Oil Outlook to 2025

OPEC Secretariat Paper

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Executive Summary

This background paper for the 10th Meeting of the International Energy Forum (IEF) aims to highlight some of the key factors that are likely to influence the world oil scene in the coming years. The IEF has developed into an important opportunity for genuinely open and constructive dialogue among all parties at the highest level, with increasing recognition of the need to understand issues of mutual concern.

Demand for energy is clearly set to continue to grow. It is also evident that oil is expected to maintain its leading position in meeting the world's growing energy needs for at least the next two decades. In the reference scenario, oil demand is set to rise by 30 mb/d over the next twenty years, reaching 113 mb/d by 2025. Although developing countries are set to account for most of this rise, OECD countries will continue to account for the biggest proportion of world oil demand. Energy poverty will remain an important issue over this period: there will remain large differences in the consumption of oil per capita, with developing countries consuming on average five times less oil per person by 2025 compared to OECD countries.

The transportation sector will be the main source of future oil demand growth. Growth in the OECD is expected to continue to rise, although saturation effects should increasingly have an impact upon the increase in vehicle ownership. The potential for increases in vehicle ownership, however, is far greater in developing countries. Indeed more than half of the countries in the world possess less than one vehicle for every ten people, compared to an average of six for every ten people in the OECD. Nevertheless, the level of ownership per capita in developing countries will remain well below that of OECD countries.

From the supply perspective, the resource base is sufficient to satisfy expected world oil demand growth. Estimates of global ultimately recoverable reserves for conventional oil have been increasing due to such factors as technology, successful exploration and enhanced recovery from existing fields. Non-OPEC supply is expected to continue to expand during this decade and beyond. Over the medium-term, total non-OPEC output has the potential to grow substantially, over the period 2005-2010 by 6 mb/d, with demand increasing by 7.5 mb/d over those years. Regionally, Russia and the Caspian region will lead non-OPEC growth, with the bulk of the increase expected to come from the Caspian. Outside these areas supply growth is driven primarily by increases in offshore West Africa, offshore Latin America, and non-conventional in North America. Non-OPEC supply is eventually expected to reach a plateau post-2015, at 58-59 mb/d.

Over the longer-term, it is therefore expected that OPEC will be relied upon to supply most of the incremental barrel of demand. By 2025, oil production levels, including natural gas liquids (NGLs), rise to 54 mb/d. However, even then non-OPEC countries will account for the larger part of world oil production.

These projections underline the need for substantial investment along the entire hydrocarbons supply chain. Expansion of non-OPEC capacity is two to three times more costly than in OPEC, with this gap widening over time. The highest cost region is the OECD, which also experiences the highest decline rates. Up to 2025, total upstream investment requirements in the reference case over the next twenty years amount to $1.9 trillion (in 2005 dollars). The OECD accounts for more than one-third of this figure. Over the next ten years, requirements in (i) OPEC, (ii) developing countries, and (iii) Russia and the Caspian states, are of a similar order of magnitude to one another. All three of these non-OECD groups require around $100 billion investment by 2010 and close to another $100 billion each in the following five years. It should be noted, however, that these figures are limited to estimated costs of field development, and do not include the development of new infrastructure, such as for pipelines, storage and ports.

The global scale of upstream investment that this reference case outlook implies is not expected to be greater in magnitude than that witnessed in the past. This is the result of the gradual shift from higher cost non-OPEC to lower cost OPEC supply. Nevertheless, oil prices must be sufficient to mobilise the resources to supply the market with the necessary oil.

In line with OPEC's longstanding commitment to support oil market stability, OPEC crude capacity expansion plans already in place are expected to result in almost 38 mb/d of crude capacity by the end of 2010, an increase of nearly 5 mb/d from end-2005. Similarly, production capacity of NGLs and other liquids will be expanded by almost 2 mb/d to reach 6 mb/d by 2010. This capacity growth is underpinned by over 100 E&P projects totalling $100 billion; these projects are in addition to all energy infrastructure investments, such as pipelines, export terminals, and downstream expansion. This investment is expected to further increase OPEC spare capacity.

This demonstrates the seriousness OPEC attaches to the concerns expressed by consuming countries with regard to the need for security of energy supply, and the contribution that OPEC continues to make in providing a firm foundation for future market stability. This is an undertaking that OPEC is both willing and able to perform, and its role in this respect is becoming better understood and appreciated. OPEC is making known well in advance plans for expansion in production capacity, not only to satisfy increased demand, but also to offer an adequate level of spare capacity. These measures will support security of supply to consumers, to the benefit of the world at large.

Nevertheless, the need for enhanced energy security has to be seen from both supply and demand perspectives, which are mutually supportive. Uncertainty over future demand translates into large uncertainties over the amount of oil that OPEC Member Countries 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. The need for security of demand is a legitimate concern for producers, just as consumers express concern over security of supply. With more transparency in the evolution and implementation of policies, better assessments can be made as to how future demand is likely to evolve. In turn this would help make the appropriate capacity expansion decisions – to meet both an increased demand for OPEC oil and offer an adequate level of spare capacity – while at the same time not wasting precious financial resources.

Downside risks to demand are more substantial than upside potential: there are a range of important drivers, in particular energy and environmental policies in consuming countries and technological developments, tending to push in one direction, i.e. to reduce demand. It is to be expected, therefore, that uncertainties over possible future demand patterns are skewed towards the downside.

Scenarios are developed that demonstrate how – given the role that OPEC plays in supporting market stability – uncertainties over future oil demand translate into a wide range of possible levels of necessary investment. Even over the medium-term to 2010, there is an estimated range of uncertainty of $50 billion for required investment, increasing to $140 billion by 2015. This clearly confirms the legitimacy of the concerns expressed by OPEC that there is a real risk of wasting much-needed financial resources.

The issue of security of demand is therefore a very real one. Moreover, it is intrinsically linked to the issue of security of supply: without the confidence that demand for OPEC oil will emerge, the incentive to undertake investment can be reduced, because of the concern over the possible emergence of large levels of unused capacity, which, in turn, would place downward pressures upon oil prices. This would result in huge revenue losses and OPEC Member Countries, as developing countries with strong competing needs for financial

resources, would be adversely affected in terms of available resources for education, healthcare, infrastructure, etc.

The investment challenge, however, extends along the entire supply chain. The downstream sector is a very important part of that chain, with current tightness in the form of inadequate refining capacity putting pressure on oil prices. Several factors will shape developments in this sector in the coming decade: the rising volume of crude oil that needs to be refined, the expectation of a continued move towards demand for lighter products, and the movement of product specifications towards significantly cleaner products, driven by environmental concerns. The downstream sector will require significant investment to address these challenges.

However, investments in the refining sector are coming at a considerably slower pace than warranted by the expected demand growth. It is estimated that about $160 billion in capacity investment will be required by 2015, with another $150 billion needed for maintenance and replacement of lost capacity. These estimates do not include the infrastructure required beyond the refinery gate, such as pipelines and terminals. Beyond 2015, the investment challenge in the refining sector is not expected to ease.

The downstream sector could very well remain a source of market instability over the coming years: a more orchestrated effort is clearly required to ensure sufficient capacities are in place in the future. There is therefore a pressing need for discussion among all parties, and ways need to be explored that could accelerate expansion plans, and create the right investment climate. Most importantly, it needs to be recognised that the primary responsibility for investment in this sector lies with consuming countries.

Beyond the investment challenge, a critical question is whether the increasing use of fossil fuels is consistent with the third pillar of sustainable development, namely the protection of the environment. Energy scenarios project a substantial increase of CO_2 emissions throughout this century. Although scientific uncertainties remain regarding the science and consequences of climate change, precautionary measures are being considered. Since well over half of emissions are attributable to power stations and industrial activities, these sectors therefore constitute prime targets for emission reduction efforts.

Some of the policies considered for addressing the climate change issue support an increased role for renewable energy sources. However, practical and economic considerations limit the current contribution of new renewables to just two per cent of global power generation. This low base implies that exceptionally high rates of growth would have to be sustained over many years in order for these sources of energy to contribute significantly to the global energy mix. It is also important to recognise the high costs of renewables. With regard to nuclear power, strong negative public sentiment exists in many parts of the world, based on concerns over plant safety and radioactive waste disposal. Technological options that allow continued use of fossil fuels in a carbon-constrained world must therefore be considered. One promising example is carbon capture and storage, which could represent an affordable means of achieving a large part of emissions reductions.

In sum, this paper aims to provide the appropriate background for discussion given the important opportunity the IEF provides for energy producers and consumers to address major issues of common concern. The key ideas emerging can be summarised as:

- OPEC will continue to support security of supply to consumers;
- Security of energy demand is an inherent factor in supporting long-term market stability;

- Timely and adequate investment in the downstream sector is needed, with the close involvement of consuming countries and international oil companies: incentives for expansion in refining capacity are necessary; and
- Steps need to be taken to move carbon capture and storage technology forward with large-scale demonstration projects.

Finally, there is a discernibly strong spirit of cooperation in the producer-consumer dialogue. The 10th Meeting of the IEF represents an important occasion for furthering the mutual awareness of concerns and should provide a valuable platform for a candid exchange of views on many important issues. It is important that dialogue be both widened and deepened in a constructive spirit, as we move forward together in the 21st century in our common quest for market stability and in our progress towards the goal of sustainable development for all.

1. Introduction

This background paper for the 10th Meeting of the International Energy Forum (IEF) aims to highlight some of the key factors that are likely to influence the world oil scene in the coming years. The IEF has developed into an important opportunity for genuinely open and constructive dialogue among all parties at the highest level, with increasing recognition of the need to understand issues of mutual concern.

Since the 9th IEF Meeting in 2004, energy and non-energy commodity nominal prices have risen to unexpectedly high levels. In May 2004, at the time of the previous IEF Meeting, the OPEC Reference Basket price stood at $36/b, but by the beginning of 2006 it had risen in nominal terms to over $60/b. In real terms, however, the price was far lower than the levels seen in the early 1980s. These movements were influenced by a convergence of factors: exceptionally strong and synchronised economic growth brought a surge in demand in 2004 that had not been seen to such a degree for almost three decades, which led to concerns over the near-term availability of spare production capacity.

Nevertheless, from an upstream perspective, the market has been well-supplied over this period. OPEC raised its production to help satisfy the increased demand for oil and ensure adequate inventory levels, while accelerating the expansion of crude oil production capacity to meet future increases in demand and maintain sufficient spare capacity. Despite the impact of Hurricanes Katrina and Rita on oil facilities in the US Gulf Coast region, OPEC's assurances of healthy supply helped prevent this supply interruption from developing into a crisis. Indeed, in September 2005, OPEC additionally agreed to make available to the market, should it be called for, spare capacity of around 2 mb/d from Member Countries. This decision was made despite there being ample crude oil supplies with inventory levels above their five-year average.

Despite this evidently sufficient supply, non-fundamental pressures have increasingly directed price movements. Firstly, speculative activity drove prices to levels that were not supported by inherent upstream fundamentals. Moreover, it has become apparent that tightness in refining capacity in most regions of the world has been a key factor behind the pressure on crude prices. Inadequate past investment and increasingly stringent product specifications have resulted in a lack of effective global refining capacity.

