

World Oil Outlook

OPEC Secretariat background paper

15th International Energy Forum Ministerial
Algiers, Algeria, 26th – 28th September, 2016

Table of contents

Key insights	i
1. Introduction	1
2. Oil market developments	2
3. World oil outlook	5
3.1 Overview of the Reference Case	5
3.2 Energy and oil demand	8
3.2.1 Energy demand in the Reference Case	8
3.2.2 Oil demand in the Reference Case	10
3.2.3 Alternative economic growth scenarios	14
3.3 Liquids supply	15
3.3.1 Liquids supply in the medium-term	15
3.3.2 Liquids supply in the long-term	17
3.3.3 Alternative non-OPEC supply scenarios	18
3.4 Downstream	21
4. Climate change and sustainable development	28
5. Concluding remarks	32

KEY INSIGHTS

Oil market developments

- The most obvious market development since the last International Energy Forum (IEF) Ministerial meeting in May 2014 has been the oil price collapse. The OPEC Reference Basket (ORB) price dropped by nearly \$90/b, or 80%, between June 2014 and January 2016, from \$111/b to below \$23/b. Since then crude oil prices have generally seen a slight upward trend and have moved above \$40/b. The sharp oil price downturn was primarily linked to fundamentals, and it has reflected uncertainties in the world economy, as well as oil market dynamics that have been supply driven.
- The low oil price environment has had an impact on prospects for both demand and supply in the short- and medium-term, and some lasting effects can be expected in the long-term. Exploration and production (E&P) capital expenditures fell significantly in 2015 and expectations are similar for this year. It is anticipated that the total cut over the two years will approach \$300 billion. This has had broad implications for the industry with many projects being deferred or cancelled altogether, a dramatic fall in oil rig counts (in the US by more than 80% from its peak two years ago), and huge industry job lay-offs. The low oil price has also had negative consequences for oil exporting countries.
- World economic growth of 2.9% in 2015 was lower than 2014. It was particularly affected by a slowdown in emerging markets. Global economic growth in 2016 is forecast estimated at 2.9%, the same level as last year. In 2017, global economic growth is forecast to creep higher to 3.1%. Growth will be impacted by the dampening effect of the UK vote to leave the EU and below potential growth in several other countries, such as Russia, Brazil and China.
- The impact of the oil price decline on demand was most visible in 2015 with growth reaching 1.5 million barrels a day (mb/d), including significant contributions from the OECD area. Total world oil demand averaged 93 mb/d in 2015, with demand in the non-OECD area already exceeding the levels of OECD during the year. Oil demand prospects in 2016 and 2017 remain robust, with growth forecast at around 1.2 mb/d for both years. Asia will again be the leading demand growth region, capturing more than 50% of the share in global growth.
- On the supply side, the escalating impact of lower oil prices and spending cuts on the industry has reversed the strong growth trend in non-OPEC supply. This decelerated from 2.3 mb/d in 2014 to 1.4 mb/d in 2015 and in 2016 it is expected to contract by around 0.6 mb/d. The negative trend is expected to ease, with a moderate growth of 0.2 mb/d. in 2017. Oil companies, despite considerable cost reductions and productivity gains as well as hedging options, have been confronted with serious financial strain and tightening liquidity.

- The market instability with a significant oversupply in 2015, including the prevailing stocks overhang, has continued into 2016. Nevertheless, the adjustment process towards reducing the imbalance in the global oil market is now taking place.

Long-term outlook

- Demographic trends will continue to have a significant impact on energy demand. World population will increase from 7.2 billion in 2014 to 9 billion in 2040, but it is expected to age significantly in the next few decades. The urbanization rate will reach 63% by 2040.
- Growing by 3.5% per annum (p.a.) on average between 2014 and 2040, the global economy is expected to more than double during this period. The average growth rate for the OECD is estimated at 2.1% p.a., while developing countries will account for three-quarters of the growth, averaging 4.6% p.a. for the forecast period. China and India alone will account for half of this growth. Despite improving per capita incomes, the inequality within and among nations in terms of wealth distribution will remain a challenge.
- Global energy demand is set to increase by almost 50% in the period to 2040. Much of this growth will continue to be concentrated in the developing world as industrialization, population growth and the unprecedented expansion of the middle class will propel the need for energy, while energy consumption in OECD regions will increase by less than 5% during the period 2014–2040.
- Oil and gas will continue to dominate the energy mix, albeit with shifting trends. Combined, the two fuels are expected to supply around 53% of the global energy mix by 2040.
- The downward revision to coal's percentage share within the energy mix by 2040 is driven mainly by lower than previously anticipated demand growth for coal in China – the world's largest producer and consumer – as well as a further switch away from coal in the US.
- Other renewables (mainly, wind, solar and geothermal) are expected to continue to grow at strong rates, averaging 7.6% p.a. However, given their current low initial base, their share in the energy mix will still be a fairly modest 4.3% by 2040.
- Nuclear energy will increase at 2.2% p.a. on average, making up 5.9% of the world's total energy consumption by 2040.
- The oil demand response to lower prices in the medium-term is constrained by factors such as efficiency improvements and energy conservation measures; oil substitution through gas, biofuels and renewables; policies and regulations; and the recent removal of subsidies in several countries.
- In the long-run, oil demand in the OECD regions is expected to decrease by 8 mb/d, down to 37.8 mb/d in 2040. However, oil demand in developing

countries is expected to increase significantly, by almost 26 mb/d, to reach 66.1 mb/d at the end of the forecast period.

- While oil demand growth will continue to come mainly from the transportation and petrochemicals sectors, slowing economic growth, declining population growth rates and further energy efficiency improvements will lead to gradual deceleration of long-term demand growth.
- The penetration of alternative fuel vehicles will increase in the next two decades, but will remain at low levels in the absence of major technology breakthroughs.
- Total tight crude growth to 2040 is expected to face limitations that lead to a plateau of approximately 5.6 mb/d, starting around 2025, followed by a slight decline towards the end of the forecast period. The main long-term increases in non-OPEC crude supply come from Latin America and the Caspian region. Non-tight crudes, natural gas liquids (NGLs), including unconventional NGLs, oil sands and biofuels will be the key to non-OPEC long-term supply growth.
- Total non-OPEC supply is projected to rise from 56.5 mb/d in 2014 to 61.5 mb/d in 2025, but it then declines to 59.7 mb/d by 2040. The uncertainty in non-OPEC supply is skewed to the upside.
- The increase in the overall requirement for OPEC crude between 2015 and 2040 is almost 10 mb/d, while for non-OPEC liquids it is just over 3 mb/d.
- At a global level, oil-related investments required to cover future demand for oil over the forecast period to 2040 is estimated at almost \$10 trillion (in 2014 dollars).
- Investments needed for the upstream sector are estimated at \$7.2 trillion and in the midstream and downstream sector combined it is around \$2.7 trillion in the period to 2040 (in 2014 dollars).
- What this underlines in the current market environment is the delicate balance between prices, the cost of the marginal barrel and future supplies. This balance is essential in making sure the necessary future investments take place.

Downstream

- In the downstream sector, capacity rationalization mainly in OECD countries, and capacity expansion in developing countries are expected.
- Lower oil prices in the past two years have acted to defer numerous refinery projects and to spur some limited medium-term demand growth. Despite some refinery closures that have taken place in recent years, medium-term refining and demand are still not in balance. Therefore, the outlook remains for a period of sustained international competition for product markets and for a continuing need for refinery closures.

- For the period 2015–2020, additional refining capacity of 7.1 mb/d for crude distillation units resulting from major refining projects, plus around 0.8 mb/d of ‘capacity creep’ during the same period, is primarily concentrated in areas of strong demand growth, particularly Asia.
- Compared to longer term requirements, refinery capacity additions are ‘front loaded’. Even with the effects of lower crude oil prices, the total additions expected to be on stream by 2020 represent over 40% of the 20 mb/d of cumulative total additions projected as required by 2040.
- The ongoing eastward shift in oil trade will intensify, and the Middle East is projected to lead the export growth.
- Demand for light products and middle distillates will continue to expand, but residual fuel is set to decline. This is a natural reflection of the expected strong demand in petrochemicals, and the road and aviation transportation sectors.
- The slowing pace of needed refinery capacity additions and the increasing volumes of NGLs and other non-crude supply additions will impact future crude intake volumes.
- Projections highlight a continuing need to increase conversion capacity relative to distillation.
- OPEC Member Countries are also making investments in the refining industry, both at home and overseas. The focus is on creating more added-value from exported products, and building refineries in regions where demand is growing.
- Global marine fuel regulations could have ramifications for refining and oil markets as the International Maritime Organization (IMO) regulations call for global standards for sulphur content in marine fuel to be tightened to 0.5%, from the present 3.5%.

Uncertainties and challenges

- The industry is clouded with uncertainty stemming primarily from economic developments, policy measures and technology. These uncertainties underline the genuine concern that exists over security of demand, which should be seen as the other side of the coin to security of supply.
- From the policy perspective, recent energy policy changes focus primarily on emissions reduction through the use of different sets of measures, such as efficiency improvements across various sectors, support to renewable energy, the removal of subsidies and price controls.
- The Intended Nationally Determined Contributions (INDCs) submitted to the United Nations Framework Convention on Climate Change (UNFCCC) during 2015 provide an important indication about the future direction of energy policies in many countries.

- The 21st Session of the Conference of the Parties (COP21) held in Paris, France, at the end of 2015 was a significant and historic event. COP21 adopted the intensely negotiated new climate change agreement and called it the 'Paris Agreement'. This will have significant implications for the energy industry.
- The Paris Agreement seeks to stabilize global warming, by the end of century, at 2°C or 1.5°C above the mean atmospheric temperature of the pre-industrial period. Achieving this temperature target requires a significant cut in the global emissions of greenhouse gases (GHGs). While the potential for emissions reduction exists in many human activities, a number of factors – most importantly, the availability of appropriate technologies and the financial resources associated with emissions reduction – are considered necessary.
- Energy access remains a crucial global challenge as more than a billion people have no access to electricity. They need access to reliable, safe and secure modern energy services to live and prosper.
- Oil can play a role in helping alleviate energy poverty, through sustainable and supportive policies and investments. The oil industry can contribute to this effort by increasing the diversity and continuity of energy services to the poor.
- The OPEC Fund for International Development (OFID), which was established by OPEC Member Countries in 1976 as a collective channel of aid to developing countries, has provided financial assistance to date totalling \$18.7 billion through 3,529 operations – many of which are in Africa and address poverty alleviation, including energy poverty, through a range of actions that also support access to renewable energy sources. In addition, most OPEC Member Countries have established funds for international help and cooperation.

1. INTRODUCTION

The inclusive role of the International Energy Forum (IEF) as the principal organization in advancing consumer-producer dialogue and for the world energy community has been widely acknowledged. This has been particularly facilitated through enhanced interaction between producing and consuming countries, productive dialogue, experience sharing, and a platform for improved data transparency.

The specified areas for IEA-IEF-OPEC cooperation, as guided by the 12th IEF Ministerial Meeting and the Cancún joint Ministerial Declaration of March 2010, have resulted in very productive joint activities that have been held annually since 2011. In 2016, a number of events have taken place.

In February 2016, the sixth IEA-IEF-OPEC Symposium on Energy Outlooks was held in Riyadh, Saudi Arabia, again providing an excellent platform for furthering cooperation and dialogue, and bringing together experts from around the world. Bearing in mind the challenges witnessed in energy markets in 2015, the discussions on outlooks and the impacts of the low oil price environment on supply and demand, stability and growth, were timely and important.

In March 2016, the IEA, IEF and OPEC hosted their fifth joint workshop on the Interactions between Physical and Financial Energy Markets at the OPEC Secretariat in Vienna, Austria. The event focused on recent oil market volatility; the role of financing and hedging in oil market developments; financial oil market regulation; and a review of current and potential Asian oil benchmarks. Moreover, the third IEA-IEF-OPEC Symposium on Gas and Coal Market Outlooks is planned to take place in the last quarter of 2016 in Paris, France.

During the year OPEC also continued its active participation in the Joint Organisations Data Initiative (JODI). This initiative aims to improve transparency and the completeness of global oil and gas data. OPEC has been one of the main drivers of the JODI programme and currently participates in both JODI Oil and JODI Gas, along with other as partner organizations, under the co-ordination of the IEF Secretariat.

This background paper analyzes the outlook for energy and oil demand and supply, together with the uncertainties, challenges and opportunities. It aims to support the discussion and deliberations at the 15th IEF Ministerial Meeting that will take place in OPEC Member Country, Algeria.

