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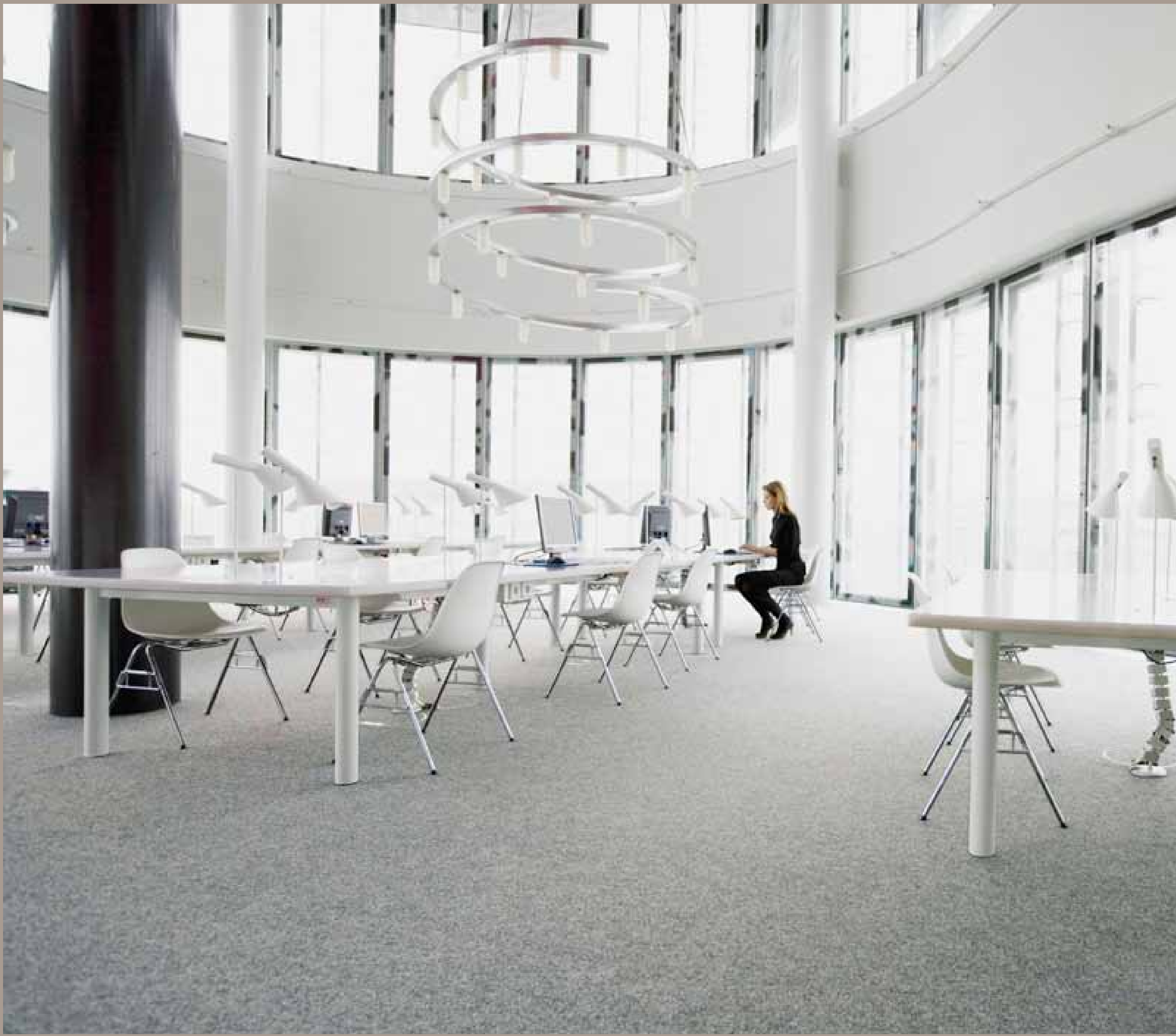
Technology Intervention for Value Creation and Sustainability

pwc

"We shall require a substantially new manner of thinking if mankind is to survive."

Albert Einstein



The bumpy road

Technology imperative

Scientific endeavours to create new possibilities have always fructified in the form of technological advancements and accelerated societal metamorphosis. Techonological development assumes even greater criticality today as the fundamental objectives to be achieved through technology are constantly expanding– energy and emission consciousness being the recent inclusions. Technological needs have also been fuelled by the increasing integration of national economies with the global economy propelled by entrenched forces of liberalisation, globalisation and present technology.

