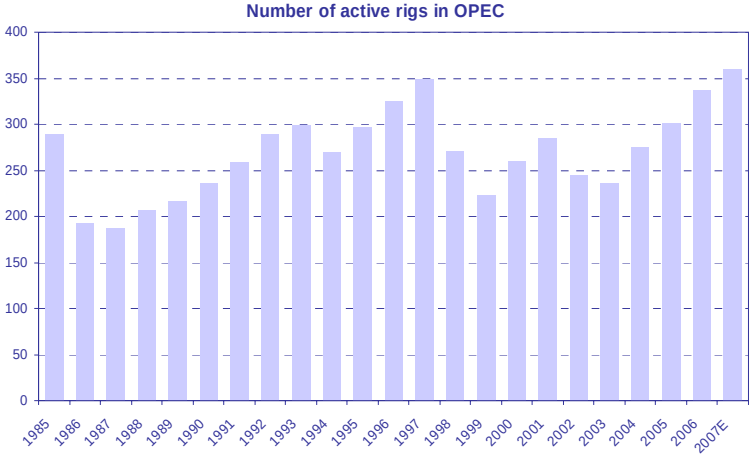
This outlook for investments in the downstream clearly illustrates, as for the upstream, the challenge stemming from security of demand for OPEC and the oil industry as a whole.

Current OPEC investment activity

Despite these uncertainties, OPEC Member Countries are undertaking large investments to expand their production and refining capacity. In the medium term, OPEC capacity growth is underpinned by over 120 projects in the upstream. Total cumulative capital expenditure to 2012 is estimated today to be likely to exceed $150 billion. These investments are expected to result in an increase of capacity by 2012 of over 5 mb/d from current levels. Moreover, the quality of crude from these new projects is overwhelmingly medium-to-light, compatible with a growth in demand expected to be driven mostly by transportation fuels. Similarly, production capacity of OPEC NGLs and GTLs will be expanded significantly, by almost 2.3 mb/d to reach 6.6 mb/d by 2012.

Another illustration of the acceleration of upstream activity is given by the number of active rigs in Member Countries. In 2007, these reached the highest level over the past two decades (Figure 18).[3]

Figure 18
Number of active rigs in OPEC



OPEC Member Countries are also investing heavily in refining and delivery infrastructure, such as pipelines, storage facilities and terminals. Very large and complex refineries are being planned or under construction, both domestically and abroad. This will help alleviate the current tightness and re-establish balance in the downstream sector, although it is recognised that this is the primary responsibility of consuming countries. Major crude distillation refinery projects in OPEC Member Countries are expected to add over 3 mb/d of additional capacity by 2012, representing an investment of close to $50 billion.

3 OPEC Annual Statistical Bulletin 2006.

4. Investment challenges

The oil outlook and investment requirements lead to the recognition that a key challenge facing the oil industry in general and OPEC in particular relates to uncertainty over how much production capacity will be required in the future to satisfy the demand for oil, while making available sufficient levels of spare capacity. Obviously, there is always the risk associated with the world economy, with its cycles of high growth being followed by periods of lower expansion, a risk which the industry manages and copes with, much as it does with the geological and other quantifiable risks. But the uncertainty over demand stems mainly from large consuming country policies that are unpredictable, unclear or with unanticipated consequences. Often, such policies discriminate against oil through taxation, subsidies for competing fuels and other measures. For producers, there is a real prospect of wasting precious resources on capacity that would not be needed. In addition, the emergence of large levels of unused capacity would lead to downward pressures upon oil prices, as it has in the past, with the compounded effect of sharply lowering oil-export revenues.

This main investment challenge, usually referred to when the concept of security of demand is invoked, is intrinsically linked to the issue of security of supply. Without the confidence that additional demand for oil will emerge and the market signals that long-run prices are supportive, the incentive for OPEC – and the industry in general – to undertake investment can be reduced; this, in turn, can lead to underinvestment and exacerbate concerns over eventual sufficiency of capacity, and thereby hamper the drive towards long-term oil market stability. Moreover, lower oil-export revenues would, in turn, negatively affect available resources for future investment, with further subsequent market instability a distinct possibility.