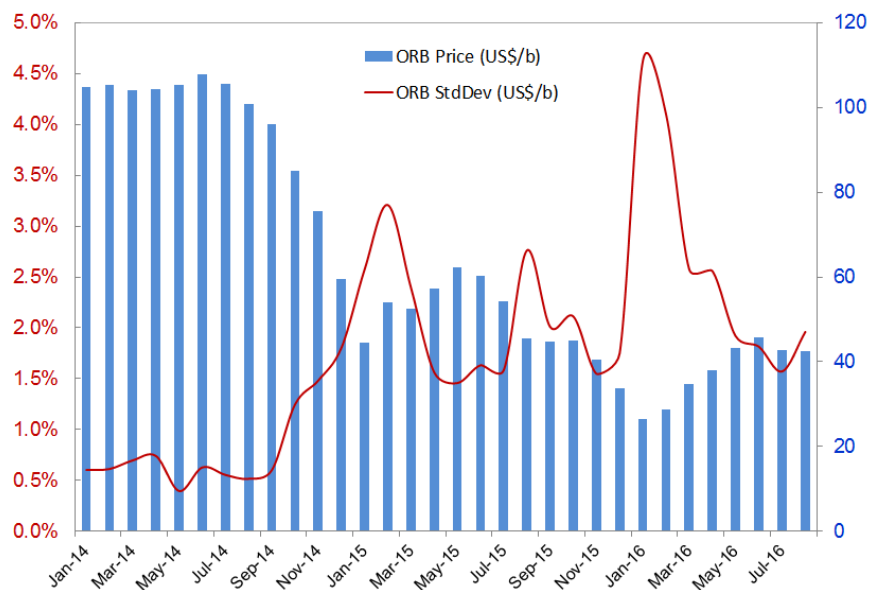
The paper initially captures the key insights and briefly discusses the most significant changes since the last IEF Ministerial Meeting in May 2014, as well as the corresponding issues that have come to the fore and which are expected to shape the energy landscape over the medium- and long-term. This is followed by a review of OPEC's Reference Case outlook for energy and oil supply and demand in the period to 2040, including alternative scenarios to address some of the key uncertainties in the outlook. The subsequent two sections reflect upon the downstream and key challenges on climate change and sustainable development.

2. OIL MARKET DEVELOPMENTS

At the 14th IEF Ministerial Meeting, held in Moscow in May 2014, crude oil prices were above \$100/b. Since then prices have witnessed some major volatility (Figure 1). Average annual oil prices almost halved in 2015 compared with 2014, settling below \$50 as global oil markets continued to suffer from a persistent oversupply coupled with increasing signs of a slowdown in the Chinese economy. Along with these two factors, a significant price decline in global equity and commodity markets abetted to depress oil prices. The engine of China's energy demand, the industrial sector, performed poorly over the year, with the Purchasing Managers' Index ending 2015 much lower than anticipated. In addition, oil prices were driven down by financial flows caused by fluctuations in other asset prices, including the US dollar.

At the beginning of 2016, OPEC Reference Basket (ORB) price, with higher volatility, slumped below \$30/b before moving upwards to again the mark of \$50/b during June (Figure 1), signalling that markets were finally healing as declining US output, falling US crude oil inventories, rising oil demand and disruptions in a number of oil producing countries helped to reduce the global excess surplus.

Figure 1
Crude oil price and volatility (2014–2016)



The transatlantic (ICE Brent versus Nymex WTI) spread or Brent premium over WTI decreased significantly in 2015 with US crude gaining some support from reduced drilling and the lifting of a ban on most US crude exports. This briefly pushed US crude to a premium to global benchmark Brent in December for the first time in about a year. Brent was pressured by oversupply. This narrowing trend supported crude imports from West Africa back to the US. The spread narrowed by from \$6.50 in 2014 to \$4.85 in 2015. In the first half of 2016, the spread narrowed further averaging \$1.51 amid a continued decline in US crude commercial stocks, and a decline in US production. The aftermath of wildfires in Alberta, Canada, also impacted the spread during the 2Q16.

With numerous challenges in the world economy, global GDP softened in 2015, reaching a growth level of 2.9%. It should also be noted that the growth became increasingly uneven; the growth differentials among various economies were large. In addition, there were still considerable quantities of unused resources in terms of labour, with high unemployment rates in some advanced economies, as well as some emerging and developing ones too. In 2006, global economic growth in 2016 is estimated at 2.9%, the same level as last year. In 2017, global economic growth is forecast to creep higher to 3.1%. Growth will be impacted by the dampening effect of the UK vote to leave the EU and below potential growth in several other countries, such as Russia, Brazil and China.

OECD economies are now forecast to grow by 1.8% 1.6% in 2016, compared to 2.2% in 2015. Next year's growth is forecast to slow to 1.6%. Growth for the Euro-zone and the UK in 2016 now stands at 1.5% in both economies, while lower growth is anticipated for 2017 at 1.2% and 0.4%, respectively. The US is forecast to have slightly higher growth in 2017 at 2.1%, after anticipated growth of 1.5% in 2016. After having postponed a 2017 sales tax increase, Japan may see slightly higher growth in the coming year at 0.9%, compared to 0.7% in 2016.

In 2017, India and China are expected to continue to expand at considerable rates of 7.2% and 6.1%, respectively, although this is slightly lower than in 2016 when growth is estimated at 7.5% and 6.5%, respectively. While both Brazil and Russia are forecast to remain in recession for a second consecutive year in 2016, they are both forecast to recover in 2017 with growth of 0.4% and 0.7%, respectively. This will be fuelled by improving domestic demand and rising commodity prices.

Among the numerous challenges for global economic growth in the second half of 2016 and for 2017, the outcome of the UK's decision to leave the EU will be of great importance. In addition, the monetary policies of major central banks will continue to be influential, but are expected to remain accommodative across the globe.

With a low oil price environment, the year 2015 was exceptional for oil demand. Oil consumption growth was above 1.5 mb/d, the second highest level of growth in the past ten years, with 2010 being the highest. In contrast to 2014, both OECD and non-OECD contributed to this increment, growing by 0.4 mb/d and 1.1 mb/d, respectively. This growth was propelled by lower oil prices that encouraged transportation fuel demand, in addition to solid gains in the petrochemical sector in China, the US and the Asia-Pacific.

For 2016, oil demand is anticipated to grow by around 1.2 mb/d, below last year's growth, but still broadly robust. Demand in the OECD region is projected to grow by 0.3 mb/d, with the US leading the way, while Europe is expected to be broadly flat compared to the previous year and the Asia-Pacific (OECD) is anticipated to decline. Positive projected growth in the US economy and continued healthy growth in the road transportation sector are seen to outweigh the downside assumptions for overall US oil demand, mainly linked to fuel substitution and vehicle efficiencies.

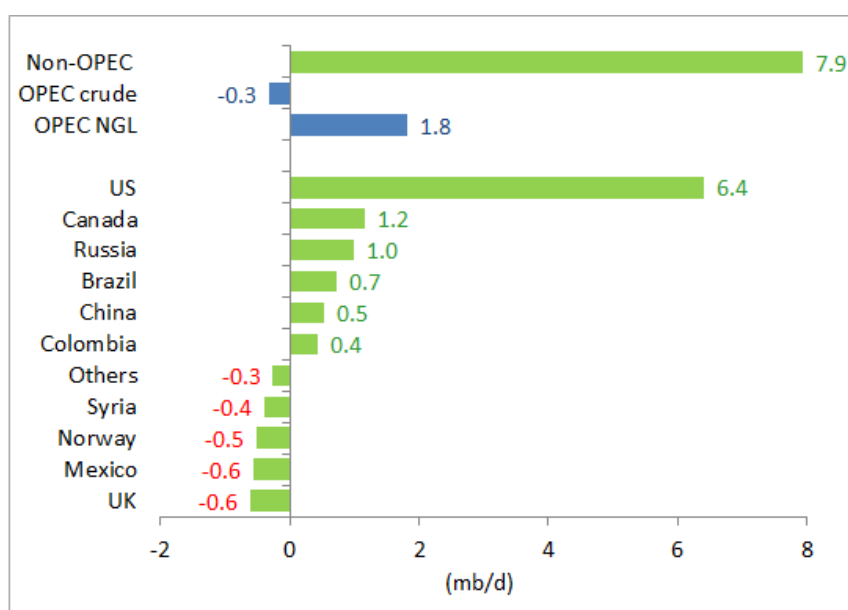
Oil demand growth in 2017 is projected at around 1.2 mb/d. Various positive assumptions have been considered in the 2017 projection, the most notable being the slight improvement in global economic activities; higher road transportation fuel consumption, due to the strong rebound in vehicle sales in the US, China and India; and demand for petrochemical feedstocks from new projects in the US and China.

On the other hand, efficiency in fuel consumption is assumed to increase steadily in various regions and potential subsidy reductions will also have a greater impact on oil consumption. As a result, OECD oil demand is anticipated to increase by a marginal 0.1 mb/d, with OECD America being firmly in the positive, while OECD Europe and the Asia-Pacific are expected to decline. Non-OECD growth is expected to be around 1.1 mb/d, with the Other Asia region being the major contributor to overall growth.

Non-OPEC oil producers saw a historically strong expansion of oil supply in 2014, with remarkable growth of 2.3 mb/d. In 2015, non-OPEC oil production showed further strong growth of 1.4 mb/d, despite the decline in oil prices and a 26% cut in global E&P spending. Additional production from already-sanctioned projects coming on stream was a key driver behind this continued healthy growth.

Putting OPEC and non-OPEC oil supply growth in recent years into perspective, it is observed that non-OPEC supply growth between 2008 and 2015 was more than 7.9 mb/d, of which the US (6.4 mb/d), Canada (1.2 mb/d), Russia (1.0 mb) and Brazil (0.7 mb/d) constituted the significant part of it (9.3 mb/d). OPEC crude oil production growth over the same period was even negative, while additional growth of 1.8 mb/d was attributed to OPEC NGLs (Figure 2).

Figure 2
Cumulative growth in liquids supply (2008–2015)



In 2016, cuts in global capital expenditures (capex) are expected to continue to be significant, negatively impacting the amount of new oil discoveries. Some \$300 billion is estimated to be cut from company's capex in 2015/2016. This would continue the declining trend in new discoveries started last year in which less than 3 billion barrels were added to the discovered oil, much less than in previous years. Overall, non-OPEC supply in 2016 is expected to contract by 0.6 mb/d, with US oil output contracting by around 0.4 mb/d mb/d.

For 2017, non-OPEC oil supply is projected to increase slightly by 0.2 mb/d. In regional terms, declines in OECD are projected around 0.1 mb/d, while developing countries in Africa and Latin America are forecast to register growth. The forecast for non-OPEC supply next year is associated with a high level of risk, mainly due to price developments.

The rise in global supply and its outpacing of the increase in world oil demand has resulted in a steady global oil inventory build since mid-2014. The difference to the five-year average in terms of OECD commercial stocks reached nearly 380 million barrels at the end of February 2016, before slowing down to about 340 mb at the end of July 2016. Stocks in the non-OECD region also rose since the end of 2014 by around 200 million barrels to nearly 2250 million barrels, encouraged by lower crude oil prices.

The expected increase in world oil demand along with the projected minor growth in non-OPEC supply in 2017 will help to reduce the imbalance in the fundamentals, and result in easing the excess supply.

3. WORLD OIL OUTLOOK¹

3.1 Overview of the Reference Case

Trends in future energy demand and supply presented in this background paper are based on the assumption that the global economy, driven by demographic and productivity trends, will grow by 3.5% p.a. on average during the period 2014–2040.

This assumption is primarily driven by growing population. Based on the UN World Population Prospects, world population will increase from 7.2 billion in 2014 to 9 billion in 2040. Population growth in the OECD region is expected to be rather low, while Eurasia is anticipated to see its population decline in the period to 2040 driven by developments in Russia. Most population growth will come from developing countries. Middle East & Africa and OPEC Member Countries are expected to witness the highest population growth rates in the next 25 years. China's population will peak in 2028, and India will surpass China as the country with the largest population sometime around 2026.

¹ The projections and scenarios are based on the 2015 edition of the World Oil Outlook, while the 10th edition (2016) will be published in November 2016. Contrary to OPEC's current membership of fourteen as of 2016, Indonesia and Gabon are included according to their regional location and excluded from OPEC in the projections and scenarios in this section.

An important feature of this growth is the changing demographics as the world population is expected to age significantly in the next few decades. The population pyramid in 2040 is clearly less pronounced than in 2014. The share of people under 15 declines in every region, particularly in Other Asia and India. Furthermore, the share of people over 64 increases in every region, especially in China and OECD Asia Oceania. In the latter region, one out of every three individuals will be over 64 in 2040. Another important demographic trend that is anticipated to have a significant impact on energy demand is the continuous urbanization of the world. While in 1950 only one out of every three people lived in urban areas, in 2008, for the first time, more people were living in urban areas than in rural settlements. It is expected that by 2040 the urbanization rate will reach 63%.

Moreover, long-term GDP estimates also incorporate the ‘conditional convergence’ theory which assumes that in the very long-run countries will converge to the same growth rate of income per capita growth. This global convergence level is driven by technological progress. A direct implication of this is that GDP per capita in poorer countries will grow faster than in developed countries due to human and physical capital accumulation. The forecasting framework adopted in this paper assumes that the global rate of productivity growth is 1.3% p.a.