This paper considers several inter-related issues. Section 2 provides an assessment of demand and supply prospects, addressing the issues of capacity, resource availability and investment needs. This analysis is complemented by the scenario approach of Section 3, which looks at the issue of security of demand. Section 4 then considers the challenges facing the downstream sector and the extent to which this sector might remain a potential source of instability. Section 5 addresses another important area that has emerged for discussion, namely the role of cleaner oil and gas technology. One key example of this is carbon capture and storage technology as a means of limiting net emissions of CO_2. The paper finishes with some closing remarks in Section 6.

2. Oil outlook: the reference case

2.1 Main assumptions

In recent years, extremes of economic activity have demonstrated the difficulty of assessing what might reasonably be expected to occur over the next twenty years. The average rate of world economic growth in 2004, over five per cent per annum (p.a.), had not been experienced since the early 1970s, while economic growth in 2005 was the third fastest over the past two decades. On the other hand, as recently as 2001, world economic growth was at its lowest for more than a decade, while 1998 also saw weak global growth in the wake of the Asian financial crisis. With economic growth a key driver for energy demand, assumptions made are clearly fundamental to any assessments of the future evolution of global fuel consumption. Yet it is evident that prospects for future economic growth are subject to tremendous uncertainties. These should form a central part of any such assessment and are explored in Section 3.

The reference case scenario sees robust global economic growth at rates similar to those of the second half of the 1990s, averaging 3.5 per cent p.a. (at purchasing power parity) for the next two decades (see Table 2.1). The scenario foresees international trade continuing as an important driving force for economic growth, albeit amid some signs of a move towards increased protectionism.

Table 2.1
Average annual real GDP growth rates, % p.a.
Reference case

	2006-2010	*2011-2015*	*2016-2020*	*2021-2025*	*2006-2025*
OECD	2.4	2.3	2.2	2.2	2.3
Developing Countries	5.5	4.8	4.6	4.4	4.8
Transition Economies	4.4	3.4	3.2	3.0	3.5
World	3.8	3.4	3.4	3.3	3.5

OECD economic growth averages 2.3 per cent p.a. over the next twenty years in this reference case. The US economy is faced with the twin current account and fiscal deficits, which are likely to continue over the next decade, posing significant risks for the rest of the world in the form of higher interest rates that would dampen global investment and consequently economic growth. The growth forecast for the OECD Pacific region reflects the continued challenges the Japanese economy will face in the coming years, such as the large government public debt, especially in the context of an ageing population, and the need to restructure its corporate sector. European growth is also forecast to remain modest. The restrictions imposed by the EU Stability and Growth Pact limit the ability to use expansionary fiscal policies.

Over the next twenty years, the world's population is expected to increase by 1.4 billion people, to close to 8 billion, with more than 90 per cent of this growth from developing countries. This will be accompanied by a rapid rise in the level of urbanisation. Demographics are therefore likely to play an important role in both the economic development of these countries, as well as the prospects for energy demand growth.

Developing countries' economies are expected to expand at considerably faster rates than the OECD, averaging almost five per cent p.a. over the period to 2025. Regionally, South East Asia's rapid recovery following the Asian crisis indicates that the economies of the region are basically

robust, but the high pre-crisis growth rates are not expected to be revisited in the future. Latin American growth is expected to pick up from the low levels of recent years, while the Middle East and African region will show some improvements on the 1990s.

China is forecast to increasingly act as an engine of world growth. In the years 2003 to 2005, Chinese GDP grew by over nine per cent, making it the fastest growing economy in the world. Not only is China supplying goods to the world, it is increasingly acting as a demand centre as its economy booms. This in turn has had an impact upon many commodity prices, such as steel, copper, iron, lead, nickel and zinc. In the short-term, the Chinese economy is expected to continue to perform well, but there are possible dangers of overheating. In the long-term, the forecast sees strong Chinese growth, but at a more moderate level than the 1990s. Structural problems remain, however, while the competitive advantage provided by cheap abundant labour may become less apparent over time. South Asia, with India and Pakistan accounting for most of the GDP and population in this region, is expected to remain one of the fastest growing regions of the world, as further reform of the Indian economy brings increases in productivity and capital growth.

Further to these economic growth assumptions, the reference case scenario assumes that no particular departure in trends for energy policies and technologies takes place that may impact oil supply and demand. Past patterns of efficiency improvements continue and it is assumed that no additional policy measures are introduced that impact energy demand developments. In particular, regarding climate change mitigation measures, the impact of the Kyoto Protocol is assumed to be limited by the Treaty being implemented in a diluted form with little pressure for compliance.

Global resource availability will not be a constraint in meeting increases in demand, and long-term oil price developments should therefore not be affected by concern over the resource base. Stable and sustainable long-term oil price paths must be consistent with the notion that extreme prices, either too high or too low, are damaging for both producers and consumers. Prices in the reference case are consistent with robust economic growth, as well as the assumption that they are not so high as to generate such large quantities of additional oil, both conventional and unconventional, that OPEC oil production would have to shrink at rates that would imply considerable idle capacity. On the other hand, the price is sufficient to mobilise the resources to supply the market with the necessary oil.

2.2 Energy and oil demand

Given these assumptions, demand for energy is clearly set to continue to grow. Fossil fuels will continue to provide more than 90 per cent of the world's total commercial energy needs, accounting for 95 per cent of the growth in demand over the next twenty years. Oil has been in the leading position in supplying the world's growing energy needs for the past four decades, and there is a clear expectation that this will continue, at least for the next two decades. Gas is expected to grow at fast rates, steadily approaching coal in importance in the energy mix. The total contribution of hydro, nuclear and new renewables will flatten out: despite the extreme high growth rates for some new renewables, the rather low initial base makes the growth in absolute terms rather limited; some growth in nuclear power in developing countries is assumed to be accompanied by a gradual decline in industrialised regions; and the scope for increases in hydro power is likely to be limited to developing countries. The prospects for growth of non-fossil fuels are addressed in more detail in Section 5.

Figure 2.1

Energy demand by fuel type, mtoe

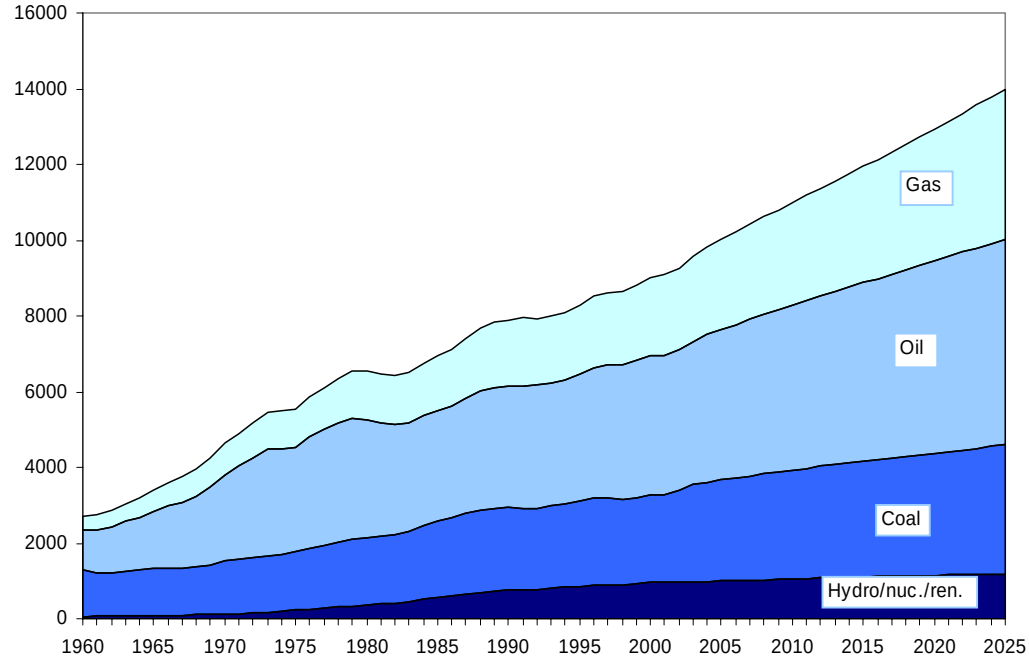


Table 2.2
World energy demand in the reference case

	Levels (mtoe)				*Growth (% pa) 2005-2025*	*Fuel shares (%)*			
	2005	*2010*	*2020*	*2025*		*2005*	*2010*	*2020*	*2025*
Oil	3978	4344	5074	5447	1.6	39.7	39.5	39.2	38.9
Solids	2668	2876	3229	3403	1.2	26.7	26.2	25.0	24.3
Gas	2372	2721	3488	3957	2.6	23.7	24.7	27.0	28.3
Hydro/Nuclear / Renewables	991	1053	1146	1188	0.9	9.9	9.6	8.9	8.5
Total	10009	10995	12938	13996	1.7	100.0	100.0	100.0	100.0

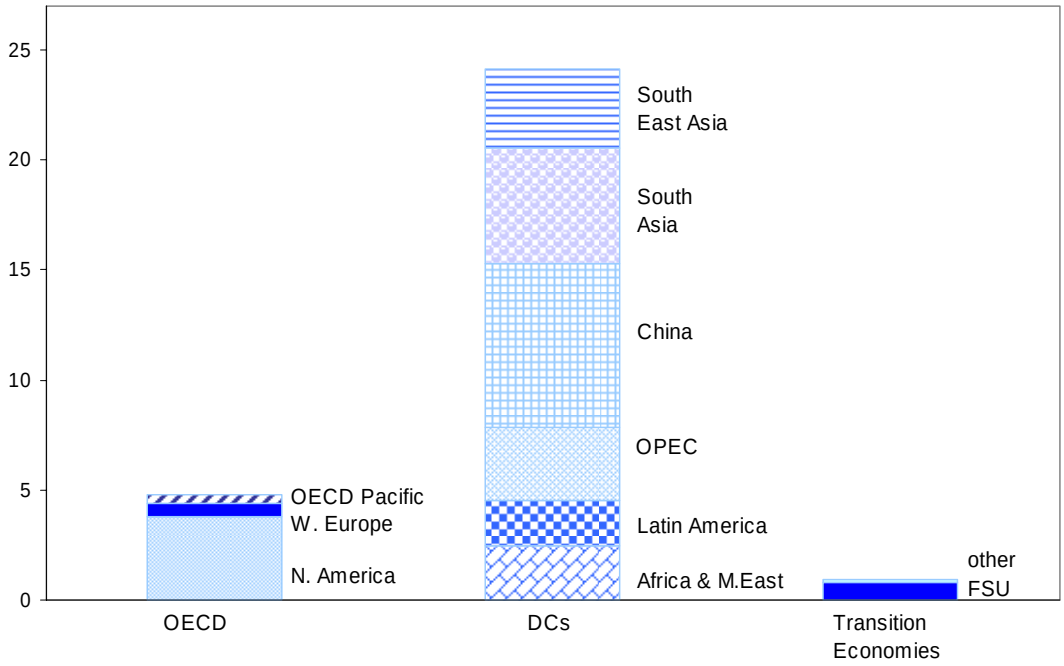
In the reference case, oil demand is set to rise by 30 mb/d to reach 113 mb/d by 2025, representing an annual average growth of 1.5 mb/d (Table 2.3). OECD countries will continue to account for the biggest proportion of world oil demand. However, 80 per cent of the increase in global oil demand will come from developing countries, whose consumption will almost double.