Moreover, the downstream outlook reveals a similar picture. It underlines that demand uncertainties in general, and policy initiatives to support the development of biofuels in particular, may lead refiners to invest in less capacity expansion than otherwise needed, should these policies fail to meet the stated targets. The result could be further downstream tightness, and, in turn, this may have a significant impact on prices, margins and volatility. Again, security of demand goes hand-in-hand with security of supply.

Given the past history of the industry and the magnitude of the financial needs, when compared to capital markets, the financing of required oil investments does not appear to constitute globally a significant challenge, although the ability to access various sources of capital may vary among industry players and stakeholders. However, as in any industry, access to capital is conditioned mainly by sound project economics, adequate financial strengths of its sponsors and acceptable below- and above-ground overall risks. In this regard, a central element is expectations for the future of the price of oil. A key challenge is to understand industry fundamentals and market signals, which are mostly of a short-run nature and could be influenced by speculative activity. Expectations of too low an oil price could lead to the cancellation of many otherwise commercial projects. Similarly, too much focus on stock market-driven high financial performance targets, such as high returns on equity, could lead to missing sizeable project opportunities, in a capital-

intensive and long lead-time industry. Many believe that this combination at the end of the 1990s may have led to the present situation.

Another important challenge is to adapt to globalisation, competition, changing trade patterns and the increasing influence of capital markets. The petroleum industry has successfully adapted to business cycles in the past. The low oil price environment of the 1990s led to sharp cost-cutting and staff-downsizing strategies, more outsourcing to petroleum services companies and to a wave of consolidation through mergers and acquisitions. Recent years have seen the emergence of national oil companies (NOCs) from producing countries, as well as large net importing countries, as key players in both the upstream and the downstream, with the objective of expanding presence outside their home country and seeking more vertical integration. This is a welcome development, as it creates more competition and diversity, as well as making available more financial resources to fund the necessary investments along the entire supply chain. On the other hand, services and construction companies need to expand their capacities to cope with the increasing demand for their services and avoid creating bottlenecks, and this may, in turn, have negative implications for them in the future, should major projects be cancelled or new competitors enter the market. Finally, many producing countries have adjusted their regulatory and fiscal regimes to the new oil price environment, so as to ensure an equitable and sustainable distribution of rents and profits and avoid excessive windfall profits.

An important factor which today hampers the economics of upstream and downstream projects is cost. The oil industry is facing a huge increase in the cost of raw materials and in all segments of petroleum services. Large increases in steel and other raw material prices have occurred, with those for steel more than doubling over the past three years. According to an IHS/CERA index,[4] upstream capital costs have increased by 65% in the last 30 months. The Oil and Gas Journal Nelson-Farrar refinery construction cost index has increased by around 40% since 2000 and many announced projects have seen their costs revised sharply upwards, sometimes by more than 100%. It is worth noting that this situation is, at least partially, the result of the low oil price environment of ten years or so ago, an environment which led to the implementation of downsizing and cost-cutting strategies, in particular in the petroleum services sector. Consequently, the growth in demand for these services since 2003 led to high utilisation rates and upward pressures on costs.

Furthermore, in addition to higher costs, industry feedback indicates that project lead-times have lengthened, due to difficulties in finding and hiring skilled labour and experienced professionals and to high utilisation rates of petroleum services capacities, in particular in procurement and construction. These extended lead-times, combined with increased capital costs, also contribute to making project economics less attractive. Often, they not only hinder the timely implementation of announced upstream or refining projects, but, in a number of cases, have led to project cancellation. The persistent shortage of a skilled, qualified and experienced labour force deserves due attention, as supply and demand for energy discipline graduates has become unbalanced in recent

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4 Source: Cambridge Energy Research Associates.

years. Universities cut back drastically in the 1980s and 1990s on the number of people graduating in energy disciplines – ironically because the industry did not need graduates in such numbers. Today, co-ordinated efforts between all the various players, namely IOCs, NOCs, service companies, academia and regulators, are needed to restore this essential capacity.