As a result, the world economy in 2040 will be 244% of what it was in 2014. Developing countries will account for three-quarters of the growth averaging 4.6% p.a. for the forecast period (Table 1). China and India alone will account for half of this growth. The average growth rate for the OECD is estimated at 2.1% p.a. Within the OECD, the region with the highest expected growth is OECD America, driven by healthy population expansion. For Eurasia, an average growth rate of 2.1% p.a. is projected over the forecast period.

Table 1
Long-term real GDP growth rates in the Reference Case
(% p.a.)

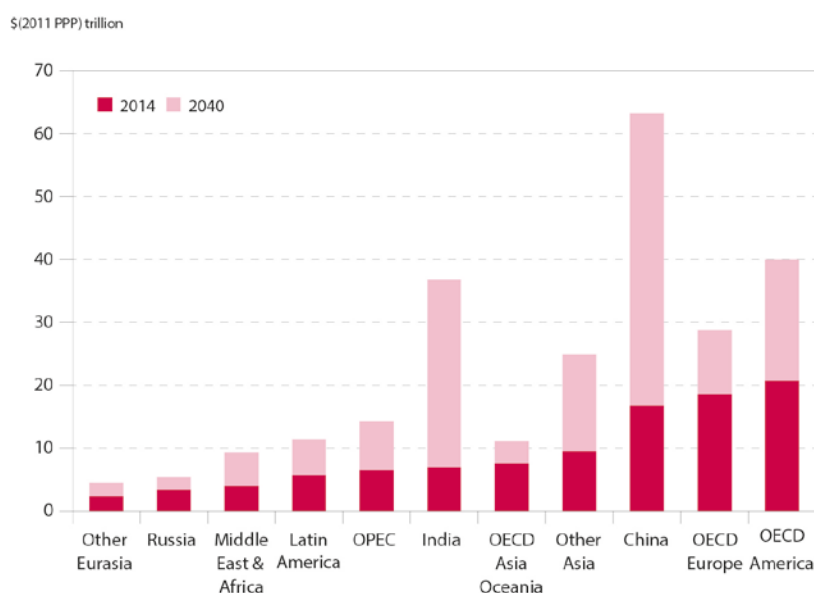
	2014–2020	2020–2030	2030–2040	2014–2040
OECD	2.2	2.1	1.9	2.1
Developing countries	5.1	4.8	4.1	4.6
Eurasia	1.4	2.4	2.2	2.1
World	3.6	3.6	3.3	3.5

Regional GDP estimates are shown in Figure 3. It is evident that the configuration of the world economy will change significantly in the next 25 years. In 2014, China’s GDP is 9% lower than OECD Europe and 19% lower than OECD America. However, in 2040, its GDP compared to these two regions will be 120% and 60% higher, respectively.

In fact, China’s share in world GDP will increase steadily from 16% in 2014 to 25% in 2040. The case of India is even more pronounced. Its weight in the global economy is anticipated to more than double during the forecast period, from 7% to

15%. Furthermore, India's GDP will exceed that of OECD Asia Oceania and OECD Europe, and approach the size of that of the OECD America region by the end of the forecast period. Estimates also suggest that Latin America and OPEC will overtake OECD Asia Oceania in terms of GDP, while Other Asia's GDP will approach the size of OECD Europe by 2040.

Figure 3
Real GDP by region in 2014 and 2040



Besides economic development, projections also take into account policies already in place. It should be noted, however, that it is accepted that the policy process will evolve over time through the introduction of new policies as a reasonable extension of past trends and as a reflection of current debate on policy issues.

Recent changes in energy policies focus primarily on emissions reduction through the use of different sets of measures. One set of measures targets tighter fuel efficiency standards, such as Phase 2 of the Corporate Average Fuel Economy (CAFE) standards for heavy-duty vehicles in the US, the new Corporate Average Fuel Consumption standards (CAFC) in India and the introduction of EURO 6 standards in the EU. These are typically supplemented by better energy efficient standards for residential buildings (for example in China, the US, and the EU). Another set of measures relates specifically to the power sector either through specific targets for emissions reduction (for example, the Clean Power Plan in the US) or through support to renewable energy in the sector (for example, EU efforts to increase the share of renewable energy). Finally, the removal of subsidies and price controls in several countries (such as India, Egypt, Malaysia and the UAE) also contributes to the overall policy focus.

The INDCs submitted to the UNFCCC during 2015, also provided an important indication about the direction of future energy policies in many countries.

Last, but certainly not least, technology plays an important role in shaping future energy and oil demand. Technological developments will help expand the exploration for new reserves, enhance mobility, improve efficiencies, and find new uses and applications for energy, oil and its derivatives.

In the case of oil, the introduction of new technologies – such as that of enhanced oil recovery (EOR) for maturing oil fields and those that facilitate production from shale plays and deep sea areas – allows producers to turn previously inaccessible unconventional reservoirs into producing fields. Technology will also help to limit the increase in upstream costs through energy efficiency programmes or improved oil field management, such as smart fields and the electrification of oil field operations. In addition, alternative energies like solar or wind can be integrated into oil exploration and production activities in order to reduce emissions and improve the environmental aspects of production.

Further downstream, technology will continue to play a prominent role in several directions. It could further reduce, or slow, the share of oil in many traditional and well-established areas, such as the power and transportation sectors. On the other hand, it could also expand and increase energy and oil demand into new markets and for new applications, as well as areas where oil's share is in decline. In this respect, carbon capture and utilization (CCU) offers opportunities to combine power generation from fossil fuels by reinjecting CO₂ into maturing oil fields. CCU can enhance energy security by collecting CO₂ and using it for EOR, while at the same time making hydrocarbon-based power generation carbon neutral.

Technological improvements, in terms of alternative fuels and new drive concepts, are anticipated to limit the demand growth in the transport sector to a moderate or modest pace. The costs of car electric batteries are anticipated to be further reduced in the coming decades and the performance will improve. However, without major breakthroughs in battery technology, the concept of plug-in battery electric cars may not achieve mass market appeal very soon due to the many inconveniences and consumer reservations. Nonetheless, lower battery costs and maturing technology will be supportive for hybrid electric vehicles, thus leading to further improvements in overall fuel economy.

Renewable forms of energy are also becoming more competitive. Onshore wind energy is expected to become one of the most efficient and cleanest ways to generate electricity at a nearly similar cost to coal or combined-cycle natural gas plants. Moreover, given the current pace of cost reductions, photovoltaic or concentrated solar power could become competitive to wind energy in the longer term.

3.2 Energy and oil demand

3.2.1 Energy demand in the Reference Case

As an essential ingredient for growth and development, energy has become the driving force of the modern economy. From 1970–2013, global energy consumption increased by 157% – from 104 million barrels of oil equivalent per day (mboe/d) to 268 mboe/d. In this period, the majority of the growth occurred in parts of the

developing world where advancing high levels of industrialization, urbanization, population growth and income growth have increased energy demand by almost 500% over the period 1970–2013. OECD energy consumption also increased during this period, but only by 69%, due to the adoption of new energy efficient technologies, an increased focus on low energy-intensive industries and limited population growth.

In the years ahead, global energy demand is set to grow by 49%, from 268 mboe/d in 2013 to 399 mboe/d by 2040 (Table 2). This corresponds to an average growth rate of 1.5% p.a. Much of this will continue to be concentrated in the developing world. Industrialization, population growth and the unprecedented expansion of the middle class will propel the need for energy there. By 2040, the developing world is expected to make up 63% of total global energy consumption, a marked increase from 50% in 2014. OECD energy consumption, on the other hand, is anticipated to only increase 5% from 2013–2040, due to the continued focus on low energy-intensive industries, improved energy efficiency and slowing economic growth.

Table 2
World primary energy demand in the Reference Case

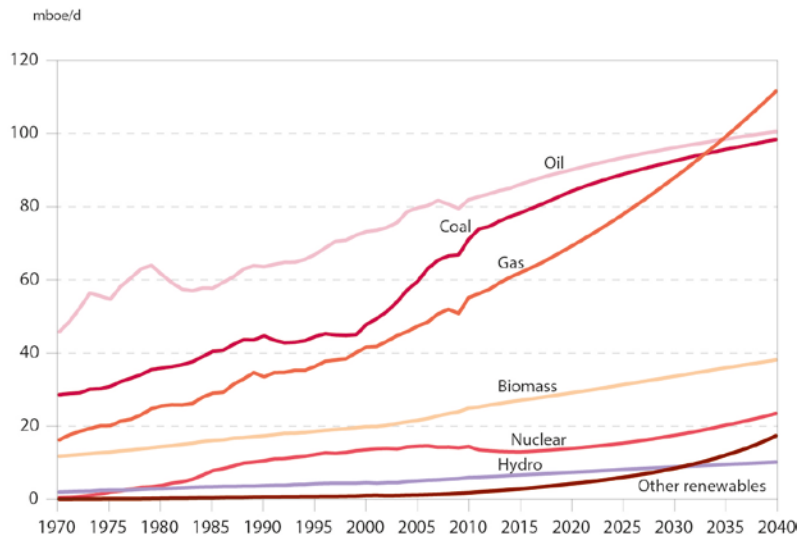
	Levels mboe/d				Growth % p.a.	Fuel shares %			
	2013	2020	2030	2040	2013–40	2013	2020	2030	2040
Oil	84.4	90.1	96.1	100.6	0.7	31.5	30.2	27.9	25.2
Coal	76.1	84.2	92.4	98.3	1.0	28.4	28.3	26.8	24.6
Gas	59.2	69.1	87.7	111.5	2.4	22.1	23.2	25.5	27.9
Nuclear	13.1	13.9	17.5	23.5	2.2	4.9	4.7	5.1	5.9
Hydro	6.3	7.4	8.9	10.2	1.8	2.4	2.5	2.6	2.5
Biomass	26.2	29.1	33.6	38.1	1.4	9.8	9.8	9.8	9.5
Other renewables	2.4	4.3	8.4	17.4	7.6	0.9	1.4	2.4	4.3
Total	267.6	298.0	344.6	399.4	1.5	100.0	100.0	100.0	100.0

In parallel to changes in total energy consumption, the demand for primary energy sources has also evolved over time and is projected to change in the coming years. Since the 1970s, traditional fossil fuels have been the dominant energy source (Figure 4). Oil, the leading energy source in 1970, made up 43% of total energy demand, while the shares of coal and natural gas were at 27% and 15%, respectively. By 2013, however, these figures had shifted somewhat. The share of natural gas had increased to 22%, while that of oil had dropped to 32% (Table 2). Coal's share remained roughly constant over the period.

Although traditional fossil fuels have remained the primary energy source, alternative fuels are gaining share. Following technology advancements, and with countries under pressure to look for sustainable alternatives to traditional fossil fuels, alternative energy sources have emerged. These include nuclear, hydropower, biomass and other renewables, which have evolved and emerged as viable substitutes to fossil fuels, partly as a consequence of targeted incentives and policies. Making up

13% of total energy consumption in 1970, nuclear, hydropower, biomass and other renewables have seen modest growth, increasing their share in global energy consumption to a combined 18% by 2013.

Figure 4
Global energy mix by fuel type, 1970–2040



Moreover, changes in the energy mix are expected to continue, though fossil fuels will continue to dominate the mix at almost 78% by 2040. In the next 20 years, oil will remain the fuel with the largest share of global energy use. However, its relative weight is projected to decline in the coming decades. By the 2030s, oil is expected to drop below 28%. A similar declining trend is anticipated for coal. By 2040, natural gas is estimated to have the largest share, making up almost 28% of global energy demand, with both oil and coal having lower shares by then. Combined, however, oil and gas are anticipated to supply around 53% of the global energy mix by 2040, similar to current levels.

Alternative energy will also witness significant changes in the coming years. Between 2020 and 2040, nuclear energy is expected to increase its production by almost 80% and make up almost 6% of total energy consumption. Hydropower and biomass, though continuing to grow, will keep their shares relatively stable – with hydro at around 2.5% and biomass within a narrow range around 9.5%. Other renewables – mainly wind and solar – are expected to grow at the fastest rates, multiplying their contribution to the total primary energy supply by more than seven times. Their overall share will nevertheless remain low, reaching around 4% in 2040.

3.2.2 Oil demand in the Reference Case

Medium-term oil demand in the Reference Case increases by an average of 1 mb/d p.a., from 91.3 mb/d in 2014 to 97.4 mb/d by 2020. During this period, oil demand in the OECD region is projected to decline by 0.2 mb/d, totalling 45.6 mb/d by 2020. Within the OECD, important decreases in oil demand are expected in OECD Europe and OECD Asia Oceania (–0.2 mb/d and –0.5 mb/d, respectively). On the

other hand, demand in OECD America is projected to grow by 0.4 mb/d between 2014 and 2020. Oil demand in developing countries is anticipated to increase by 6.1 mb/d between 2014 and 2020, reaching 46.4 mb/d by 2020. Moreover, demand in developing countries will also surpass that of the OECD by 2020. In the medium-term, demand in Eurasia is set to increase by 0.3 mb/d, reaching 5.5 mb/d by 2020.