Table 2.3
World oil demand outlook in the reference case, mb/d

	2005	*2010*	*2015*	*2020*	*2025*
North America	25.6	26.8	27.7	28.6	29.4
Western Europe	15.6	15.9	16.1	16.2	16.2

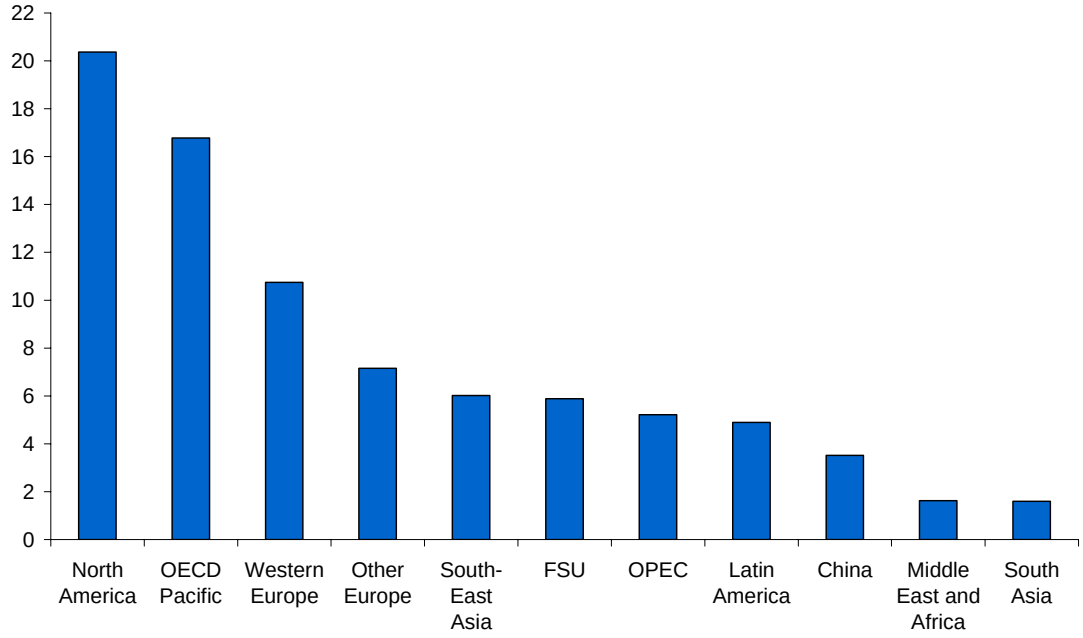
OECD Pacific	8.6	8.9	9.0	9.1	9.1
OECD	**49.8**	**51.5**	**52.8**	**53.8**	**54.6**
Latin America	4.5	5.0	5.6	6.3	6.9
Middle East & Africa	3.0	3.4	3.9	4.4	5.0
South Asia	3.2	4.2	5.4	6.8	8.5
South East Asia	4.3	5.2	6.2	7.1	7.9
China	6.7	8.5	10.3	12.1	14.1
OPEC	7.1	7.9	8.7	9.5	10.4
Developing Countries	**28.7**	**34.2**	**40.0**	**46.3**	**52.9**
FSU	3.8	4.1	4.3	4.5	4.6
Other Europe	0.9	0.9	1.0	1.0	1.0
Transition Economies	**4.7**	**5.0**	**5.3**	**5.5**	**5.7**
World	**83.2**	**90.7**	**98.0**	**105.6**	**113.1**

Figure 2.2
Cumulative growth in oil demand, 2005-2025, mb/d



Asian countries, home to half the world's population, will remain the largest source of oil demand increases in the developing world (Figure 2.2). Up to 2025, the region is expected to account for a rise of 17 mb/d, which represents two-thirds of the increase in all developing countries. Nevertheless, large differences in the consumption of oil per capita will remain. By 2025 developing countries will consume on average five times less oil per person compared to OECD countries (see Figure 2.3).

Figure 2.3
Oil use per capita in 2025, barrels



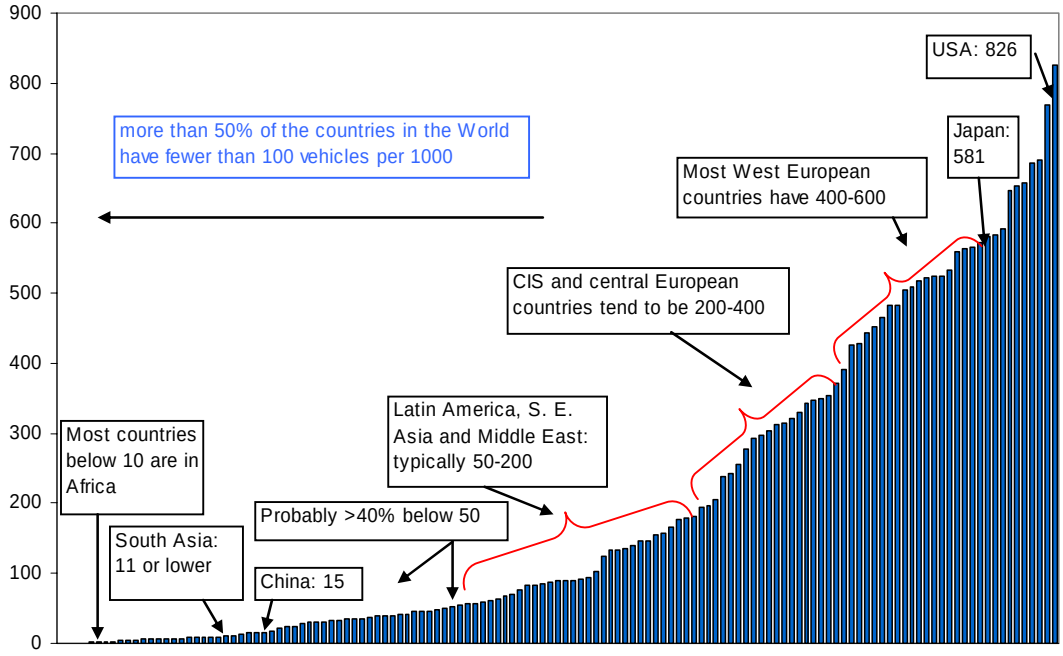
The transportation sector will be the main source of future oil demand growth. Growth in OECD countries is expected to continue to rise, although saturation effects should increasingly have an impact upon the rate of increase in vehicle ownership. Already in 2003, ownership levels in OECD countries were typically in the range of 400-600 per 1000 inhabitants in Europe and Japan, and over 800 vehicles per 1000 in the USA (see Figure 2.4).

The potential for increases in vehicle ownership, however, is far greater in developing countries with more than half of the countries in the world possessing less than one vehicle for every ten people. The potential for growth is especially apparent in China and India, where vehicle ownership stands at just 10-20 per 1000 inhabitants.

Nevertheless, the level of ownership per capita in developing countries will remain well below that of the OECD. Despite the slowing of growth, ownership levels in OECD countries are expected to increase from current average levels of around 560 per 1000 inhabitants to well over 600 per 1000 in the next decade. Meanwhile, despite the far swifter growth rates that are expected in developing countries, even at per capita levels, by 2025 ownership in India and China is still expected to be well below 100 vehicles per 1000, while other developing countries, on average, will see ownership remain below 150 vehicles per 1000 over the period to 2025.

Figure 2.4

Vehicle ownership in 2003, per 1000



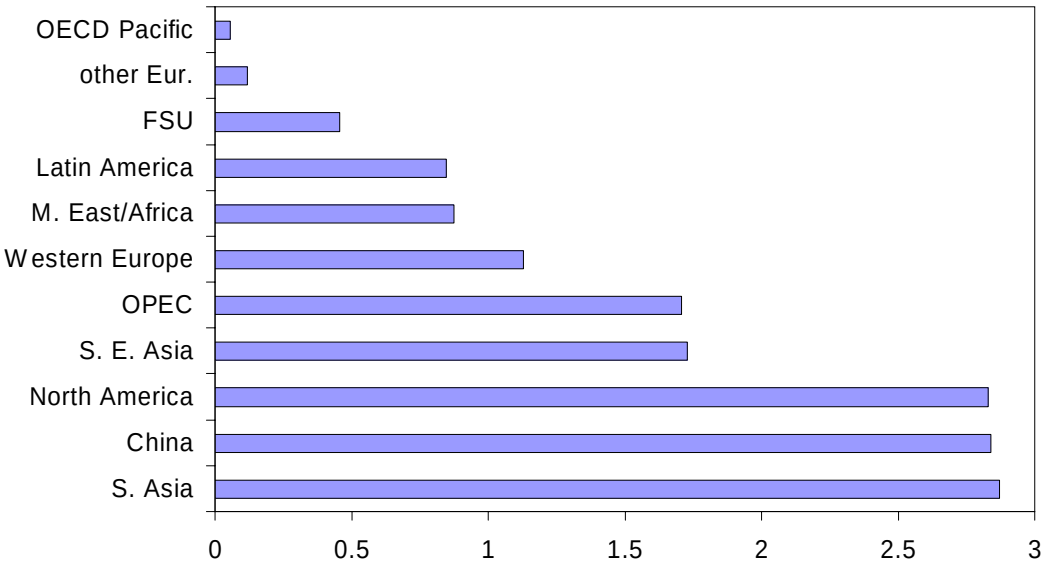
However, it should be noted that there are several potential important constraints and uncertainties associated with these rates of expansion in vehicle ownership. Examples include the availability of suitable infrastructure as well as possible policy developments. Alternative assumptions for the relevant saturation levels across regions can also lead to rather different demand patterns that would be expected to emerge. Thus, despite the clear role of Asian countries in contributing to future demand expansion, especially from the transportation sector, there are substantial uncertainties regarding the future scale of vehicle ownership.

Another important element of the projection concerns the rate of decline in oil use per vehicle in the various regions. There is more scope for decline in developing countries, compared to OECD countries, as the fleet age decreases, servicing improves, and newer, more efficient technologies are continually improved and introduced. In developing countries there is also greater scope for increases in passenger car ownership, relative to trucks. Overall, average efficiency of oil use per vehicle in developing countries improves at twice the rate of OECD countries in this scenario. However, ambiguities remain as to how other possible developments, such as those related to policy or the effects of congestion, might play important roles in affecting future demand patterns.

Of the non-transportation oil use, the main expected source of increase will be in the residential and industrial sectors of developing countries. Oil use in households has tended to increase in line with income growth, and 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 for natural gas and electricity, especially in middle income regions.

Figure 2.5

Growth in oil consumption in road transportation 2003-2025, mboe/d



2.3 Oil supply

2.3.1 The resource base

From the supply perspective, one important initial observation to make is that the resource base is sufficient to satisfy expected world oil demand growth. Estimates of world ultimately recoverable reserves (URR) for conventional oil have been increasing due to such factors as technology, discoveries and enhanced recovery from existing fields. The latest estimates of URR put the total figure at more than 3 trillion barrels. Indeed, worldwide URR has increased from just 0.6 trillion barrels in the 1940s, to 2 trillion barrels in the 1970s, up to the most recent mean assessments by ExxonMobil, the US Geological Survey (USGS) and IHS Energy that put URR in the range of 3.3-to-3.9 trillion barrels. Most studies conclude that two-thirds of the conventional resources lie in OPEC Member Countries. These estimates exclude non-conventional resources, which could add large additional volumes to the resource base.

The most recent increased estimates by the USGS are also due to reserve growth from discovered oil fields, which has contributed substantially to the total URR, particularly in the US over the last two decades. More studies concerning reserve growth are being undertaken in order to understand the additional potential this may have, particularly outside the US, possibly resulting in the addition of more oil reserves. However, reserve growth is expected to contribute in the future together with yet-to-find (YTF) resources. Looking at YTF resources, the conclusion of many studies is that there remains a significant amount to be found, with the bulk lying in the Middle East, Russia, South America and West Africa. The USGS estimates that as much as 25 per cent (900 billion barrels) of the total identified liquid resources outside the USA remain undiscovered.