Role in the energy sector

Economic growth coupled with ever-increasing population is envisaged to facilitate the transition of developing economies to an energy-intensive era of growth as a result of industrialisation, infrastructure development and increased transportation, which will result in energy demand exceeding supply. The energy sector in general and oil and gas in particular, therefore, continues to strive for techonological development to bridge the burgeoning gap in the demand and supply of primary energy.

We believe that efforts to reduce demand for energy alone may not suffice to restore the energy demand-supply imbalance. This is on account of increasing societal aspirations coupled with abated willingness to migrate to more energy efficient amenities. Therefore, achievement of energy security depends on our ability to strike a balance between reducing energy demand and increasing the supply.

A well-synchronised and concerted effort from all stakeholders of a vast and complex energy system is required for achieving energy security. In this context, the oil and gas industry, by virtue of being the most dominant source of primary energy, is well placed to contribute to this cause, in the form of innovation. In this industry, ***innovation*** spans beyond laboratories in order to achieve operational excellence and gain competitive advantage.

As part of PwC's Global Annual CEO Survey, we found out that CEOs consider innovation and R&D significantly important for the sustainability of their businesses.

Broad objectives of CEOs in their key markets (% of CEOs naming objective for next 12 months in each of their three most important markets)

Base: China (383); USA (275); Brazil (188); India (176); Germany (152); Russia (101); UK (81); France (66); Japan (62); Australia (53)

Source: PwC 15th Annual Global Survey 2012, Base: 1258 Respondents

This fact was reinforced by the WIPO[1] statistics database which concluded that demand for patents increased across the world from around 800,000 patent applications in the early 1980s to 1.8 million by 2009, with the greatest increase in demand occurring in the mid-1990s. Growth in patent applications was stable until the 1970s, followed by acceleration, first in Japan and then in the US. Growth in fast-growing middle-income countries such as China and India picked up from the mid-1990s onwards. In this context, it may also be noted that though the patents applied for and granted to developing countries viz. India, China, etc. have increased, the number of technologies commercialised has not been able to keep the same pace. It may therefore be argued that technological innovations in developing countries are divorced from commercial realities.

R&D activities in India, especially in the hydrocarbon sector, exhibited remarkable resilience to lingering effects of global economic slowdown. Encouragement by the government of India in the form of tax exemption, unstinted efforts by Indian oil majors and availability of cost-competitive cutting-edge skills have helped India position itself as an R&D hub, with the likes of Shell, Castrol, Siemens, etc. setting up R&D centres.

The need of the hour is an optimal blend of incremental and breakthrough innovations with due consideration to economics. The oil and gas industry, in its pursuit for energy security, is in continuous quest of innovative technologies. With this background, this report focuses on technology interventions desired to meet industry challenges.

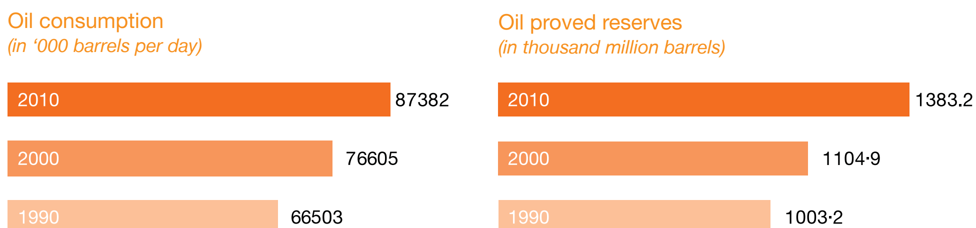
[1] *WIPO: World Intellectual Property Organisation*

Maintaining the momentum

Upstream sector

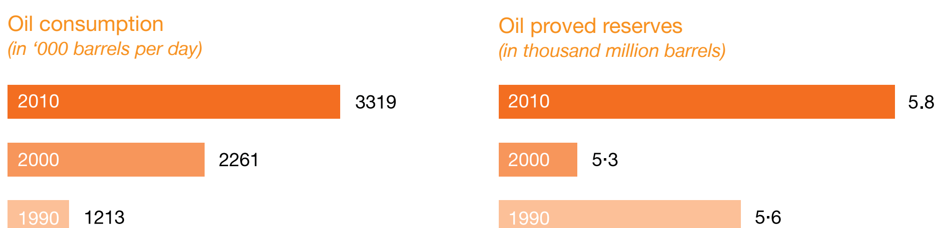
Unabated energy needs have made the addition of significant new hydrocarbon reserves a necessity. Oil consumption has grown by an average rate of more than 3% from 1990 to 2010. On the other hand, proved reserves have increased at an average rate of 0.5% during the same period. India also resonates the same global trends as discussed below.