In the long-term, the Reference Case sees oil demand increasing by 18.4 mb/d between 2014 and 2040, reaching 109.8 mb/d at the end of the forecast period. As shown in Table 3, demand in the OECD region is expected to decrease by 8 mb/d, down to 37.8 mb/d in 2040. In contrast, oil demand in developing countries is expected to increase, by almost 26 mb/d, to reach 66.1 mb/d at the end of the forecast period. Finally, demand in Eurasia is estimated at 5.8 mb/d in 2040. This represents a minor increase of 0.6 mb/d between 2014 and 2040.

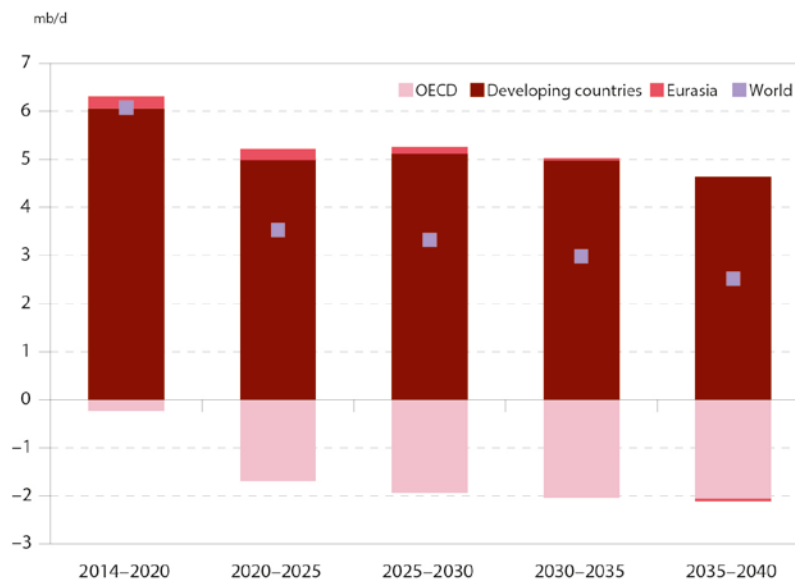
Table 3
Long-term oil demand outlook in the Reference Case
(mb/d)

	Levels							Growth
	2014	2015	2020	2025	2030	2035	2040	2014-2040
OECD America	24.2	24.5	24.6	23.7	22.6	21.4	20.2	-4.0
OECD Europe	13.5	13.6	13.3	12.8	12.3	11.8	11.3	-2.2
OECD Asia Oceania	8.1	8.1	7.7	7.4	7.0	6.7	6.3	-1.8
OECD	45.8	46.2	45.6	43.9	41.9	39.9	37.8	-8.0
Latin America	5.6	5.7	6.2	6.6	6.9	7.2	7.5	1.9
Middle East & Africa	3.7	3.8	4.2	4.7	5.1	5.6	6.1	2.4
India	3.8	3.9	4.7	5.7	6.9	8.3	9.6	5.8
China	10.5	10.8	12.4	13.9	15.4	16.7	18.0	7.5
Other Asia	7.5	7.7	8.6	9.6	10.7	11.6	12.3	4.8
OPEC	9.3	9.5	10.2	10.8	11.5	12.1	12.6	3.3
Developing countries	40.3	41.4	46.4	51.4	56.5	61.5	66.1	25.8
Russia	3.4	3.4	3.4	3.5	3.5	3.5	3.4	0.0
Other Eurasia	1.8	1.8	2.0	2.2	2.3	2.4	2.4	0.6
Eurasia	5.2	5.2	5.5	5.7	5.8	5.9	5.8	0.6
World	91.3	92.8	97.4	100.9	104.3	107.2	109.8	18.4

In terms of demand growth, Figure 5 shows an overall downward trend during the forecast period. While medium-term global oil demand is expected to grow by 6.1 mb/d during the period 2014–2020, growth decelerates to 3.5 mb/d during the period 2020–2025 and 3.3 mb/d for 2025–2030. During the timeframe 2030–2035, it further decreases to 3 mb/d and then to 2.5 mb/d over the last five years of the forecast period. On an annualized basis, global demand growth gradually declines from an average of around 1 mb/d during the medium-term to around 0.5 mb/d each year during the period 2035–2040. Decelerating economic growth, declining population growth rates, policies and further energy efficiency improvements are behind this downward growth trend.

However, Figure 5 reinforces a similar observation seen in the medium-term. That is that long-term demand growth is clearly driven by developing countries. The OECD shows negative growth for the whole period (except for 2015 and 2016). The expected oil demand decline is mainly a result of efficiency improvements and the progressive penetration of alternative fuel vehicles in the road transport sector. Additionally, efficiency gains in the residential, commercial and public services sector, coupled with the continued switching away from oil in the electricity sector are expected to add downward pressure on oil use. In contrast, demand growth is expected in the aviation sector and in petrochemicals, which will help limit the oil demand decline. Eurasia shows marginal positive growth up to the mid-2030s, before assumed efficiency improvements, supported by a fall in population, reverses the trend for the rest of the forecast period to a marginal demand decline.

Figure 5
Global oil demand growth in the long-term

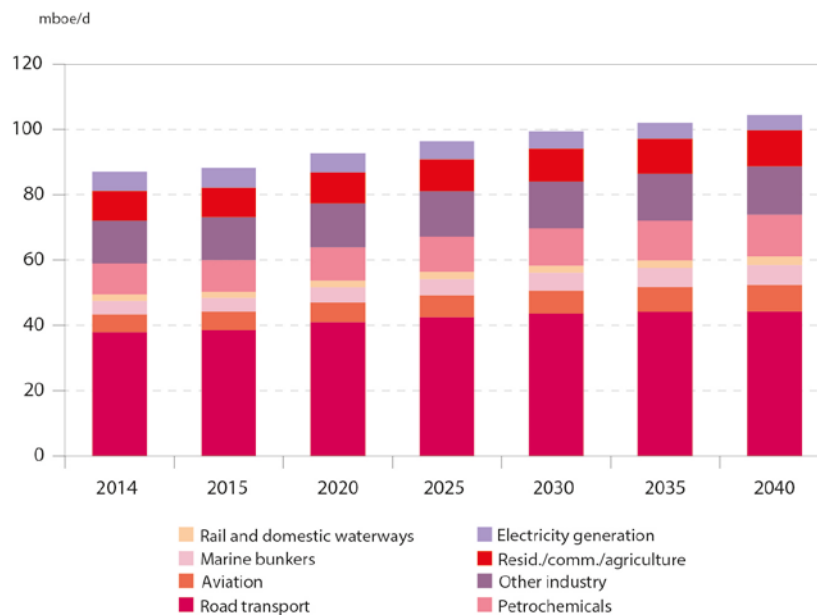


The long-term demand prospects for developing countries are dominated by developing Asia (China, India and Other Asia), which accounts for most of the growth. Demand growth in developing countries is led by the transportation sector, particularly by the road sub-sector, as a result of growing demand for mobility on the back of increasing income levels, trade and urbanization. As developing countries continue to industrialize and develop their infrastructure, the petrochemical and other industry sectors will also support demand growth in the years to come. It is also interesting to observe the growing weight that India has on demand growth supported by high economic growth and good demographic prospects. While in the medium-term India accounted for 15% of the growth in developing countries, at the end of the forecast period its contribution increases to almost 30%.

Figure 6 shows global oil demand by sector. Road transportation is clearly the largest contributor to demand with 38 mboe/d in 2014 (44% of total demand). It is expected to increase to 44.4 mboe/d (42% of total demand) in 2040. Furthermore, over one-third of the demand growth between 2014 and 2040 comes from the road

transportation sector. Other industry, comprising primarily iron and steel, glass and cement production, construction and mining, is the second largest sector with 13.1 mboe/d in 2014 (15% of total demand). It is expected that this sector will continue to have the second highest oil demand level in 2040 with 14.6 mboe/d. The petrochemicals sector is also an important source of oil demand. In 2014, 9.5 mboe/d was consumed in this sector (11% of total demand). Strong growth is expected in the future, adding a further 3.4 mboe/d by 2040. Demand in the residential/commercial/agriculture sector totalled 9 mboe/d in 2014 (10% of total demand). In 2040, it is estimated that demand will have increased by 2 mboe/d.

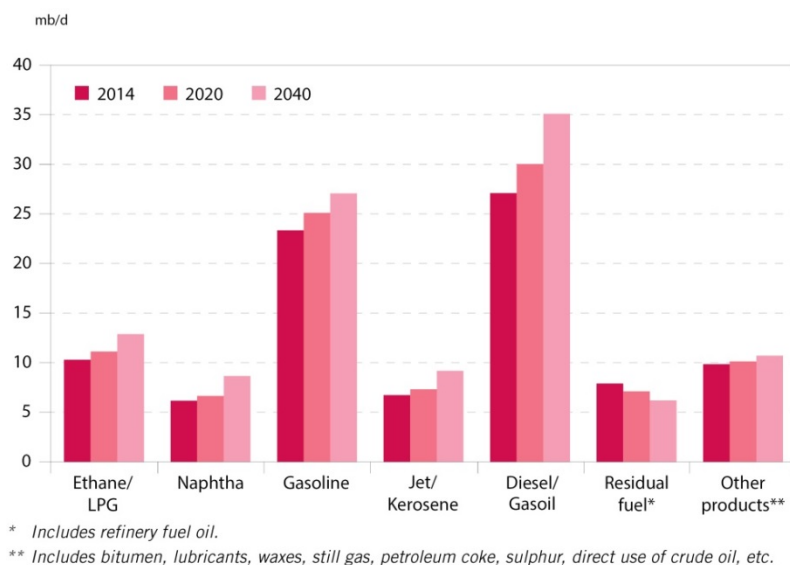
Figure 6
Global oil demand by sector in the Reference Case



The use of oil in electricity generation is marginal. In 2014, sectoral demand added up to 5.9 mboe/d (7% of total demand). Looking ahead, this is the only sector where demand is expected to decline, falling to 4.7 mboe/d in 2040. Demand in the aviation sector totalled 5.4 mboe/d in 2014 (6% of total demand). An additional 3 mboe/d is expected by 2040. In the marine bunkers sector demand was 4.2 mboe/d in 2014 (5% of total demand) and an additional 2 mboe/d is expected by 2040. Finally, the rail and domestic waterways sector has the smallest level of oil demand, accounting for only 1.9 mboe/d in 2014 (2.2% of global demand). It is, however, estimated that demand will increase to 2.5 mboe/d by 2040 (2.4% of global demand).

The Reference Case product demand outlook is shown in Figure 7. There are several interesting trends worth noting. Firstly, with the exception of residual fuel, increasing demand is expected for all refined products. Demand for residual fuel will instead decline by 1.7 mb/d between 2014 and 2040. Secondly, important demand increases are expected in diesel/gasoil (8 mb/d) and gasoline (3.7 mb/d). This highlights the importance of the road transportation sector as a source of growing oil demand. Finally, strong growth is expected in middle distillates, which will account for 57% of the demand growth in refined products.

Figure 7
Global product demand in the Reference Case



3.2.3 Alternative economic growth scenarios

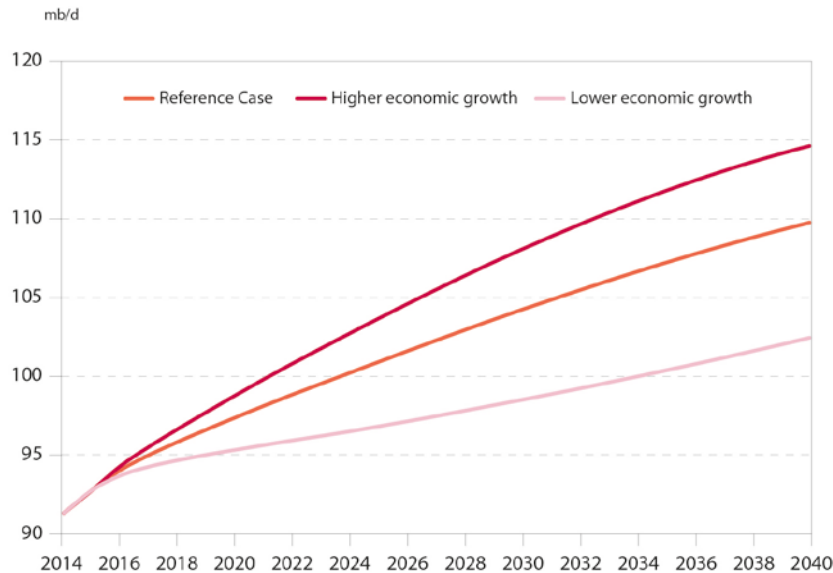
The global oil market faces a variety of uncertainties and challenges which come from a wide variety of sources. It is evident that the global economic outlook remains a fundamental source of uncertainty. Even though the world is becoming increasingly less oil-intensive, the economy continues to be a fundamental market driver. Therefore, economic turbulences are inevitably translated into industry uncertainty. In order to account for this source of uncertainty, alternative scenarios have been constructed. While in the Reference Case average global growth for the period 2014–2040 was assumed at 3.5% p.a., in the higher economic growth scenario it is 3.7% p.a., and in the lower one it is 3.1% p.a.