2.3.2 Non-OPEC supply

Over recent years, non-OPEC production has been confronted with a series of challenges, including the period of low oil prices in 1998-99. Yet despite this, during the five-year period 2000-2005, the annual growth of non-OPEC production averaged close to 0.9 mb/d, stronger than much of the growth observed over the past two decades, underpinned by growing global E&P investment.

Non-OPEC supply is expected to continue to expand during this decade and beyond. Over the medium-term, total non-OPEC output has the potential to grow substantially. Annual growth is expected to average in the range of 1.2 and 1.4 mb/d over 2006-2008 and more than 0.9 mb/d in 2009-2010. Over the period 2005-2010 this represents a cumulative increase of close to 6 mb/d. Regionally, Russia and the Caspian region will lead non-OPEC growth, with the bulk of the increase expected to come from the Caspian. Outside these regions, supply growth is driven primarily by increases in offshore West Africa, offshore Latin America, and non-conventional in North America. The Middle East, OECD Asia and other parts of Asia will show modest gains, whilst Western Europe is expected to decline driven by a fall in output from the North Sea.

Table 2.4
World oil production outlook in the reference case, mb/d

	2005	***2010***	***2015***	***2020***	***2025***
USA and Canada	10.4	10.8	11.1	11.4	11.2
of which: non-conventional	1.4	2.0	2.9	3.9	4.4
Mexico	3.8	4.0	4.1	4.0	3.6
W. Europe	5.7	4.9	4.4	4.0	3.5
OECD Pacific	0.6	0.9	1.0	1.1	1.1
OECD	**20.5**	**20.6**	**20.7**	**20.5**	**19.5**
Latin America	4.2	4.8	5.4	5.8	5.9
Middle East & Africa	5.5	7.1	7.8	8.0	8.0
Asia	2.7	3.1	2.7	2.4	2.1
China	3.6	3.7	3.8	3.8	3.8
DCs excl. OPEC	**16.1**	**18.6**	**19.7**	**20.0**	**19.9**
Russia	9.4	10.3	10.9	11.1	11.1
Caspian and other FSU	2.1	3.9	4.5	4.9	5.3
Other Europe	0.2	0.2	0.2	0.1	0.1
Processing gains	1.9	2.2	2.5	2.8	3.0
Non-OPEC	**50.1**	**55.8**	**58.3**	**59.4**	**58.9**
OPEC (incl. NGLs)	**33.1**	**34.9**	**39.7**	**46.2**	**54.3**
World	**83.2**	**90.7**	**98.0**	**105.6**	**113.1**

This assessment is based on expected trends of producing fields by country, including over 300 new developments. However, more projects are likely to emerge in the years ahead. Looking at non-OPEC supply in the medium-term by type of environment, it is expected that offshore (shallow and deepwater) oil production will account for most of the cumulative increase. Some of the key expected trends are:

- Deepwater production (500m or more water depth) is expected to account for approximately 50 per cent of the total cumulative increase. It has the potential to reach 6.2 mb/d by 2010 from 3 mb/d in 2005 underpinned by new developments in Angola, Australia, Brazil, Congo, Equatorial Guinea, Malaysia, Mauritania, and the US Gulf of Mexico;
- Production from fields in shallow water is expected to account for approximately 25 per cent of the total cumulative increase. Increases in Azerbaijan, Angola, China, Mexico and other countries will be partially offset by production declines in the North Sea. North Sea production is likely to decline to 4.3 mb/d by 2010 from 5.2 mb/d in 2005; and
- Onshore production is expected to account for approximately 25 per cent of the total cumulative increase driven by expansions in Canada, Kazakhstan, Sudan and Russia. Canadian oil sands production (bitumen and syncrude) has the potential to increase to 2 mb/d by 2010 versus 1 mb/d in 2005.

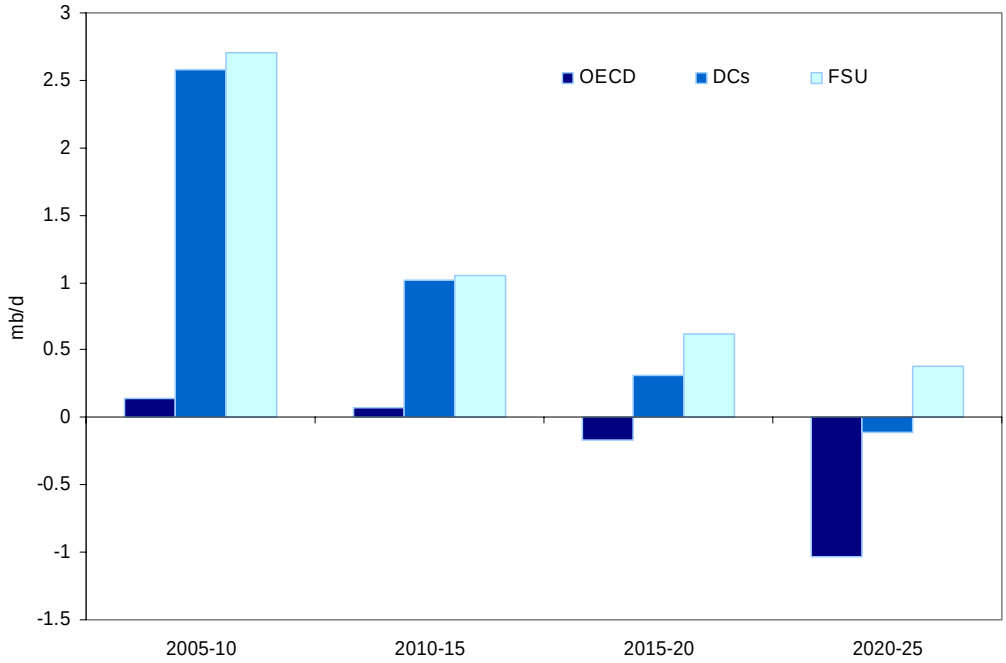
Post-2010, the reference case sees non-OPEC supply continuing to grow, albeit at lower rates than over the medium-term, reaching a plateau in the post-2015 years. Along with upward trends in Russia and the Caspian region and non-conventional, offshore environments will continue to represent the most promising future for non-OPEC production growth. Overall supply is expected to rise to 58-59 mb/d in the post-2015 period and remain near this level to 2025, by which time continued declines in the OECD will be approximately compensated by further increases in the Caspian region.

Reference case figures place Russian output eventually at a plateau of around 11 mb/d within the next decade. Caspian oil production is expected to reach more than 5 mb/d by 2025, a two-fold increase from 2005. Important export infrastructure is now in place that allows the continued expansion of large fields in the region, but in the longer-term, future pipeline availability could be a potential limiting factor. This is also the case for Russia, given that the development of resources is expected to shift from the Western Siberia and Urals regions to Eastern Siberia and Northern areas where infrastructure is less developed.

OECD countries are expected to witness a gradual decline in aggregate production levels over the longer-term. In North America, it is expected the decline in onshore lower-48 US production and Canadian conventional oil will continue to be offset by increases in non-conventional oil in Canada, and even increased production of biofuels in the USA. Nevertheless, despite the large non-conventional resource base, supply growth may be limited at some stage, due to infrastructure difficulties as well as environmental factors. Mexico is expected to experience a long plateau through 2015, declining thereafter. In Western Europe, improved oil recovery is expected to continue to prolong the life of the North Sea, but the region will continue to decline. New production in Western Europe is expected from the Barents Sea, a relatively well-endowed hydrocarbon province, lying between Norway and Russia, but significant increases are likely to be constrained by environmental conditions and operating challenges typical of Arctic environments. Some increase in the production of biofuels can be expected.

Figure 2.6

Non-OPEC supply growth by region to 2025



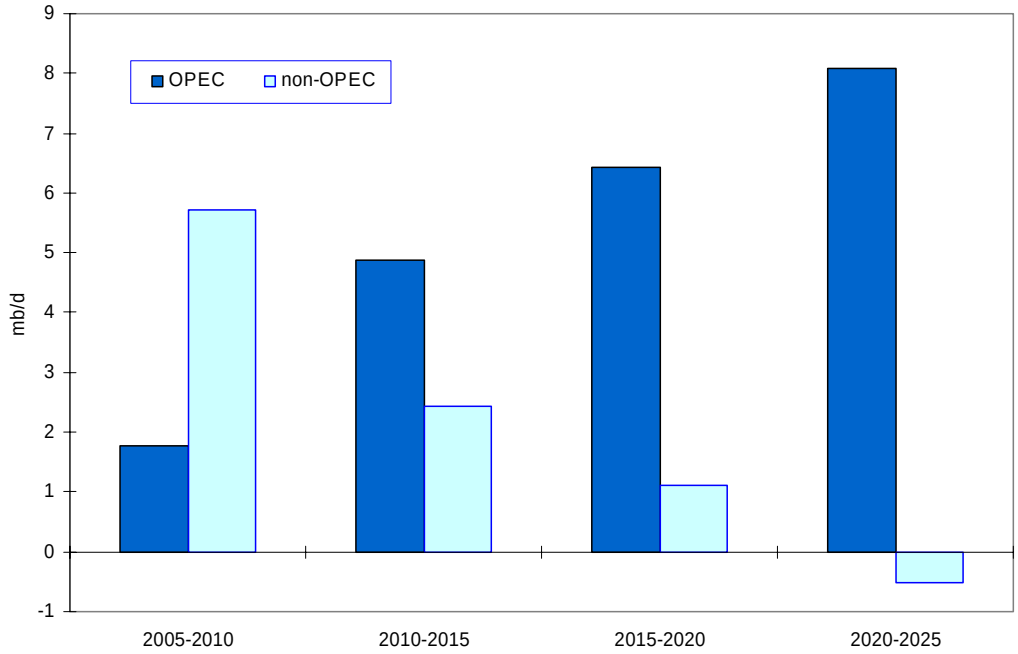
Increases in output from non-OPEC Middle East and Africa will be primarily from offshore West Africa. In Latin America, oil supply is expected to continue to increase progressively beyond 2010 driven by offshore developments in Brazil. In Asia, the reference case shows production declining gradually over the forecast period from 2010. China may experience a long plateau near current levels, but there is some upside potential. 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. The number of exploration wells drilled in the South China Sea is six times less than in the Gulf of Mexico, despite the area being eight times larger, but activity is expanding.

2.3.3 OPEC supply

Taking together the demand developments in the reference case with expected non-OPEC levels, the amount of oil needed to be supplied by OPEC Member Countries is derived. In the long-term, it is expected that OPEC will increasingly be relied upon to supply the incremental barrel. By 2025, OPEC oil production levels, including NGLs, rise to 54 mb/d in the reference case. However, even then, non-OPEC countries will account for more than half of world oil production.