Moreover, there is a need for co-ordination in redeveloping and redefining the industry's image to make the industry appeal to young people contemplating their career choice.

Another challenge for the oil industry relates to technological progress and innovation, benefiting in the past both oil supply and resource additions. The successful application of a remarkable array of technologies, such as 3D seismic and horizontal drilling, extended the reach of the industry to new frontier areas, improved oil recovery and reserve growth and reduced the environmental footprint of the industry. However, following the oil price collapse in the late 1990s, R&D spending by the oil industry has been reduced significantly. This trend needs to be reversed. Technological innovation remains key in further improving sub-surface imaging of deep and complex horizons, and improving recovery from existing fields (today, the global average recovery rate is less than 35%). Technological development is also central to the downstream sector's ability to respond to more stringent product specifications. Also of increasing importance is the development of technologies that address air quality as well as climate change concerns, such as carbon capture and storage.

Industry structure is also important. While investment requirements could be met through a number of options, including NOC-financed investment programmes or through IOC involvement, the need, rationale and ways for the involvement of IOCs may differ from one host country to another. The conditions also change with variations in the oil price environment. However, with the long project life that characterises the industry, the legal and fiscal regimes that govern the involvement of IOCs need to be efficient, so as to maximise revenues for the government, while providing sufficient incentive to the investors and, at the same time, ensuring control of the host country over its natural resources. They also need to be flexible, so as to be able to respond to changing market conditions.

A further, related issue concerns the responsibilities of investing parties to consider local impacts and social issues associated with oil-related activities. Local content of projects, reflected typically by the level of local employment and the use of locally-provided goods and services, is an important factor, and needs to be closely associated with investment in training and education. Although no one-size-fits-all model exists, support of broader social objectives is important when co-ordinated with the appropriate country authorities; this might include investment activities beyond the upstream, for example relating to providing modern energy services to local communities, such as electricity or contributions towards improving local infrastructure. The oil industry should also continuously aim to reduce its environmental footprint in the areas where it operates, thus responding to increasingly pressing demands from host governments and local communities.

Increasingly, the protection of the environment is becoming the focus of attention of governments, multilateral institutions, businesses and civil society, reflecting growing concern about local pollution and potential anthropogenic interferences with the climate system. In the past two decades, regulations aiming at improving urban air and water quality have already contributed substantially to reduced emissions of sulphur, lead, metals and other particles. Clearly, this trend is set to continue. The petroleum industry has the ability to respond successfully to these new regulations, as in the past, although probably in a costlier manner, in particular in the refining sector. In this regard, and unless regulations are introduced in a co-ordinated and progressive manner at a country or regional level, there is a risk of creating a potential for market fragmentation, as exemplified by the recent experience with 'boutique' fuels in the US and biodiesel blends in Europe, thus affecting the efficiency of the pipeline and storage systems, reducing fungibility and lowering the ability to respond to product supply disruptions.

The protection of the environment also has a global dimension, in relation to increasing greenhouse gas emissions and the potential interference with the climate system. This dimension has gained additional attention in recent months, in particular with the publication of the initial drafts of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, the organisation of high-level pluri- and multilateral discussions on this subject, including on the sidelines of the UN General Assembly, and with the preparations for the United Nations Climate Change Conference to be held in an OPEC Member Country, at Bali in Indonesia, in December.