Higher and lower GDP growth assumptions clearly have a significant impact on oil demand in comparison to the Reference Case. This is shown in Figure 8. The resulting demand outlook under the higher economic growth scenario shows that global oil demand reaches 114.6 mb/d in 2040. That is 4.9 mb/d higher than in the Reference Case. In the case of the OECD region, long-term oil demand is 1.2 mb/d higher, totalling 39 mb/d in 2040. In developing countries, the higher economic growth scenario results in oil demand increasing to 69.6 mb/d by 2040. This represents a difference of 3.5 mb/d with respect to the Reference Case. Oil demand in Eurasia reaches 6.1 mb/d by 2040, or 0.2 mb/d higher than the Reference Case.

Turning to the lower economic growth scenario, the resulting demand outlook is also shown in Figure 8. As expected, oil demand is considerably lower under this scenario. Global oil demand is estimated to be 7.3 mb/d lower than in the Reference Case, reaching 102.4 mb/d in 2040. In the case of the OECD region, oil demand is estimated to be 36.4 mb/d at the end of the forecast period. This is 1.5 mb/d lower than in the Reference Case. Demand in developing countries is expected to be 60.6

mb/d in 2040, or 5.5 mb/d lower than in the Reference Case. In Eurasia oil demand in 2040 is estimated to be 5.5 mb/d, or 0.3 mb/d lower than in the Reference Case.

Figure 8
World oil demand in the economic growth scenarios



It is interesting to observe that despite the global economy becoming less oil intensive, alternative GDP growth assumptions do have a significant effect on demand for oil. The demand range emerging from the scenarios is over 12 mb/d by 2040, further emphasizing the underlying uncertainty in the market.

3.3 Liquids supply

3.3.1 Liquids supply in the medium-term

The primary driver of non-OPEC liquids growth in the past few years has been the US & Canada. Most of the recent increases have been due to tight oil developments (a combination of tight crude and unconventional NGLs), the result of advances in the use of horizontal drilling coupled with hydraulic fracturing.

Substantial increases in non-OPEC oil supply in the period 2012–2014 eventually led to the rise in global stock levels and the price collapse that was witnessed towards the end of 2014 and during 2015. The impact from the low oil price environment on upstream investments and on supply is now clearly visible in the market. Global upstream capital expenditures for 2015 were reduced across the industry, including a significant drop in E&P investment, which was around 20% lower on average compared with 2014.

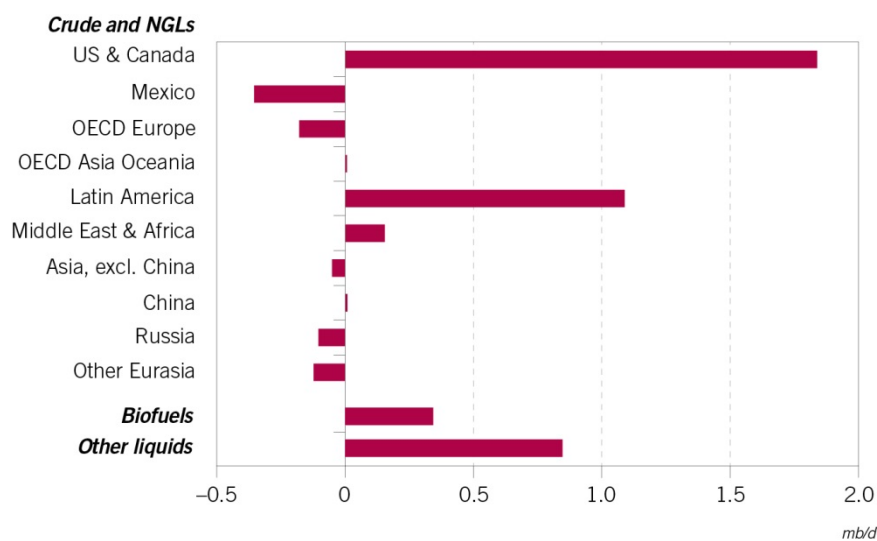
The effect of the lower oil price is most apparent with regard to tight crude production, which has a greater price elasticity of supply compared with more capital intensive sources, such as oil sands or offshore. In the absence of continuous drilling, the steep decline rates of tight crude wells imply that output

should decrease. Although the most prolific zones within some plays can break even at levels below prices observed in 2015, and are thus likely to see some continued production growth, month-on-month growth of total tight crude production has been declining.

In the medium-term, the Reference Case sees liquids supply in the US & Canada reach 19.8 mb/d by 2020, with tight crude amounting to 5.2 mb/d. Supply from Latin America (non-OPEC) increases to 6.2 mb/d, while production from Russia stays even at about 10.6 mb/d over the period. Total non-OPEC supply increases from 56.5 mb/d to 60.2 mb/d between 2014 and 2020, which is an increase of 3.7 mb/d.

Figure 9 shows the growth in non-OPEC supply between 2014 and 2020. Even though the main sources of growth are expected to come from tight crude and unconventional NGLs in the US, Latin America contributes a growth of about 1.2 mb/d over the medium-term, mainly from Brazil. The largest supply reduction, almost 0.4 mb/d of crude, is projected for Mexico, as the new energy reforms there are currently not expected to reverse the declining trend over the medium-term.

Figure 9
Growth in non-OPEC liquids supply, 2014–2020



Other liquids (excluding biofuels), which are primarily composed of Canadian oil sands, but also include some coal-to-liquids (CTLs), gas-to-liquids (GTLs) and other minor streams, rise by nearly 0.9 mb/d. Given the long development cycles for oil sands projects, production in any given year typically reflects the investment decisions made at least five years prior. Thus, the effect of a lower oil price environment on supply will generally be seen beyond the medium-term.

Despite the increasingly pessimistic outlook for biofuels on account of sustainability challenges, production is seen rising by 0.3 mb/d through the period 2014–2020. Given that biofuels supply is predominantly determined by mandates, the impact of the recent oil price decline is likely to be relatively minor in the medium-term.

3.3.2 Liquids supply in the long-term

Looking at the longer term Reference Case projections to 2040, tight crude expansion is expected to face limitations, such as steep decline rates, a transition away from sweet spots, environmental concerns, possible economic obstacles, and even shortages of equipment and skilled labour. It is therefore projected that tight crude supply in the US & Canada, constituting nearly the whole total, will reach a maximum of 5.3 mb/d just before 2025 and then start to decline gradually (Table 4).

Table 4
Long-term liquids supply outlook in the Reference Case
(mb/d)

	2014	2015	2020	2025	2030	2035	2040
US & Canada	17.3	18.1	19.8	20.3	20.4	20.4	20.3
<i>of which: tight crude</i>	4.0	4.4	5.2	5.3	5.2	5.0	4.6
Mexico & Chile	2.8	2.6	2.4	2.3	2.2	2.1	2.0
OECD Europe	3.6	3.7	3.5	3.3	3.2	3.0	2.9
OECD Asia Oceania	0.5	0.5	0.6	0.6	0.6	0.6	0.7
OECD	24.2	24.9	26.3	26.6	26.5	26.1	25.8
Latin America	5.0	5.1	6.2	6.8	6.7	6.5	6.3
Middle East & Africa	3.7	3.6	3.9	4.0	3.9	3.7	3.5
Asia, excl. China	3.5	3.5	3.6	3.6	3.5	3.2	3.0
China	4.3	4.3	4.4	4.2	4.0	3.8	3.6
DCs, excl. OPEC	16.5	16.7	18.1	18.6	18.0	17.2	16.4
Russia	10.7	10.7	10.6	10.7	10.7	10.8	10.8
Other Eurasia	3.0	3.0	2.9	3.1	3.5	3.7	3.8
Eurasia	13.7	13.7	13.5	13.8	14.2	14.4	14.6
Processing gains	2.2	2.2	2.3	2.5	2.6	2.8	3.0
Non-OPEC	56.5	57.4	60.2	61.5	61.3	60.6	59.7
<i>Crude</i>	42.7	43.2	44.3	44.4	43.3	41.4	39.5
<i>NGLs</i>	6.9	7.0	7.5	7.7	7.7	7.7	7.7
<i>of which: unconv. NGLs</i>	2.0	2.2	2.5	2.7	2.6	2.6	2.5
<i>Other liquids</i>	7.0	7.2	8.3	9.4	10.3	11.4	12.5
Total OPEC supply	35.9	37.1	37.4	39.7	43.1	46.8	50.2
<i>OPEC NGLs</i>	5.6	5.7	6.3	7.1	7.9	8.5	9.0
<i>OPEC GTLs*</i>	0.3	0.4	0.4	0.5	0.5	0.5	0.5
<i>OPEC crude</i>	30.0	31.0	30.7	32.1	34.7	37.9	40.7
Stock change**	1.1	1.7	0.2	0.2	0.2	0.2	0.2
World supply	92.4	94.5	97.6	101.1	104.4	107.4	110.0

* This item includes other non-crude streams, such as MTBE.

** Stock change assumptions reflect commercial stock inventories, development of Strategic Petroleum Reserves (SPR), and the rising need for stocks as refinery capacity expands.

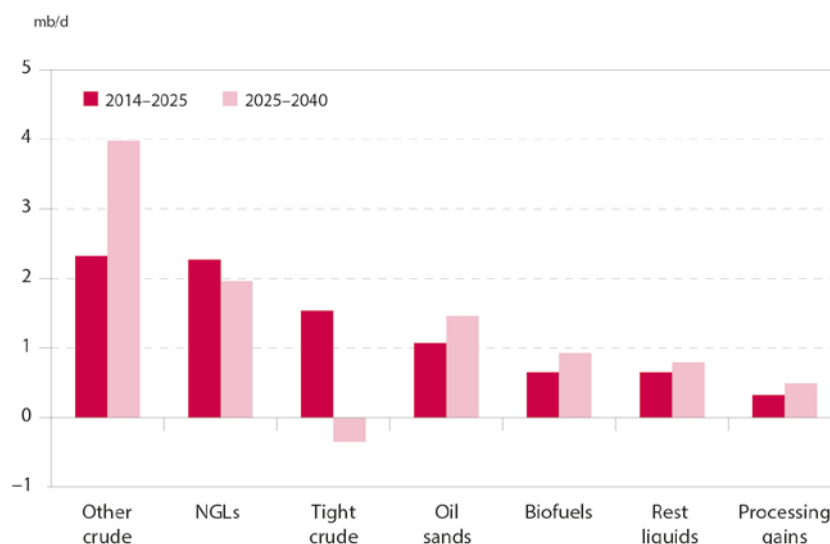
The main long-term non-OPEC supply increases come from Latin America and the Caspian region. Non-tight crudes, NGLs (including unconventional NGLs), oil sands and biofuels will be the key to non-OPEC long-term supply growth. As can be seen

in Table 4, total non-OPEC supply rises from 56.5 mb/d in 2014 to 61.5 mb/d in 2025, but then declines to 59.7 mb/d by 2040. Non-OPEC crude declines over the period, from 42.7 mb/d in 2014 to 39.5 mb/d in 2040.

As a result of non-OPEC supply developments, OPEC crude rises over the long-term, reaching 40.7 mb/d in 2040. Moreover, the share of OPEC crude in the total world liquids supply in 2040 is 37%, which is above the 2014 levels of almost 33%.

The relative importance of the various liquids to supply growth over the period 2014–2025 versus 2025–2040 is shown in Figure 10. From 2014–2025, tight crude, other crude and NGLs (including unconventional NGLs) exhibit the highest additions. From 2025–2040, conventional crudes and NGLs, oil sands and biofuels become increasingly important sources of supply growth as tight crude production reaches a maximum and then contracts. Tight crude supply prospects over the long-term are primarily found in the US, but also Canada, Russia and Argentina.

Figure 10
Changes in liquids supply



3.3.3 Alternative non-OPEC supply scenarios

There are large uncertainties associated with non-OPEC supply, particularly in a lower oil price environment. To account for the uncertainties, scenarios have been developed to explore how alternative sets of supply drivers could lead to lower or higher non-OPEC supply.