Figure 2.7

Incremental OPEC and non-OPEC production in the reference case

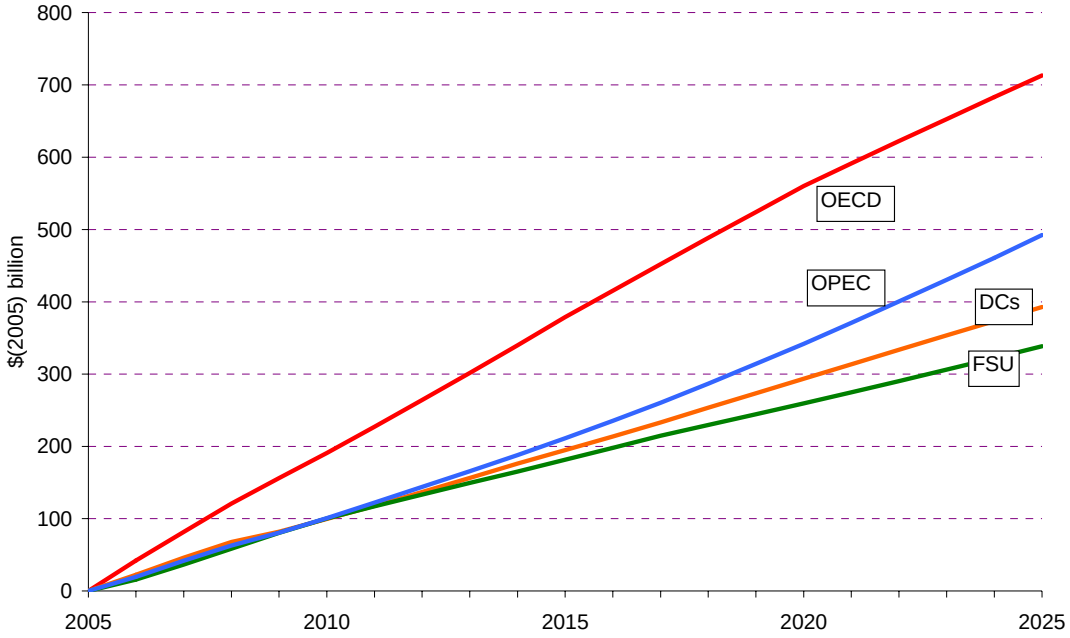


These supply projections underline the need for substantial investment to be made along the entire hydrocarbons supply chain. An estimate of upstream investment requirements has been made, accounting for not only the net additional production capacity necessary, but also that which will be needed to compensate for declines in existing capacity. Expansion of non-OPEC capacity is two-to-three times more costly than in OPEC, with this gap widening over time, as average costs in non-OPEC regions gradually rise. The highest cost region is the OECD, which also experiences the highest decline rates. Up to 2025, total upstream investment requirements, from 2006 onwards, amount to $1.9 trillion (in 2005 dollars). The OECD accounts for 37 per cent of this figure. Over the first ten years of the projection, requirements in OPEC, non-OPEC developing countries, and Russia and the Caspian states are of a similar order of magnitude to one another: all three of these non-OECD groups require around $100 billion of investment by 2010, and close to another $100 billion in the following five years (Figure 2.8).

The global scale of upstream investment this reference case outlook implies, however, is not expected to be greater in magnitude to that witnessed in the past. This is the result of the gradual shift from higher cost non-OPEC to lower cost OPEC supply. It should be noted, however, that these figures are limited to estimated costs of field development, and do not include the development of new infrastructure, such as pipelines, storage and ports. It is also important to recognise the large degree of uncertainty over future demand and supply and, hence, the required additional OPEC oil. Given these uncertainties, a key challenge will be to anticipate the appropriate level of demand to make the necessary investments needed to maintain and expand upstream capacity, as well as the corresponding downstream infrastructure.

Figure 2.8

Cumulative upstream oil investment requirements in the reference case, 2005-2025



For the medium-term, investment plans for OPEC Member Countries are already in place. It is important, therefore, to consider this investment activity in the specific context of both recent developments, as well as possible medium-term supply and demand.

In recent years, OPEC production has risen to the highest level in over twenty years in response to strong oil demand growth, as well as the temporary slow-down in the rate of increase of non-OPEC supply. In addition, OPEC crude capacity has continued to increase, while the production of NGLs is also on the rise.

Spare capacity in OPEC Member Countries in 2005 was around 2 mb/d, sufficient to ensure the market was at all times well supplied. In line with OPEC's longstanding commitment to supporting oil market stability, further OPEC crude capacity expansion plans over the medium-term are expected to result in almost 38 mb/d of crude capacity by the end of 2010, representing an increase of nearly 5 mb/d from end-2005. Similarly, production capacity of NGL and other liquids will be expanded by almost 2 mb/d to reach 6 mb/d by 2010. OPEC capacity growth is underpinned by over 100 E&P projects totalling $100 billion. These projects are in addition to all energy infrastructure investments, such as for pipelines, export terminals, and downstream expansion.

Recalling that, in the reference case, demand grows at 1.5 mb/d annually, and is expected to be accompanied by strong medium-term increases in OPEC NGLs and non-OPEC production, this leaves little or no room for increases in OPEC crude output over the coming three-to-five years. OPEC capacity expansion plans therefore give rise to the expectation that significant increases in spare capacity will occur over the medium-term. Indeed, the reference case scenario would involve OPEC spare capacity rising to 5-8 mb/d over this timeframe.

These expected developments demonstrate the contribution that OPEC continues to make in providing a firm foundation for future market stability. It should also be acknowledged, however, that these investments are subject to significant potential risks, especially with regard to the rate of future demand growth. It is therefore a genuine and legitimate concern of OPEC that too large levels of idle capacity could emerge, wasting much-needed financial resources, and placing downward pressures on prices. Some of the downside risks to oil demand growth are considered in Section 3.

2.3.4 The role of upstream technology

It is worth dwelling on some of the examples of the evolution and application of the remarkable array of upstream technologies that affect both oil supply and the additions of more resources. Powerful technologies and tools are being used today by international and national oil companies for exploration, development, reservoir evaluation, production and cost reduction. Examples are 3D and 4D seismic, nuclear magnetic resonance, high-curvature and horizontal drilling, intelligent completions and the use of information technology (IT). In the future, it is expected that much more IT and other technologies will be advanced and integrated in the development of oil and gas resources. New technologies have, *inter alia*, improved drilling success rates, increased oil recovery rates, and made possible the exploration of new frontier areas.

In the decades ahead, technology is expected to play a significant role in the prospects for both non-OPEC supply and OPEC capacity expansions. In OPEC Member Countries, the application of advanced upstream technologies is expected to continue to result in increased recovery rates and the development of new plays.

The continued development and application of technologies in the upstream oil sector is therefore a central factor in meeting the challenge of supplying the growing demand for oil. Technology has led to continual revisions of the resource base, often blurring the distinction between conventional and non-conventional oil, and continues to improve our knowledge of geological conditions, the efficiencies in finding and development operations, as well as to increase recovery rates. These technologies are in use throughout the world, and are key to understanding the upstream sector: how it has evolved and the future role it will play in rising to the challenges ahead.

3. Uncertainty in the outlook

In the reference case, the expectation is that OPEC will be increasingly relied upon to supply the incremental barrel. This is an undertaking that OPEC is both willing and able to perform. OPEC is making known well in advance plans for expansion in production capacity, not only to satisfy increased demand, but also to offer an adequate level of spare capacity. These measures will support security of supply to consumers, and will be to the benefit of the world at large.

Nevertheless, the need for enhanced energy security has to be seen from mutually supportive supply and demand perspectives. Uncertainty over future demand translates into large uncertainties over the amount of oil that OPEC Member Countries 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. The need for security of demand is a legitimate concern for producers, just as consumers express concern over security of supply. With more transparency in the evolution and implementation of policies, better assessments will be possible as to how future demand is likely to evolve. In turn this would help make appropriate capacity expansion decisions – to meet both an increased demand for OPEC oil and offer an adequate level of spare capacity – while at the same time not wasting precious financial resources.

Downside risks to demand are more substantial than upside potential. 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 are a range of important drivers, in particular energy and environmental policies in consuming countries and 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 this asymmetry in mind, a scenario has been developed which depicts a possible future where the drivers of change give rise to a 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 percentage points lower annually than in the reference case. This could stem from a number of factors. For example, a deadlock or long delays in the Doha Round of the World Trade Organization (WTO) could fail to deliver on the promise of increased liberalisation, leading to increased protectionism, reduced capital flows and, ultimately, lower world economic growth. Moreover, concerns about the problems associated with the US current and budget deficits will continue to weigh on the US dollar, which could have deflationary implications.

This *Lower growth* scenario is both credible and realistic; it 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, the introduction of alternative vehicles could reduce the potential increase in oil demand for transport in the longer-term. This scenario would be consistent with the acceptance of the high cost of subsidies that would be required to remove the cost premium associated with technologies such as hybrid vehicles. For the timeframe to 2025, fuel cell vehicles, on the other hand, continue to have a very small share of the market as technical and cost barriers remain too high.

Overall, the scenario sees unconventional vehicles making up about 10 per cent of the vehicle stock in the OECD regions in 2015. In all other regions of the world the share of alternative fuel vehicles reaches about seven per cent. The implication is a reduction in oil use per vehicle in the OECD regions at an additional 0.5 per cent p.a. compared to the reference case.

Table 3.1
Oil demand in the Lower Growth scenario, mb/d

	2010	***2015***	***2020***	***2025***
OECD	50.6	50.6	50.3	49.8
Developing Countries	33.6	38.3	43.1	47.8
Transition Economies	4.9	5.0	5.0	5.0
World	89.1	93.9	98.4	102.6
Difference from reference case	***2010***	***2015***	***2020***	***2025***
OECD	-0.9	-2.1	-3.5	-4.8
Developing Countries	-0.6	-1.7	-3.2	-5.0
Transition Economies	-0.1	-0.3	-0.5	-0.6
World	-1.6	-4.2	-7.2	-10.5

Table 3.2 shows that, in this *Lower Growth* scenario, world oil demand is more than 10 mb/d lower by 2025 than in the reference case. The only source of growth in this scenario is developing countries, although demand is down by 5 mb/d from the reference case for this group. Average annual growth in demand is just 1 mb/d annually.

Table 3.2
OPEC and non-OPEC production in the Lower Growth scenario, mb/d

	2010	***2015***	***2020***	***2025***
Non-OPEC	55.2	56.9	57.5	56.8
OPEC (incl. NGLs)	33.9	37.0	40.9	45.8
Difference from reference case				
Non-OPEC	-0.6	-1.4	-1.9	-2.1
OPEC (incl. NGLs)	-1.0	-2.7	-5.2	-8.4

With this lower demand, there are downward pressures upon oil prices, as well as upon the amount of oil demanded from OPEC. Lower prices have some negative impact upon non-OPEC supply, although the impact is modest, with output 2 mb/d lower by 2025 compared to the reference case, plateauing at the slightly lower level of 57-58 mb/d. By far the largest impact is upon the amount of oil that would be supplied by OPEC in this scenario, falling by over 8 mb/d compared to the reference case. 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. How to ensure the appropriate level of investment takes place, in the context of such uncertainty, and particularly given the long lead times involved, is a major challenge.

As mentioned above, uncertainties concerning demand exist in both directions, and even stronger growth than in the reference case can also be readily conceived. Stronger economic growth could emerge if geopolitical and economic conditions give an even stronger impetus to world trade and to capital flows and transfer of technology. This would result, for example, from completion of a more ambitious Doha Development Round, where the benefits from trade liberalisation are felt more strongly than in the reference case. In the *Higher Growth* scenario, average economic growth is assumed to be 0.5 per cent higher than in the reference case.

The stronger resulting growth in oil demand is assumed to eventually lead to some consumer reactions and energy policy responses which 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.