The challenge for the petroleum industry is to adapt to the evolution towards a carbon-constrained world in a proactive manner and at a time where there are still many uncertainties regarding the scope of long-term limitations/reductions in GHG emissions and about the relative contributions of technology, mandatory/voluntary targets and timetables, taxation and flexible mechanisms, such as emissions trading or the clean development mechanism. The oil industry is in the position to turn this challenge into an opportunity, by promoting cleaner fossil fuel technologies, and, in particular, the technology of carbon dioxide capture and storage, into deep geologic formations. This technology has the potential to contribute to significant net reductions in CO_2 emissions. The oil industry needs to play a more active role in research, development and demonstration, in defining industry standards for site selection, monitoring and verification, and contributing to improved public acceptance. Having said this, developed countries, bearing the historical responsibility and having the technological and financial capabilities, should take the lead in the development and deployment of this technology.

5. Concluding remarks

Energy is crucial for sustainable development and its use is expected to increase under all scenarios in response to demand for heat, light and mobility from a growing and more urban population. Access to modern energy services is a key contributor to poverty eradication and to the achievement of the UN Millennium Development Goals.

Fossil fuels will continue to satisfy the lion's share of the world energy needs for the foreseeable future, and oil is set to remain the leading source of energy, in particular in the transportation sector. Oil resources are plentiful. How to find, develop, produce, transport, refine and deliver oil to end-users in an efficient, timely, sustainable, economic, reliable and environmentally-sound manner remains a key objective. OPEC is contributing to this objective. This is demonstrated by the huge investments that are currently underway to add new production capacities. Furthermore, OPEC's commitment to ensure regular supply to consumers is enshrined in its Statute, and has been reaffirmed most recently in its Long-Term Strategy, adopted by the Ministerial Conference in September 2005.

However, the challenges are many. The first and foremost relates to the uncertainty over the amount of oil that is needed in the future, stemming from consuming countries' policies. These are greatly hampering the decision-making processes of OPEC Member Countries, with regard to investment in further capacity. For example, the recent policy announcements in the US and the EU setting ambitious biofuel targets are blurring the demand picture and do not encourage investments, both upstream and downstream.

Instead, energy interdependence should be the guiding light, where security of demand goes hand-in-hand with security of supply. While spare capacity provided by OPEC Member Countries provides a solid foundation for security of supply, the need for security of demand is integral to that process. Furthermore, it has become increasingly clear over the years that a key challenge for energy supply is not one of availability. Rather, it is about deliverability.

Yet deliverability of oil is linked to many more issues than just spare crude oil capacity. Substantial investment is required downstream, for example, in distillation capacity, together with adequate conversion and intermediate processes. This should be supported by a more attractive investment climate, with greater transparency and co-ordination in fuel specification regulations.

But the industry must also be attractive to prospective graduates and other skilled personnel. Serious shortages of skilled labour have become a major concern, and this is something that should be addressed by the various stakeholders as a matter of priority.

The structure and practices of the industry are constantly evolving, and this should be recognised. For example, NOCs from importing countries are growing in stature, and becoming very active in the upstream, adding to competition and enhancing investment. At the same time, NOCs from exporting countries, are attaining a maturity and technical ability that lets them compete more openly with international oil majors. Intermediaries,

such as service companies, banks and financial institutions, are also playing expanded and more diversified roles right across the supply chain.

The oil industry is becoming more globalised, complex and interdependent. And this highlights the importance of pragmatic, structured dialogue among all parties.

The establishment and development of the International Energy Forum, greatly encouraged by OPEC, is a prime example of this. One of its main activities, the Joint Oil Data Initiative – set up by six international organisations, including OPEC – is already improving the flow of transparent and reliable oil statistics within the industry, helping support investment, among other things. The recent setting-up of the Forum's Secretariat in Riyadh means that it can benefit from operating at the heart of this major oil-producing country, with the surrounding established infrastructure and the generous support of the host nation, Saudi Arabia.

Energy dialogue has also been expanded and enhanced in many other parts of the world, and OPEC has had a big role to play in this. This is very much welcomed by all responsible parties interested in the sound, orderly development of the industry.

But dialogue needs to go even further – it needs to be constructive, inclusive and open at all times. And it should also be cognizant of the needs and responsibilities of all oil producers and consumers, oil exporters and importers, developed and developing nations, and present and future generations.