Both the upside and downside scenarios could stem from either above- and/or below-ground issues. For example, upside potential could come from greater resource quantities than commonly assumed, improved technology, favourable policies, and a sympathetic public attitude towards production techniques. Downside risks may stem from more stringent environmental and regulatory policies, depletion in productive zones, and a lack of available infrastructure and services, among others. The scenario

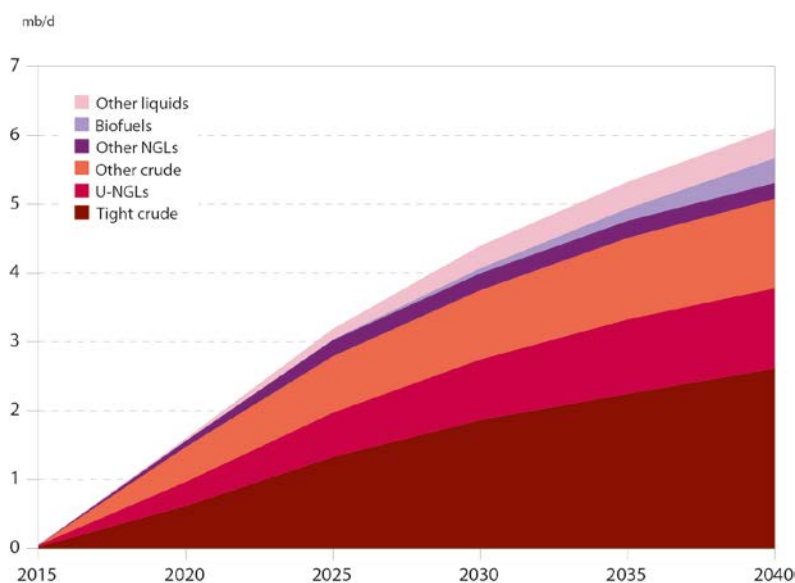
analysis is enhanced by addressing supply drivers at a country level in the medium- to long-term.

The upside supply scenario addresses alternative plausible paths for different elements of non-OPEC supply. Clearly, its aggregate impact on non-OPEC supply constitutes an optimistic view, as it considers that several upside drivers co-exist and adds up their effects. Similarly, the downside supply scenario could be considered a rather pessimistic view on potential non-OPEC supply, but one that could emerge under a combination of circumstances.

Both upside and downside scenarios for non-OPEC supply adopt the same granular methodology that have been used in recent editions of OPEC's World Oil Outlook (WOO).

The aggregate liquids added to the Reference Case in the upside supply scenario amounts to approximately 6.1 mb/d by 2040. Around 62% of this additional supply comes from tight crude and unconventional NGLs, both in North America and in other assessed countries. Figure 11 summarizes these additions per type of liquids supply.

Figure 11
Additional liquids supply in the upside supply scenario compared to the Reference Case



In the downside supply scenario summing up all the liquid supply potential losses yields a reduction of about 1.1 mb/d in 2020. This increases over the forecast period, reaching 2 mb/d in 2030 and 3.3 mb/d by 2040 (Figure 12). Much of the reduction is in the form of crudes and NGLs, which together account for over 64% of the total losses in 2040.

Figure 13 shows a comparison of non-OPEC supply in the Reference Case, the upside and downside supply scenarios. As is evident, the risk is skewed more to the

upside, on account of greater upside potential for tight oil. The downside scenario is less pronounced, since the Reference Case already accounts for constraints that limit the potential of tight oil over the long-term. In 2040, liquids supply reaches 59.7 mb/d in the Reference Case, 65.9 mb/d in the upside scenario and 56.5 mb/d in the downside scenario.

Figure 12
Reductions to liquids supply in the downside supply scenario compared to the Reference Case

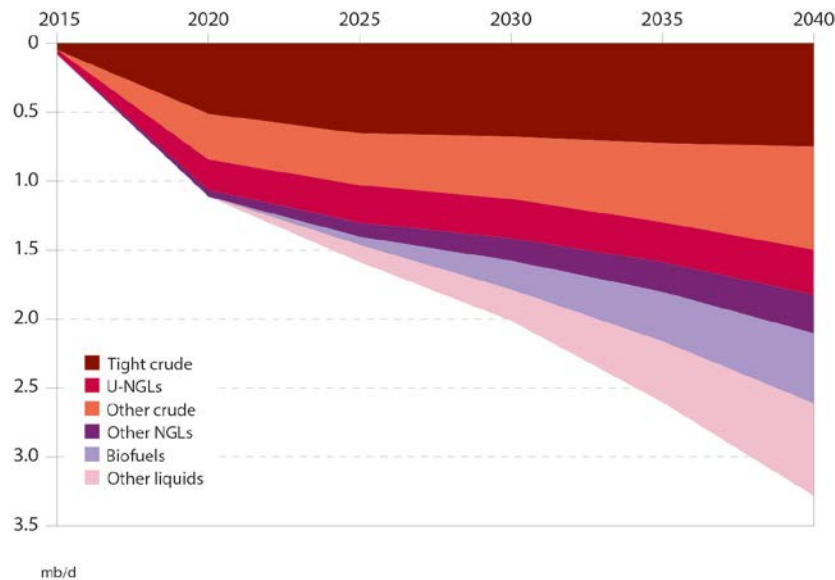
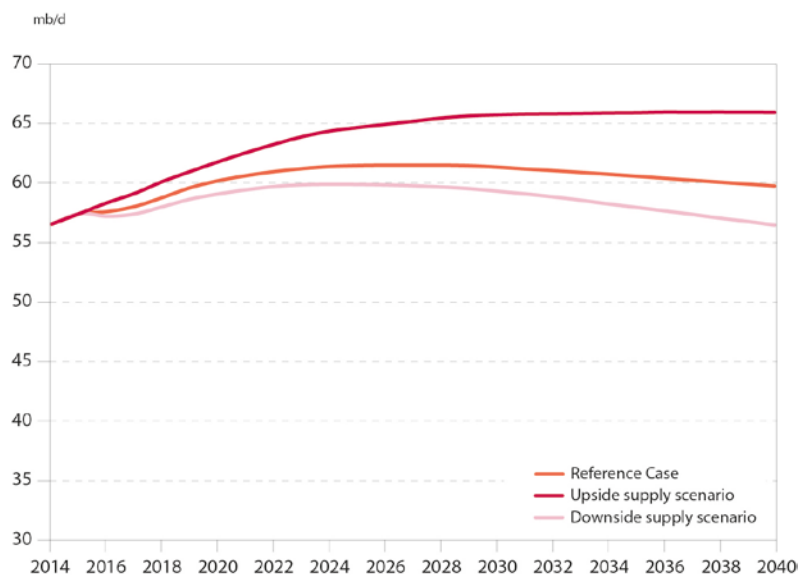


Figure 13
Non-OPEC supply in the Reference Case, the upside and downside supply scenarios



The implications for OPEC crude are calculated by subtracting non-OPEC supply (in each scenario) and OPEC NGLs from world demand. In the downside non-OPEC

supply scenario, OPEC crude rises to 43.9 mb/d in 2040, which is 3.2 mb/d higher than the 40.7 mb/d in the Reference Case. In the upside non-OPEC supply scenario, OPEC crude is estimated at 34.5 mb/d, which is 6.2 mb/d lower than in the Reference Case. As the uncertainty in non-OPEC supply is skewed to the upside, the uncertainty for OPEC crude is therefore skewed to the downside.

The resulting range for OPEC crude in 2040 amounts to 9.4 mb/d, which highlights the challenges for OPEC Member Countries' long-term investment decisions. As already highlighted, the uncertainties also come from a wide variety of sources, including policy developments, the pace of technological advancement and the evolution of costs, among others. Ultimately, this translates into a large range of investment requirements for OPEC to satisfy future requirements – the implication being that there are substantial, tangible risks associated with both under- and over-investment. This is especially critical due to the fact that oil-related investments involve complex decisions with long lead-times and long payback periods.

3.4 Downstream

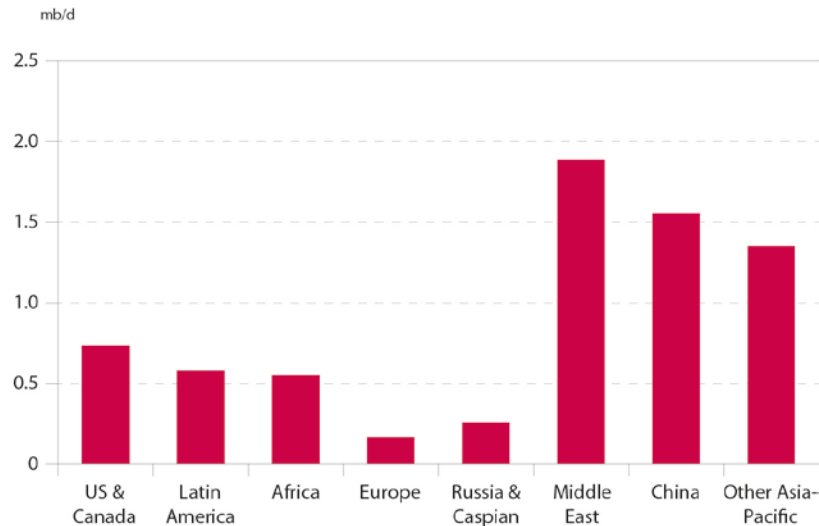
Recent downstream outlooks have highlighted a medium-term trend for refining capacity additions to be well in excess of the required incremental refinery output, presaging in turn a period of intense international competition for products markets and a potential need for significant additional closures. The drivers of this mounting competition have centred on new export refineries coming on stream in the Middle East, India and potentially Brazil, together with a rejuvenated US refining sector and European refineries desperate to find markets for gasoline so that they can produce more co-product diesel.

The current outlook broadly continues as per recent years, but with some key 'twists' as a result of the recent drop in crude oil prices. In terms of the pace and scale of capacity additions, a series of project deferrals has occurred in the lower oil price environment, resulting in a total of 7.1 mb/d of additional crude distillation units from major refining projects for the period 2015–2020, plus around 0.8 mb/d of 'capacity creep' during the same period. This constitutes a sharp fall in downstream investments compared to previous years. The projects are mainly concentrated in developing regions and, within those, predominantly in the Asia-Pacific and the Middle East (Figure 14). This focus is consistent with that of previous outlooks.

The medium-term perspective for the assessed refining capacity supply versus demand balances shows that the potential incremental annual crude runs average 1.2 mb/d through to 2020. In comparison, the refining annual global demand growth for the period 2015–2020 is projected to average 1 mb/d p.a., seen on an incremental basis as summarized in Figure 15, and under the assumptions of maximum sustainable annual utilizations for new projects. It should be borne in mind that around 15% of the required growth will be covered by incremental supplies from biofuels, NGLs and other non-crude streams, leaving 85% to come from crude-based products, thus the figure comes down to around 0.85 mb/d annually on average. The net result is for an outlook where incremental refinery output potential and incremental refinery product demand are projected to be closely in balance through to 2017. Thereafter, however, a gap opens up such that, by 2020, the cumulative 7.2

mb/d of refinery production potential results in an overhang of 2.1 mb/d given the 5.1 mb/d projected as required from refineries.

Figure 14
Distillation capacity additions from existing projects, 2015–2020



While still in significant excess, this capacity surplus is somewhat lower than projected in previous outlooks. Hence, the recent crude price drop is having the effect of – at least partially – rebalancing the market in the medium-term, leading to a reduced capacity overhang from 2015 through to 2020. While the degree of the overhang has fallen, the message from previous outlooks that these projections point to a period of rising international competition for product markets remains valid, as well as the need for continuing refinery closures on a significant scale, if depressed refining margins are to be averted.

Figure 15
Additional cumulative refinery crude runs, potential* and required**

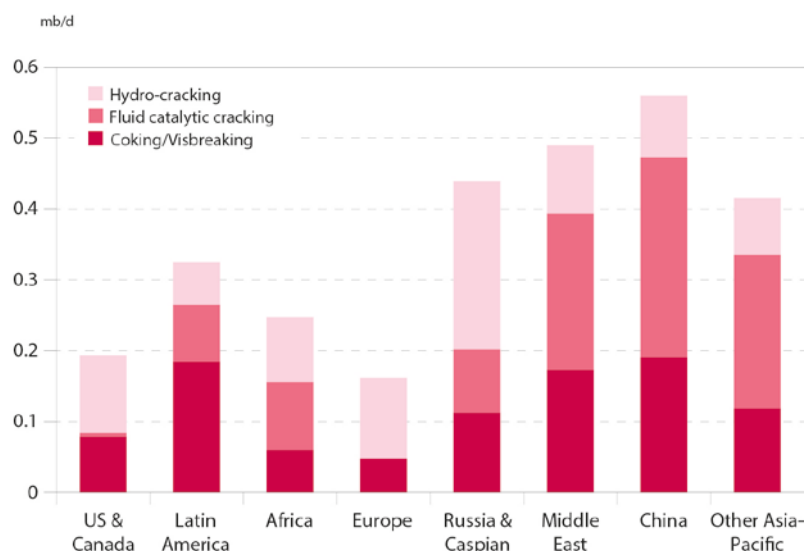


The assessed distillation capacity will be accompanied by an additional 8.8 m/b of secondary units divided into 2.8 mb/d of conversion units, 4.9 mb/d of desulphurization capacity and 1.1 mb/d in the form of octane units. Compared to 2014 though, these current project additions represent a reduction in the amount of secondary units if additions of around 1 mb/d for condensate splitters, which generally come with little or no associated secondary processing, are factored in. The change may also reflect a trend toward a ‘levelling out’ in secondary processing.