Table 3.3
Oil demand in the Higher Growth Scenario, mb/d

	2010	***2015***	***2020***	***2025***
OECD	52.0	53.8	55.2	56.5
Developing Countries	34.6	41.3	48.4	56.3
Transition Economies	5.1	5.5	5.9	6.2
World	91.7	100.7	109.5	119.0
Difference from reference case	***2010***	***2015***	***2020***	***2025***
OECD	0.4	1.1	1.4	1.9
Developing Countries	0.4	1.3	2.1	3.5
Transition Economies	0.1	0.2	0.4	0.5
World	1.0	2.6	4.0	5.9

It can be seen from Table 3.3 that this *Higher Growth* scenario gives rise to world oil demand that is almost 6 mb/d higher by 2025 than in the reference case. Most of this additional growth in demand is in developing countries. Average annual growth in demand is close to 1.8 mb/d annually.

The higher demand increases the amount of oil that is demanded 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 less than 2 mb/d higher by 2025 compared to the reference case. The reaction to the higher oil price is partly limited by higher finding, development and operating costs which are assumed for this scenario. The amount of oil demanded from OPEC in this scenario, including NGLs and non-conventional oil, is around 4 mb/d higher than the reference case.

Table 3.4
OPEC and non-OPEC production in the Higher Growth scenario, mb/d

	2010	***2015***	***2020***	***2025***
Non-OPEC	56.2	59.1	60.5	60.2
OPEC (incl. NGLs)	35.5	41.6	49.1	58.8
Difference from reference case				
Non-OPEC	0.4	0.8	1.1	1.3
OPEC (incl. NGLs)	0.6	1.8	2.9	4.5

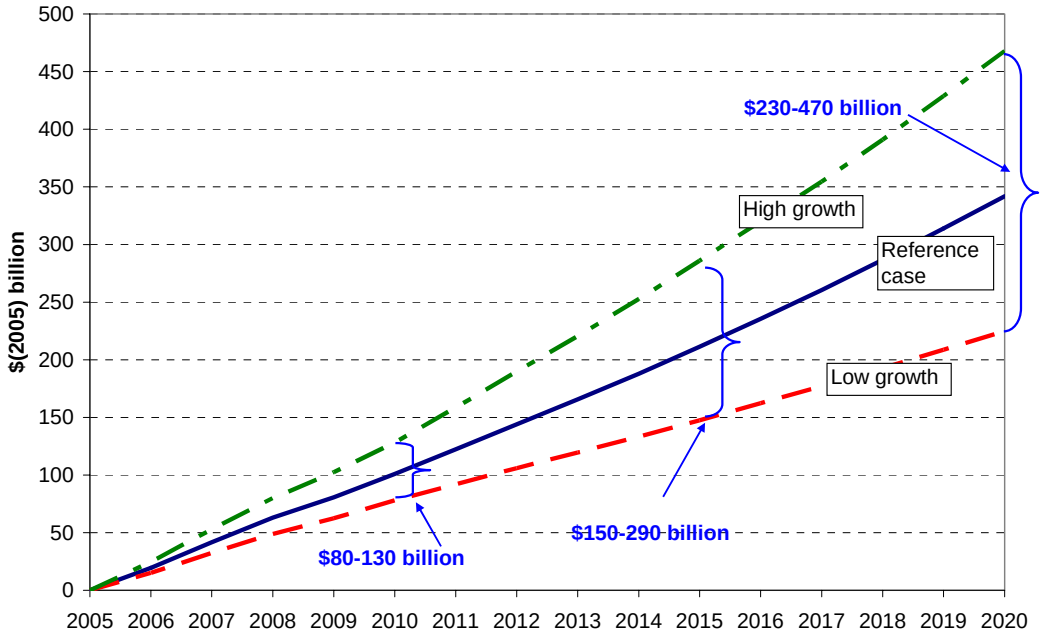
As we have seen in these scenarios, given the role that OPEC plays in supporting market stability by supplying the residual barrel, the uncertainties translate into a wide range of possible levels of future oil supply that will be demanded from OPEC. With a high and low growth case, a range of over 12 mb/d opens up for the possible amount of oil that OPEC might have to supply by 2025.

These scenarios for OPEC production have been used to estimate a range of possible investment needs in OPEC Member Countries over the coming two decades. Clearly, this involves not only accounting for net expansion in capacity, but also for compensating for declines in production

that would occur in existing facilities without such investment. Moreover, investment needs in OPEC Member Countries are additionally burdened by the objective of maintaining sufficient spare capacity.

Figure 3.1 shows clearly the large impacts of demand uncertainties on OPEC. For example, by 2020 an estimated uncertainty of $240 billion for required OPEC investment can be envisaged, with the *Lower growth* scenario suggesting a cumulative requirement of just under $230 billion, instead of $470 billion in the *Higher growth* case. Of course, the time frame to 2020 is sufficiently long to adjust expansion plans in accordance with evolving demand patterns. But the types of investment that are required vary substantially, and lead times can be long, particularly if the necessary infrastructure is not in place. Even over the period to 2010, there is an estimated range of uncertainty of $50 billion for required investment, increasing to $140 billion by 2015. This clearly demonstrates that there is a real risk of wasting much-needed financial resources.

Figure 3.1
Cumulative OPEC investment requirements:
How much is needed?



The issue of security of demand is therefore a very real one, and constitutes a legitimate concern for OPEC Member Countries. Moreover, it is intrinsically linked to the issue of security of supply: without the confidence that demand for its oil will emerge, the incentive to undertake investment can be reduced, which, in turn, can exacerbate concerns over eventual sufficiency of capacity, and thereby hamper the drive towards long-term oil market stability. Alternatively, the emergence of large levels of unused capacity would lead to downward pressures upon oil prices. This would result in a huge loss of revenues, and OPEC Member Countries, as developing countries with keenly felt competing needs for financial resources, would be adversely affected in terms of available resources for education, healthcare, infrastructure, etc. Moreover, lower revenues would, in turn, negatively affect available resources for future investment, with further subsequent market instability a distinct possibility.

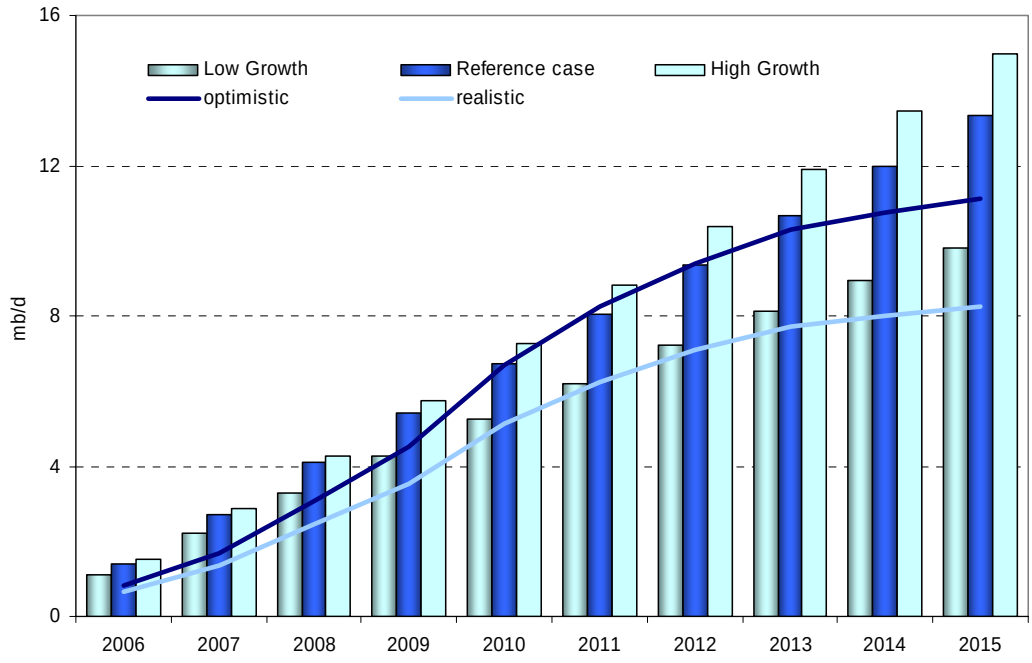
4. Downstream challenges

As emphasised earlier in this paper, the downstream sector is a very important part of the supply chain, with the current tightness in the form of inadequate refining capacity putting pressure on oil prices. Several factors will shape developments in this sector in the coming decade. The first concerns the rising volume of crude oil that needs to be refined. Another element is how the oil product demand structure will change, with the expectation that there will be a continued move towards lighter products. At the same time, product specifications are moving towards significantly cleaner products that will require substantial reductions in sulphur content, as well as improvements in other quality parameters, driven by environmental concerns. Therefore, the downstream sector will require significant investment to meet growing product demand and to address emerging mismatches between crude slate, product demand and product specifications.

A large-scale linear programming model has been used to analyse these important issues. Under the reference case scenario, worldwide crude runs are projected to increase by about 6.5 mb/d by 2010 and 13 mb/d by 2015 from 2005 levels. Considering recent relatively high refinery utilisation rates, distillation capacity expansion would be expected to at least keep pace with growing demand. However, a review of known refining expansion projects does not support this, as can be seen in Figure 4.1.

Figure 4.1

Distillation Capacity Additions vs Incremental Crude Runs



In these calculations, each known refining project was associated with one of four categories according to its current status, representing the projects either: (i) under construction; (ii) in the engineering stage; (iii) in the planning stage; or (iv) under consideration. Another factor to be considered in this respect is capacity creep.[1] In the USA, the average rate of creep in recent years has been around 0.5-0.75 per cent p.a. for crude units and somewhat higher, 0.75 per cent-to-1.5 per cent

[1] Unannounced capacity expansion through minor projects within existing facilities.

p.a., for upgrading units. In Europe and OECD Pacific, it is plausible that similar rates of creep would apply, with a range of significantly lower rates in other regions. Worldwide, it is estimated that creep projects will add within the range of 0.25 per cent-to-0.5 per cent to crude distillation capacity per annum. For major secondary units, the range is estimated slightly higher at 0.35 per cent-to-0.75 per cent worldwide. Applying different rates of success and delay in the implementation of refining projects, as well as capacity creep, two scenarios for possible distillation capacity expansions have been developed: *realistic* and *optimistic*. The *realistic* scenario assumes implementation rates that were typically observed in previous years (100, 90, 50 and 40 per cent for each of the four categories respectively) combined with average worldwide capacity creep of 0.25 per cent per annum. The *optimistic* scenario assumes higher than typical rates (i.e. 100, 100, 70 and 50 per cent for each category) and average capacity creep of 0.4 per cent.

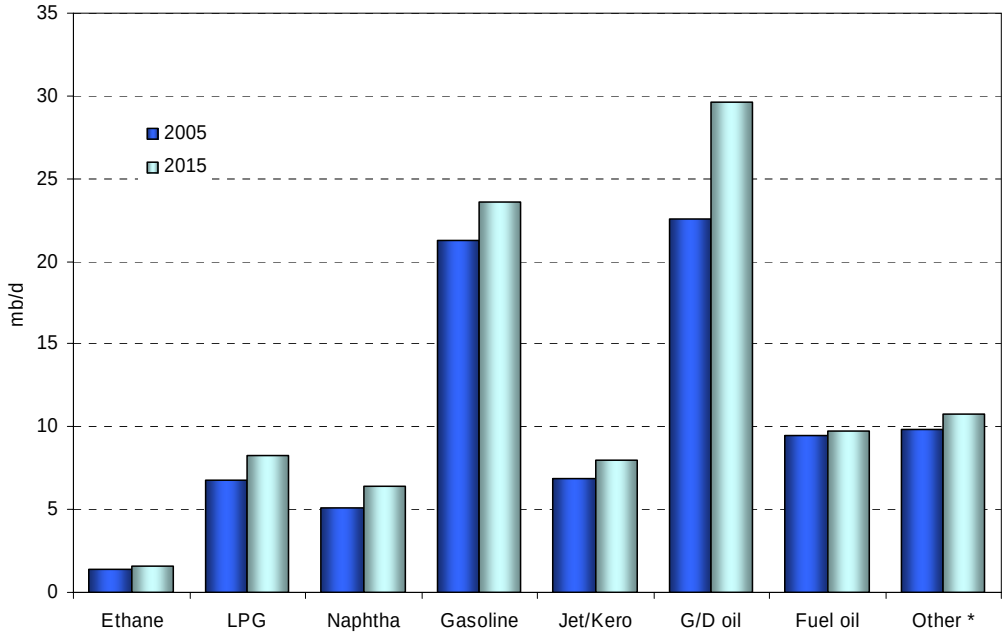
These two possible rates of expansion for the downstream sector have then been considered in the context of the scenarios for demand developed earlier in the paper. In both cases, despite the number of substantial refining projects announced recently, especially in the second half of 2005, whether grassroots projects, plant reconfiguration or expansion of existing capacities, long construction lead times –typically four-to-five years for sizeable projects – will most likely mean that the existing refining tightness will not ease until at least 2010. By then, crude runs resulting from the reference case demand increase can only be met if existing refining projects progress at least as fast as in the *optimistic* scenario. On the other hand, the typical rate of implementation of these projects, as represented by the *realistic* scenario, will provide hardly sufficient capacity, even in the *Lower growth* scenario. This will place additional pressure on utilisation rates, with corresponding implications for the price of products and crude oil.

Therefore, from the current perspective, investments in the refining sector are coming in at a considerably slower pace than warranted by expected growth in demand. A more orchestrated effort is clearly required to ensure sufficient capacities are in place in the future.

Besides rising volumes, the structure of refined products demand will also undergo significant change. Indeed, in the next decade the demand structure will shift further towards a higher share of light and middle distillates, gasoil/diesel, naphtha and liquefied petroleum gas (LPG) in particular. Middle distillates (gasoil/diesel and kerosene) are expected to show the strongest growth among the products, increasing by more then 8 mb/d between 2005 and 2015 followed by naphtha and LPG. Demand for gasoline will increase only moderately, by around 2.4 mb/d globally. However, gasoline growth rates vary widely by region, with negative rates expected in Europe due to the continued trend towards 'dieselisation', moderate increases in North America, and much stronger growth in Asia. Demand for fuel oil and other heavy products should remain relatively flat (see Figure 4.2).

Figure 4.2

Global product demand 2015 vs 2005



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

Consequently, in addition to crude distillation capacity requirements, the expectations described above will put further pressure on the refining sector with respect to the expansion of conversion capacity. Data for conversion capacity projects present a similar outlook to those for crude distillation, although somewhat less severe. Here, announced additions should keep pace with incremental requirements in the short-term as a new round of conversion capacity additions begins to take shape in India, China, Latin America, the United States and Europe. There is more flexibility for the industry with respect to conversion capacity as revamping and debottlenecking plays a larger role and construction lead times are shorter. However, from the current perspective, by 2010 a deficit of around 1 mb/d of conversion capacity would appear unless additional investments are made.

Required conversion capacity should also be viewed in the context of the expected crude slate. For the remainder of this decade, the quality of incremental non-OPEC production will be predominantly medium and light – in terms of API gravity – so that the weighted average of non-OPEC production may in fact improve slightly, rather than deteriorate. In terms of OPEC crude quality, the overall assessment on a project basis indicates that most of the new oil will be overwhelmingly light to medium, driven by expansions in Algeria, Libya, Nigeria and Saudi Arabia. Thus, up to 2010, the average crude slate is likely to remain stable with only a marginal shift in average API gravity. In terms of sulphur content, the trends may be more predictable as most of the new oil is sour while the losses are predominately sweet (<0.5 per cent sulphur), but even then the deterioration may not be pronounced and the average sulphur content is not expected to increase more than 0.1 per cent-to-0.2 per cent by 2010. Longer-term, a moderate decline in overall crude quality is expected to occur.

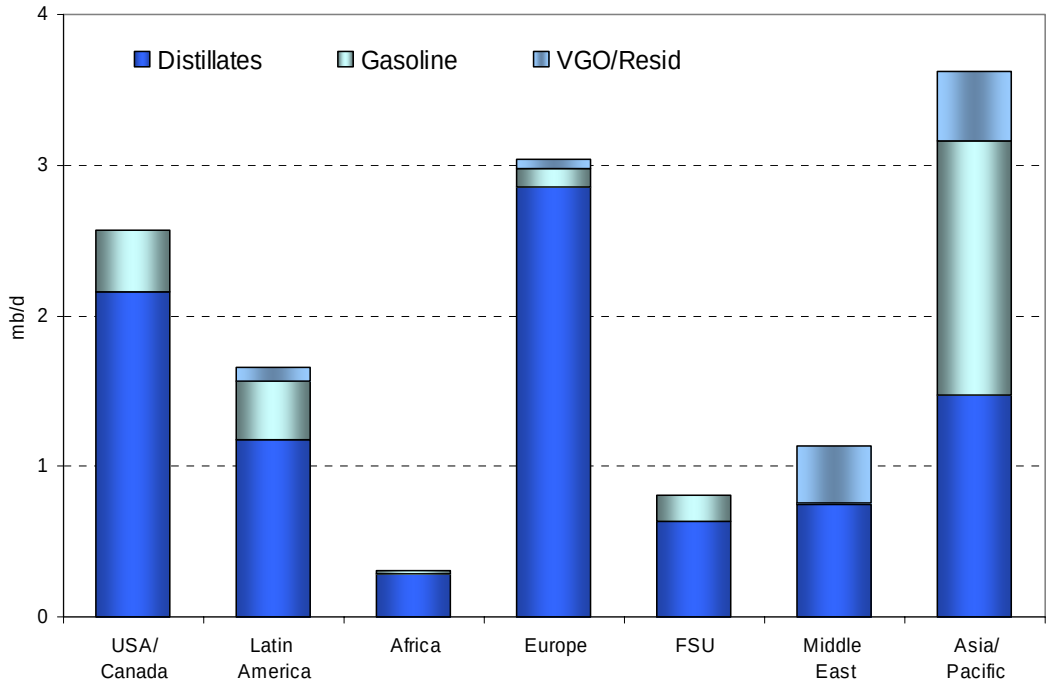
Growing concerns over the environmental aspects of energy demand is also reflected in ever-tighter quality specifications for refined products. After almost completing the phase out of leaded fuels, the main focus of regulatory bodies has turned towards the reduction of sulphur levels in gasoline and automotive diesel. Despite great regional variations in current quality specifications and

different timeframes for future implementations, the trend in developing countries is to reduce sulphur content in gasoline and diesel to 50 ppm (or below) by 2010, while most of the OECD countries are aiming to have 10 ppm standards by this time. Moreover, significant changes are also expected for other products. For example, permissible residual fuel sulphur levels have already been reduced in Europe, and new regulations for marine bunker fuels are likely to tighten sulphur standards in several regions. Needless to say, all of these changes will impact the refining sector significantly.

OPEC's downstream optimisation model projects the refining system will need more then 13 mb/d of additional desulphurisation capacity by 2015, on top of known projects (Figure 4.3). This is dominated by requirements to produce additional ultra-low sulphur gasoline and diesel. Desulphurisation requirements will be significant across all regions. The bulk of these units are projected in OECD regions as these move faster towards ultra-low sulphur fuels, 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 high European standards.

Figure 4.3

Additional desulphurisation capacity requirements
2015 vs 2005

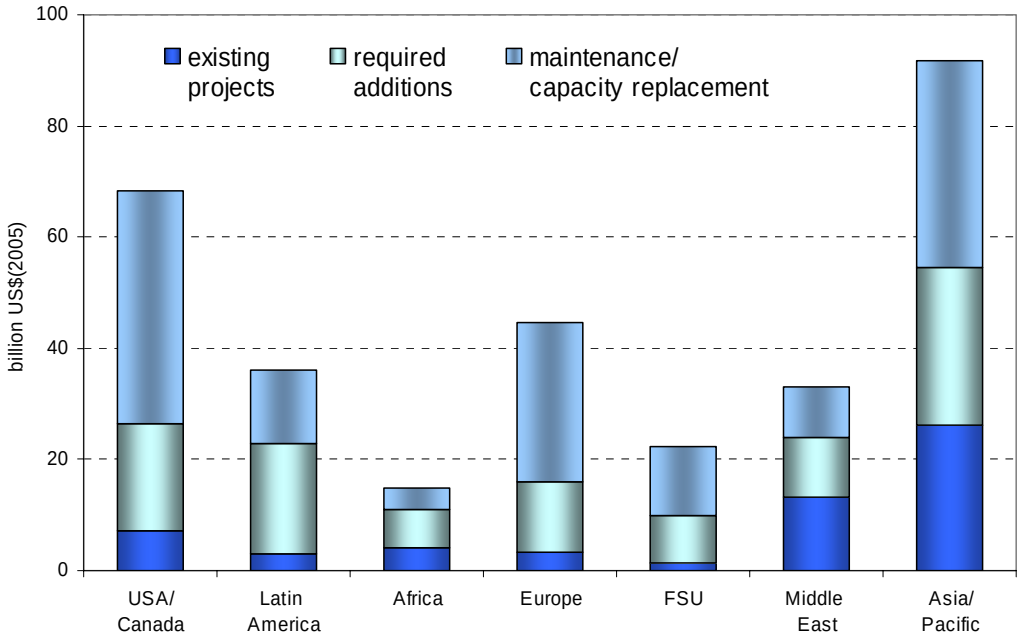


To meet these challenges, about $160 billion in capacity investment will be required by 2015 and another $150 billion needed for maintenance and replacement of shut-down capacity (Figure 4.4).

Asia is expected to be the dominant region in terms of downstream investment requirements absorbing more than 30 per cent of global investments. Substantial investments are being made – and will be required in the future – in the Middle East which aspires to be an exporting region of clean products. Investment requirements elsewhere are also substantial, because of capacity expansions and the large expenditure implied by the need to move towards cleaner products. Looking at the decade beyond 2015, it is expected that the size of investments flowing into the refining system need to remain comparable to that between 2005 and 2015. By then, two major factors will impact on the final level of investments. On the one hand, the shift in additional capacity expansion towards developing countries will be even more pronounced, which will give refiners additional options for less expensive expansion through capacity creep. However, this will likely be compensated through higher costs resulting from tighter and more widely spread regulatory measures with respect to product quality specifications, including stricter targets for aromatics, olefins, and cetane.

Figure 4.4

Refinery investments in the reference case
2005-2015



Finally, 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.

These estimates of required capacity, together with the available evidence of emerging investment trends, all suggest the downstream sector could very well remain a source of market instability over the coming years. It is therefore a pressing area for discussion among all parties, and ways need to be explored to accelerate expansion plans and create the right investment climate. In this connection, it needs to be recognised that the primary responsibility for investment in this sector lies with consuming countries.