The global conversion units for the period 2015–2020 are split almost evenly between hydro-cracking units at just under 0.9 mb/d, fluid catalytic cracking (FCC) at 1 mb/d and coking at close to 1 mb/d. As shown in Figure 16, most regions will see additions to each of the three conversion units. The exceptions are the US & Canada and Europe where there is an absence of FCC additions. This also represents a moderate shift away from hydro-cracking additions generally leading the way. It should also be noted that the 1 mb/d of FCC additions by 2020 will serve to add an appreciable volume of higher octane blendstocks in the form of FCC gasoline.

The desulphurization additions are geared toward non-OECD countries and partly reflect recent trends towards cleaner products within these regions – predominantly following European standards. OECD countries have largely completed moves to ultra-light sulphur (ULS) standards for on-road diesel and are also moving toward such standards for off-road and heating oil. This leaves developing countries’ continuing moves toward EURO 3/4/5 as the main force behind ongoing hydro-treating capacity expansion. Another factor at play is the deferral of some clean fuels projects in the aftermath of the crude price drop, for instance in Mexico and Saudi Arabia.

Figure 16
Conversion projects by region, 2015–2020



Octane unit additions are at 15% of incremental distillation, modestly below the base capacity level. These comprise catalytic reforming, isomerization and alkylation, of which catalytic reforming comprises the majority at 0.7 mb/d. The new octane

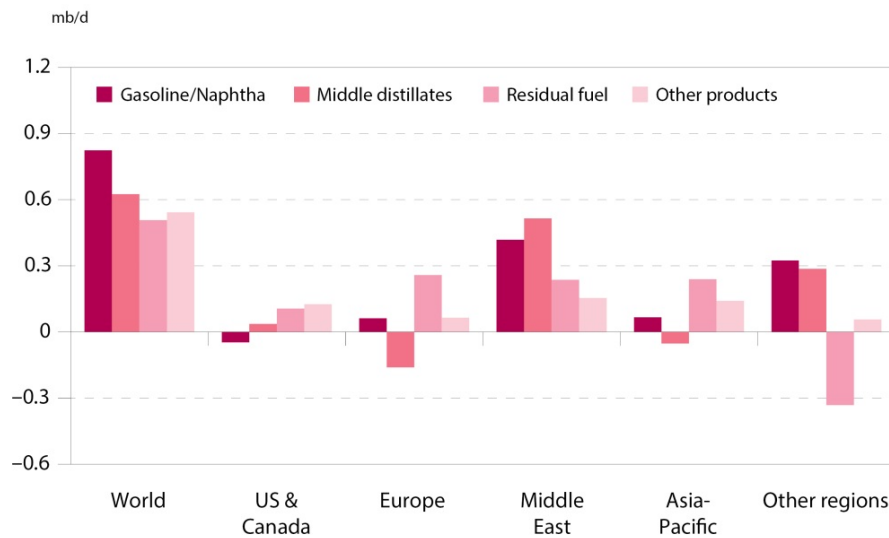
capacity will be primarily constructed in regions where increases in gasoline demand are expected, notably Asia (0.3 mb/d) and the Middle East (0.3 mb/d). These units will be supplemented by somewhat over 0.2 mb/d of isomerization and 0.1 mb/d of alkylation capacity at the global level.

The medium-term perspective for refining products supply versus demand balances, resulting from existing projects, shows that almost half, or 3.1 mb/d (48%), of the cumulative potential incremental output increase by 2020 is from middle distillates, and 2.2 mb/d (35%) is from light products, naphtha and gasoline. The ability to produce fuel oil is set to decrease slightly, by 0.2–0.3 mb/d, and the ability to produce ‘other products’ is set to rise by 1.3 mb/d, assuming new secondary units are fully used – at the 90% level.

Across all products combined, the cumulative global surplus in the medium-term is around 2.5 mb/d. All regions are expected to have aggregate surpluses in the range of 0.2–0.4 mb/d in 2020, but with deficits in one major product category. The most significant deficits are for distillates in Europe, but also for residual fuel in ‘other regions’. The Middle East is projected to be the one region with surpluses in every product group by 2020 and by far the highest aggregate surplus at 1.3 mb/d. The Asia-Pacific has surpluses for residual fuel and ‘other products’ and is close to balance on both naphtha/gasoline and distillates. This is a change versus last year when a deficit of nearly 0.5 mb/d was foreseen for distillates. Europe is close to balance on naphtha/gasoline and ‘other products’, in deficit on distillates and in surplus on residual fuel. The US & Canada is quite balanced across all four product groups, with small surpluses in residual fuel and ‘other products’. Interestingly, the region is exhibiting a very small deficit in naphtha/gasoline. The ‘other regions’ are collectively in surplus on naphtha/gasoline and distillate, but short on residual fuel. The results are referred to in Figure 17 which also takes into account product supply coming from non-refinery streams, such as additional biofuels, CTLs, GTLs and products from gas plants.

Turning to the long-term projections (2020–2040), global results for the Reference Case show that significant global distillation capacity additions will still be needed and are expected to reach 20 mb/d by 2040. Crude throughputs are forecast to rise to 90.4 mb/d by 2040, and the average utilization rate is estimated to decline to 81.5 % by 2040 after a minor medium-term improvement. The annual rate of increase in refinery crude runs is projected to steadily decline due to a combined effect of a gradual slowing in the annual demand growth rate and steady increases in non-crude supplies. Moreover, long-term capacity requirements are ‘front-loaded’ and the pace of needed refinery capacity additions inexorably slows over the extended time horizon. Global capacity additions continue to closely match global demand growth in the longer term despite the fact that non-crude supplies continue to increase. Long-term outlook projections for capacity additions support the view that domestic demand growth will be the primary driver of new projects rather than an opportunity to export products.

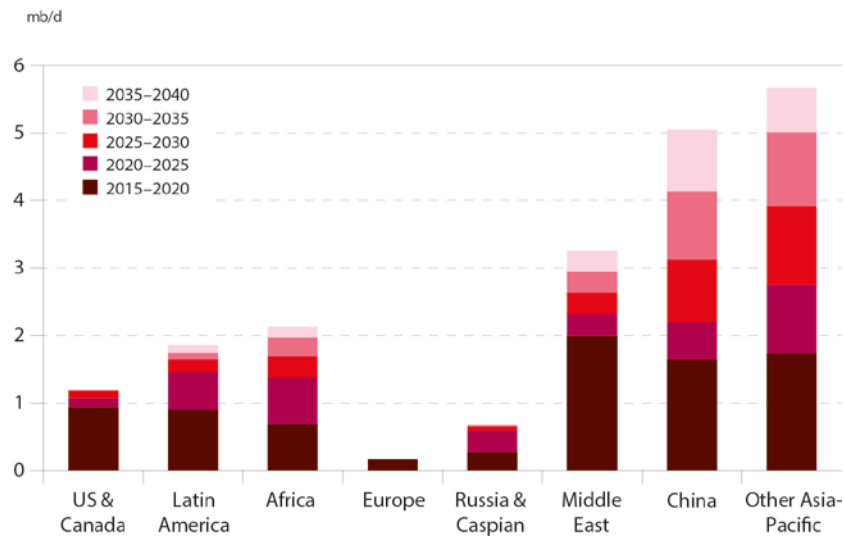
Figure 17
Expected surplus/deficit* of incremental product output from existing refining projects, 2015–2020



* Declining product demand in some regions contributes to the surplus. This is especially the case of gasoline/naphtha and fuel oil in Europe which show emerging surplus despite little capacity additions in the region. Gasoline and fuel oil are affected in other regions as well.

The long-term capacity additions presented region-wise in Figure 18 show that the Asia-Pacific increasingly takes the lion's share with 63% of the global total, driven by regional demand growth. The Middle East, Africa and Latin America have respective shares of 11%, 12% and 8% over this period, with domestic regional growth again an important factor. The drop in the Middle East's share during 2020–2040 versus 24% from 2015–2020 stems from the very substantial additions taking place during, as well as before, this period. The Russia & Caspian region is projected to maintain a similar share of 4% of global additions from 2020–2040. For the US & Canada, the 2020–2040 share drops to 2%, with only minimal additions post-2030, due to steady regional demand decline. For the same reason, no capacity additions are projected for Europe post-2020 – or for Japan and Australasia. Rather, continuing closures can be anticipated over and above those assumed by 2020. Model results indicate these closures could be in the order of 1.5 mb/d globally by 2030 and 3 mb/d by 2040. The main concentrations for closures are expected in Europe, followed by the US & Canada.

Figure 18
Crude distillation capacity additions in the Reference Case, 2015–2040

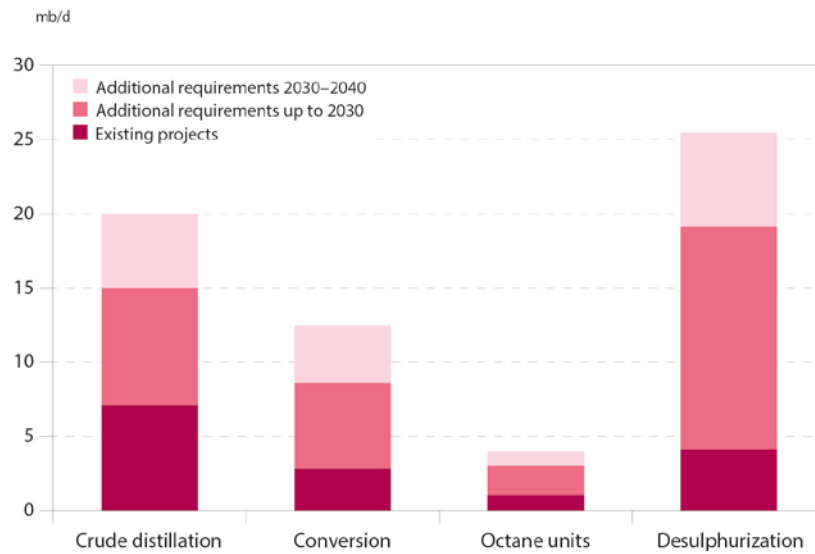


At the global level, driven by long-term demand growth for light clean products, combined with flat to declining residual fuel demand, the long-term projections for secondary units (Figure 19) indicate the need to add some 12.5 mb/d of conversion units, more than 25 mb/d of desulphurization capacity and 4 mb/d of octane units in the period to 2040. This is above the refining base as of the end of 2014. The easing of global distillates demand growth by 2040 and a partial shift in favour of gasoline has led to a modest reduction in the new hydro-cracking projected capacity (5.4 mb/d) relative to FCC (4.1 mb/d) and bottom of the barrel units. Projections for coking/visbreaking (2.9 mb/d) additions are rather steady. FCC additions, in contrast, are relatively ‘front-loaded’ in the periods to 2020 and from 2020–2030.

Additions are minimal in Europe and minor in the US & Canada. Requirements will be led by the Asia-Pacific at around 45% or close to 5.5 mb/d of total future additions to 2040. Significant additions are also projected for Latin America, Africa, Russia & Caspian and the Middle East, in the range of 1–2 mb/d for each region. In all these regions and in the Asia-Pacific, capacity growth is relatively steady over the period to 2040, reflecting the projected progressive trend toward lighter products and away from residual fuel oil. As noted elsewhere, the increase of more than 2 mb/d by 2040 in Latin America is also driven by the expansion in heavy crude supplies that the region is expected to witness.

Above the 4.1 mb/d of desulphurization capacity included in assessed projects to 2020, a further 15 mb/d by 2030 and an additional 6.3 mb/d from 2030–2040 are needed. With regard to the main product categories, of more than 25 mb/d of global desulphurization capacity additions during the period 2014–2040, some 69%, or 17.5 mb/d, are for distillate desulphurization, followed by 4.2 mb/d for gasoline sulphur reduction. The remainder, almost 4 mb/d, is for VGO/resid processing.

Figure 19
Global capacity requirements by process type, 2015–2040



In terms of the regional breakdown, total additional desulphurization capacity by 2040 is projected at 11.5 mb/d in the Asia-Pacific region, of which China comprises 4.8 mb/d. The figures for the Middle East and Latin America are around 4.8 mb/d and 4 mb/d, respectively. These expansions are driven by the extension of the refining base, as well as by demand growth and stricter quality specifications for both domestic and exported products. Significant additions are also projected for Russia & Caspian (2.2 mb/d), in line with the region's tightening domestic quality standards and the intent to produce diesel to ULS standard for both domestic use and export to Europe.

Trends in future regional oil demand, supply and the related expansion of the refining industry will have important implications for inter-regional oil movements. Recent projections emphasize the Middle East's leading role in the international crude oil trade. Despite flat medium-term crude exports, engendered mainly due to the rapid increase in regional refinery capacity by 2020, total crude exports from the Middle East are projected to reach 24 mb/d by 2040, more than 6 mb/d higher than in 2013. In terms of destination, the dominant flow is toward the Asia-Pacific, attracted by this region's rising demand.

At the same time, crude exports from the Middle East to other major destinations are expected to decline, especially in the long-term, and local use is expected to increase by 4 mb/d between 2013 and 2040. While part of the resulting refined products will go toward meeting rising regional demand, product exports from the region's new refineries will also grow.