5. Cleaner oil and gas technology

As we have seen, OPEC's long-term projections indicate that fossil fuels, oil in particular, will continue to support socio-economic development of all regions of the world. Indeed, there is a broad consensus that fossil fuels will remain the main source of supply of primary energy until at least the middle of the century. A critical question that arises is whether this increasing use of fossil energy is consistent with the third pillar of sustainable development, namely the protection of the environment.

Energy scenarios project a progressive increase of CO_2 emissions in the first half of this century. Although uncertainties remain regarding the science and consequences of climate change, the potential risk for negative impacts on the environment has led to the idea that measures should be taken, even if some cause and effect relationships are not fully understood scientifically.

The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) stressed that there is no known unique solution that could provide all of the emissions limitations and reductions needed to address these concerns. It is therefore logical to resort first to technologies that could make substantial impacts. In this regard, it is important to note that well over half of the total emissions are attributable to power stations and industrial activities. Power generation and industry therefore constitute prime targets for emission reduction efforts.

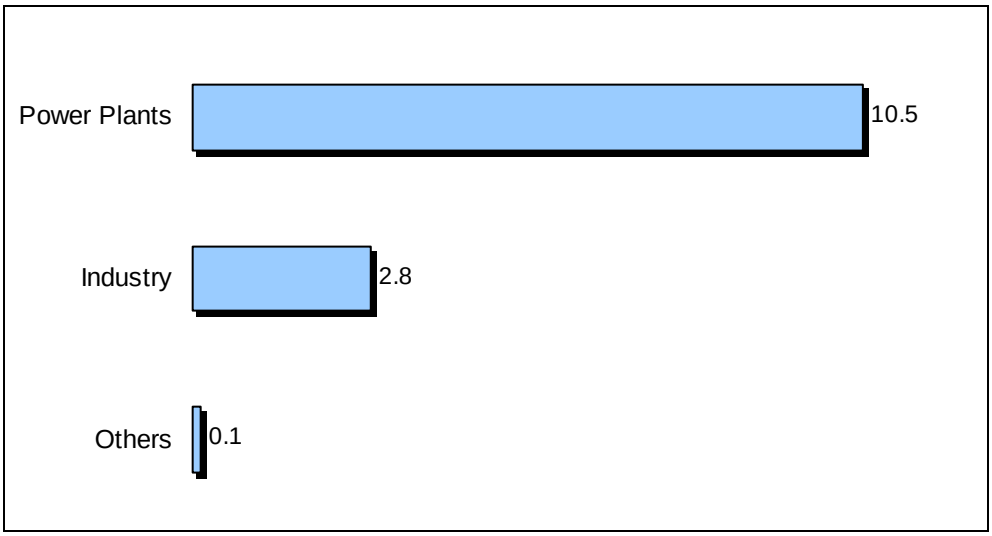
Some of the policies considered for addressing the climate change issue support an increased role for renewable energy sources. However, practical and economic considerations limit the current contribution of new renewables – wind, solar, geothermal, modern biomass and small hydro – to just two per cent of global power generation. This low base implies that exceptionally high rates of growth would have to be sustained over many years in order for these sources of energy to contribute significantly to the global energy mix. It is important to recognise the high costs of renewables. A major question is whether developing countries, from which most of the increase in energy demand is expected to come, would be willing and able to afford massive financial schemes to support renewables.

Nuclear power is also an energy option that would not increase CO_2 emissions. Although rapid growth is projected for some developing countries, the global share of nuclear in the energy mix is likely to decline over the next two decades. Strong negative public sentiment against nuclear power exists in many parts of the world, based on concerns over plant safety and radioactive waste disposal. The continued trend away from nuclear power in industrialised countries, together with the retirement of existing plants, is not likely to be balanced by the construction of new nuclear power capacity in those countries. Moreover, nuclear power is relatively expensive when compared with natural gas or coal-based power generation.

Technological options that allow the continued use of fossil fuels in a carbon-constrained world must therefore be considered. One promising technology is the use of carbon capture and storage (CCS), which would most likely be applied to large stationary sources of CO_2 emissions. In 2000, over 52 per cent (13.5 Gt) of the energy-related CO_2 emissions was attributed to large stationary sources, defined as those sources which emit in excess of 0.1 Mt CO_2 per year. In power generation

alone, almost 5,000 such sources exist worldwide, emitting a total of 10.5 Gt CO_2 per year.[2] The IPCC Special Report on CCS also examined the current global geographical relationship between these sources and their proximity to potential storage sites. In broad terms, the analysis indicates that there is a potentially good correlation between major sources and prospective sedimentary basins, with many sources lying either directly above, or within reasonable distances – less than 300km – from areas with potential for geological storage.

Figure 5.1
World emissions of CO_2 from large stationary sources in 2000, Gt



CCS involves the application of technology in three steps. First, CO_2 produced in energy-related and industrial activities is captured at source. Once the CO_2 is captured it must be transported to a suitable storage site. The purpose of CO_2 capture is to produce a concentrated stream of CO_2 at high pressure that can readily be transported to a storage site. Depending on the process conditions under which it must operate, one of three approaches of capture can be used: post-combustion systems, pre-combustion systems and oxyfuel combustion. Technologies similar to those of post-combustion capture are already used on a large scale for the separation of CO_2 from natural gas. The same technologies as would be used for pre-combustion capture are employed for the large-scale production of hydrogen. Oxyfuel combustion for CO_2 capture is currently in the demonstration phase.

Following the capture of the CO_2, transportation to a storage site is the next step. This poses no technical challenges, with the use of pipelines or ships possible, since CO_2 is liquid above pressures of around 5 bars and a temperature of 30° C.

Four options are available for storing CO_2: (i) conversion into solid inorganic carbonates using chemical reactions; (ii) industrial use, either directly or as feedstock for production of various carbon-containing chemicals; (iii) injection into the ocean at depths of more than 1,000m; or (iv) injection into geological formations. It is the fourth option, however, that has received most attention for CO_2 storage. The injection of CO_2 in deep geological formations involves many of the same technologies that have been developed in the oil and gas exploration and production industries.

Storage is not a constraint. Three types of geological formations are suitable for storage: unmineable coal seams, depleted oil and gas reservoirs, and deep saline aquifers. Table 5.1 shows the

[2] IPCC Special Report – Carbon Dioxide Capture and Storage, 2005.

IPCC estimates for the technical potential of these storage options. Saline aquifers offer the largest potential storage volumes, but for the near term, depleted or nearly depleted oil and gas reservoirs represent the most attractive option because of the possibility of linking CCS to enhanced oil recovery (EOR) or enhanced gas recovery processes.

Table 5.1
Technical potential of geological storage options

	CO_2 Storage Capacity (Gt)	
Reservoir type	***Lower Estimate***	***Upper Estimate***
Deep saline formations	1,000	possibly 10,000
Oil & gas fields	675 - 850	900 – 1,200
Unmineable coal seams	3 - 15	200

CO_2-based EOR is an established technology that has been used extensively. In the West Texas Permian Basin, CO_2 has been used for EOR for 30 years, with about 30 million tons of CO_2 currently injected annually. These projects are responsible for about 20 per cent of oil production in the region, and have increased oil reserves by between five and nearly 20 per cent of original oil in place. In Weyburn, Canada, CO_2 EOR has already increased oil production by over 9,000 b/d out of a field rate of 22,000 b/d. In sum, 30 million tons of CO_2 will be stored and 130 million barrels of incremental oil will be recovered.

The cost effectiveness of CCS relative to other greenhouse gas mitigation options will be a critical factor in determining the extent of its future deployment. There is a wide range of cost estimates, due primarily to the variability of site-specific factors, operating and financing characteristics of the power plants or industrial facilities in which CCS is used; the type and costs of fuel used; the required distances, terrains and quantities involved in CO_2 transport; and the type and characteristics of the CO_2 storage. Furthermore, the fact that there is so far little experience with integrated CCS systems adds further uncertainty regarding the performance and cost of future CCS technology. Nevertheless, the IPCC Special Report on CCS indicates that, for new coal- or gas-based power plants, the total costs, based on current technology, range from $14-to-$91 per tonne of CO_2 avoided, with a large potential for considerable reductions. Thus, CCS could represent an affordable means of achieving a large part of future emissions reductions.

Given the realistic expectation of the expanded use of fossil fuels, at least over the next few decades, the promising option of CCS offers a win-win opportunity. Steps need to be taken to move this technology forward: in particular, there is a need for large-scale CCS demonstration projects. Collaboration between producers and consumers, in particular in line with the recognition of common, but differentiated responsibilities, needs to be embarked upon. R&D efforts in other advanced and cleaner fossil fuel technologies also need to be encouraged.

6. Closing remarks

The IEF provides an important opportunity for energy producers and consumers to address major issues of common concern. Indeed, concrete, constructive and fruitful dialogue is evolving among the many parties, a clear demonstration of the interdependencies that exist and of the resolve to rise to future challenges. OPEC has a longstanding commitment to oil market stability. OPEC's role in this respect is becoming better understood and appreciated, as its continued efforts to support such stability are increasingly acknowledged as being beneficial to the world at large. Indeed, even when unexpected shortfalls in supply have occurred in the past, OPEC has repeatedly ensured that the market remains sufficiently supplied. Moreover, OPEC is also making known well in advance plans for expansion in production capacity.

Nevertheless, the issue of security of demand must be seen as an integral factor in supporting longer-term market stability, and it is as much a part of energy security as the supply perspective: security of demand and security of supply are mutually supportive. Uncertainty over future demand translates into large uncertainties over the amount of oil that OPEC Member Countries will eventually be relied upon to supply, signifying a heavy burden of risk. Investment requirements are very large, and subject to considerably long lead-times and pay-back periods. There is a legitimate concern that large levels of unused capacity could emerge, which could lead to strong downward pressures on oil prices, resulting in huge revenue losses. It is in this context that there is a call for a 'roadmap' for oil demand. With more transparency in the evolution and implementation of policies, better assessments are possible as to how future demand is likely to evolve. This, in turn, would lend support to making appropriate capacity expansion decisions that would meet the increased demand for OPEC oil and offer an adequate level of spare capacity, while at the same time not waste precious financial resources.

In addition to OPEC's commitment to stability, there is now wide recognition that there are clearly sufficient resources to satisfy future energy needs. The idea that oil production is soon to peak needs to be dispelled, as this misconception can feed security concerns. However, timely and adequate investment in the entire supply chain is necessary in the support of supply security, and the importance of the downstream sector must be emphasised. In this regard, there is a need for close involvement of consuming countries and international oil companies. Measures are necessary to provide incentives for expansion in refining capacity. OPEC, for its part, is already making a contribution to address downstream tightness, but the responsibility must ultimately lie with consuming countries.

It is also important to recognise the need to ensure that continued fossil fuel use is compatible with the protection of the environment. In this regard, technology will play a key role, and the promising example of carbon capture and storage should be pursued.

There is a discernibly strong spirit of cooperation in the producer-consumer dialogue. Joint OPEC-IEA workshops have been held annually since 2003 and dialogue has been initiated or intensified between several different groups and institutions, providing an opportunity for in-depth and fruitful exchanges. The 10th Meeting of the IEF represents an important occasion for furthering the mutual awareness of concerns and should provide a valuable platform for a candid exchange of views on many important issues. It is important that dialogue be both widened and deepened in a constructive spirit, as we move forward together in the 21st century in our common quest for market stability, and in our progress towards the goal of poverty eradication and sustainable development for all.