Crude exports from Latin America to the US & Canada are expected to remain fairly stable over the forecast period. They will see a slight increase to somewhat over 4.5 mb/d by 2020, but afterwards they stay essentially flat. A key reason is that heavy crude oil from Latin America provides a desired feedstock for the complex refineries in the US Gulf Coast and cannot easily be processed in volume in refineries

elsewhere. However, it is expected that increases in Canadian oil sands production, and in the infrastructure to deliver to the Gulf Coast, will lead to some downward pressure on crude exports from Latin America to the US & Canada. To the extent that barrels are displaced from US markets, they will be redirected to the Asia-Pacific and Europe.

In the case of Russia & Caspian, a small reduction in total crude oil exports is expected to 2025. Thereafter, regional crude production is projected to move up to somewhat over 13 mb/d, while regional crude runs decline slightly due to a combination of the region's flat demand, as well as declining demand in Europe, Russia's main product export destination. As a result, longer term crude oil exports rise moderately to around 7.3 mb/d by 2040. Subject to the assumed pipeline capacity expansions in this region, crude oil exports from the Russia & Caspian region to the Asia-Pacific come close to tripling by the end of the forecast period, compared to 2013 levels. During the same period, exports to Europe are expected to have significantly reduced from more than 5 mb/d in 2013 to around 3 mb/d by 2040. It should be noted, however, that if new pipeline capacity does not become available as assumed, then the likely implication will be a lesser decline of Russian exports to Europe. Correspondingly, more Middle Eastern or African exports would be redirected from Europe to the Asia-Pacific, mainly in the medium-term.

Crude oil exports from Africa are projected to increase slightly till around 2025, but they will then decline steadily thereafter. The range of decline is close to 1 mb/d, from 6.7 mb/d in 2020/2025 to around 5.8 mb/d by 2040. Across the entire forecast period, the decline in crude exports to the US & Canada will continue. North American tight oil production growth has eliminated significant imports of light African crudes, leaving limited volumes of medium gravity imports. African exports to Europe are projected to remain relatively stable as opportunities created by reductions in Russian & Caspian imports are offset by declines in European refinery runs. Longer term, as African refinery runs continue to increase, crude exports to the Asia-Pacific will likely decline after rising moderately in the period to 2025.

4. CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

The 'Paris Agreement' that came out at the end of COP21 in December 2016 is a landmark international achievement to address climate change as a collective and collaborative effort. OPEC considers the Agreement to be forward-looking, ambitious, supportive of sustainable development and vital for protecting the planet.

The Paris Agreement seeks to hold the increase in the global average temperature to well below 2°C above pre-industrial levels.

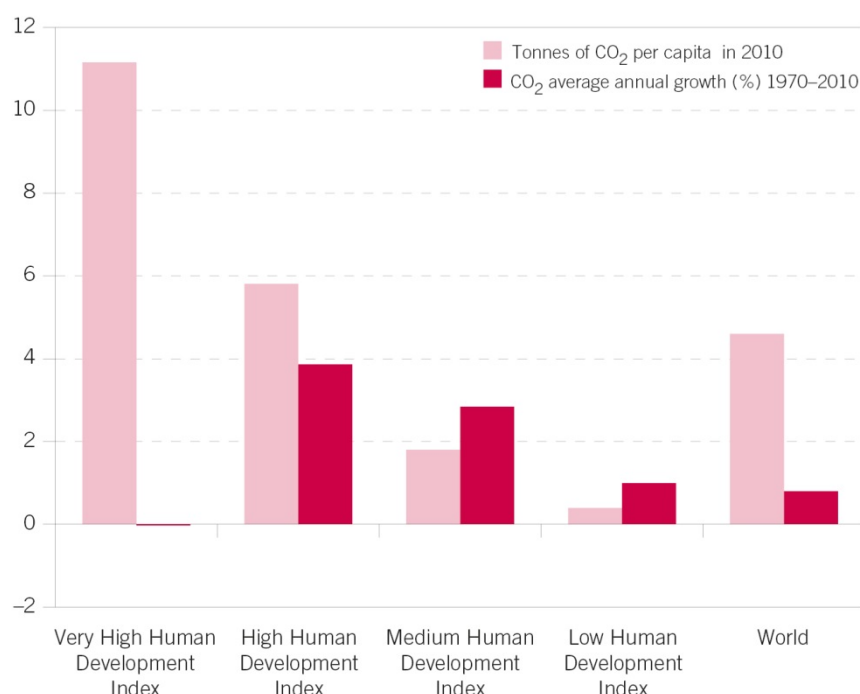
It calls for sustainable development by providing opportunities for the Parties to reduce their emissions through economy-wide and sectoral mitigation actions, in accordance with their state of development, their national circumstances, and in full compliance with the principles and provisions of the UNFCCC.

Sustaining the current level of socio-economic development, and enabling those in poverty to develop, requires the use of energy. The Paris Agreement calls for 'equity'

for all countries to develop in a sustainable manner. Therefore, it is critical to ensure that less-developed countries and future generations will have equitable access to development opportunities.

The rise in emissions is closely associated with the socio-economic development of human societies. A comparison of countries along a development spectrum indicates significant differences in per capita emissions. In general, countries with a very high Human Development Index (HDI) have more than 10 tonnes of CO₂eq emissions per capita. On the other hand, countries with a low HDI have less than 1 tonne of CO₂eq per capita – a more than tenfold difference compared to the former group (Figure 20). Addressing such a development gap as expressed in terms of HDI is important for strengthening international cooperation in addressing climate change.

Figure 20
Relationship between the Human Development Index and per capita emissions

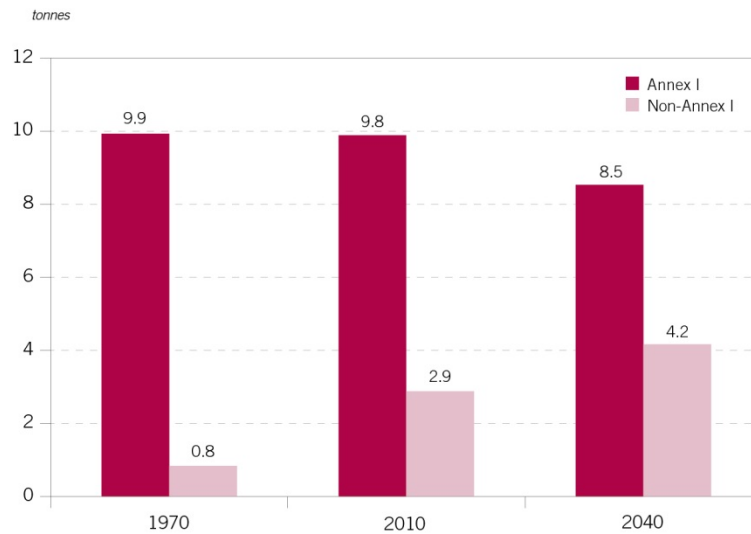


Note: In general, countries with high HDI also have high per capita CO₂ emissions and vice versa. In addition, the figure also shows that the rate of growth in CO₂ emissions in the period 1970–2010 was higher in countries with a lower HDI, indicating future rises in CO₂ emissions as these countries develop and improve their HDI. In countries with very high HDI, the level of emissions is already high and further growth in emissions is about zero.

Source: UNDP, Human Development Report 2014, Statistical tables; Table 14: Environment.

There is a significant gap in per capita emissions between countries in the Annex I and non-Annex I listing of the UNFCCC. In 1990, the per capita emissions of Annex I countries were over seven times larger than those of Non-Annex I countries. This gap has gradually narrowed over time, but even by 2040 under the Reference Case, per capita emissions from Annex I countries are projected to be still about twice that of Non-Annex I countries (Figure 21). This difference is also reflected in the historical cumulative emissions.

Figure 21
Per capita CO₂ emissions in the Reference Case, 1970–2040



Reducing GHGs, while enabling the continuation of economic development, is a challenge that needs to be addressed. Population increases and economic growth are known to be the major drivers of increased emissions. Demand for electricity, heating, transport, food, industrial output and other socio-economic needs are expected to grow as populations expand and economies grow. Fulfilling such growing demands will lead to growing emissions of GHGs. Climate policies need to maximize synergies with development priorities while minimizing trade-offs with the environment, aim for equity across countries and generations, and yet remain focused on keeping the atmospheric temperature rise to below 2°C.

Demand-side options for decarbonizing the electricity sector, as well as in sectors that consume much of the supplied electricity, include measures that seek reductions in electricity demand by changing consumer behaviour, and reducing electricity demand through energy efficiency improvements. Options to decarbonize the electricity sector on the supply-side include electricity generation from renewable sources, fuel substitution away from coal to lower carbon content fuels, such as gas, improvements in energy efficiency and the energy conversions of power plants, as well as deployment of Carbon Capture and Storage (CCS) in existing power plants and future ones.

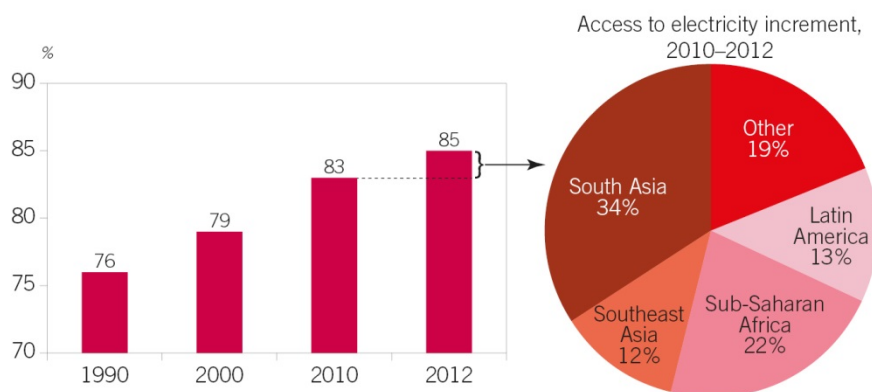
Sustainable development is a collective endeavour and can only be achieved through collective efforts – the Paris Agreement provides an effective platform for such collective efforts by establishing mechanisms for financial support and technology transfer from developed to developing countries for GHG emissions reduction.

In September 2015, the UN Sustainable Development Summit adopted the post-2015 development agenda. One of its sustainable development goals focuses on energy and calls for nations to “ensure access to affordable, reliable, sustainable and modern energy for all”.

Energy access remains a crucial global challenge as over one billion people still lack access to electricity. The vast majority of these are found in Sub-Saharan African and South Asian countries. Moreover, expanding energy access can enhance income and welfare, generate equitable employment, develop the sectors of agriculture, health and education, as well as improve quality of life and increase local resilience and self-reliance. Enhancing international cooperation to facilitate access to clean energy research and technology, investment and expansion in energy infrastructure, and upgrading technology will be crucial to achieve energy access for all. The oil industry can contribute to this effort by increasing the diversity and continuity of energy services to the poor.

Although globally the share of the population with access to electricity has increased from 83% in 2010 to 85% in 2012 (Figure 22), approximately 220 million people gained access to electricity for the first time over the period 2010–2012. There are more people with no access to electricity in Asia owing to the overall size of the population, however in Sub-Saharan African countries the growth rate in those having access to electricity has been lower than actual population growth.

Figure 22
Population with access to electricity



Source: World Bank Global Electrification Database, 2015.

While all OPEC Member Countries are developing countries and aspire to develop, they have also been supportive of other developing nations. As early as 1975, OPEC was given a mandate to include sustainable development and address environmental matters in its overall work programme. To that end, the OPEC Fund for International Development (OFID) was established by OPEC Member Countries in 1976 as a collective channel of aid to developing countries. To date, 134 countries have benefitted from OFID's financial assistance, totalling \$18.7 billion through 3,529 operations – many of which are in Africa and address poverty alleviation, including energy poverty, through a range of actions that also support access to renewable energy sources. In addition, most OPEC Member Countries have established funds for international help and cooperation.

5. CONCLUDING REMARKS

OPEC fully appreciates the role dialogue and cooperation can play in helping strengthen relationships between producers, consumers, the industry, and other major stakeholders. A cooperative and coordinated approach to a variety of challenges and uncertainties we all face is beneficial for market stability in both the short- and long-term. This includes appreciating that both security of demand and security of supply are an integral requisite of this stability, and is especially true in the current low oil price environment, which has impacted everyone, as underscored in this background paper.

It has always been one of OPEC's priorities to strive to develop and enhance current and future opportunities for energy cooperation. OPEC is continually engaged in international dialogue and global cooperation via various fora, and high-level meetings, including G20 energy initiatives.

In an increasingly interdependent world, the issues have become more complex, broad and inter-linked, which require concerted efforts and joint collaboration in finding co-operative and sustainable solutions for the common challenges such as energy security at both the demand and supply ends, timely and adequate investments, cleaner fossil fuel technologies, environmental protection, the role of petroleum in promoting sustainable development and alleviating energy poverty.

The accomplishments in collaborative efforts of the IEA, IEF and OPEC, such as the JODI programme for energy data transparency and other joint activities, have been effective for better understanding the pertinent energy and oil related issues, building confidence and supporting long-term market stability, as well as addressing the concerns of both producers and consumers.