Global oil consumption and proved reserves



Source: BP Statistical Review of World Energy, 2011

Oil consumption and proved reserves in India



Source: BP Statistical Review of World Energy, 2011

Improving recovery rates

The much-needed reserves may be added either through continued exploration or increasing the recovery factors of producing fields through improved oil recovery or enhanced oil recovery (IOR/EOR). More than 75% of the global producing fields have been in operation for longer than 25 years. These old and depleting fields continue to demand innovative ways to improve their recovery factor. Recovery factor, if improved even by an average of 1%, will have significant impact on our energy supply.

The use of polymers and surfactants to improve the efficiency of water flooding is currently a matter of investigation within the framework of EOR projects. The microbial EOR technology, which is yet to be commercialised, is estimated to increase this percentage to 30. Upstream oil companies need to invest more in such R&D activities to commercialise new and innovative technologies.

End of the 'easy oil' era

Oil companies and governments alike are continuously developing and deploying technologies to discover more oil, often in remote and hostile areas given the fact that all the 'easy oil' has already been found.

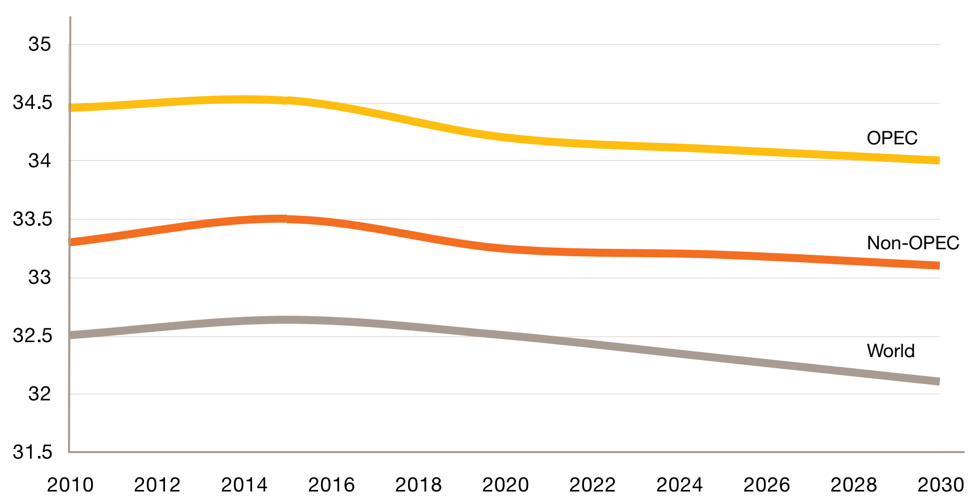
The ever-developing technology and techniques have dramatically altered the manner in which oil and gas reserves are identified, developed and produced. This includes geological modelling, improved subsurface imaging through the use of advanced 3D seismic acquisition techniques, directional drilling and the use of high-pressure high-temperature tools, improved reservoir data acquisition and simulation, as well as more efficient, compact and reliable processing equipment. Looking ahead, more technologies will need to be developed in order to enable sustainable exploitation of difficult finds and increase the maximum recovery from traditional fields.

Major upstream technology area demanding Innovation

Upstream

The Challenge	Technology area demanding innovation
Increasing the reserve	• Geological modelling • Improved subsurface imaging • Directional drilling • Data acquisition and simulation
Improving the recovery factor	• Improve efficiency of water flooding • Microbial EOR • Carbon capture and sequestration • CO_2 (miscible, immiscible)
Extraction of heavy oil	• CO_2 (miscible, immiscible) • In-situ combustion

Crude Quality outlook in terms of API Gravity (°API)



Deteriorating crude quality

Quality of crude, generally measured in terms of API Gravity, sulphur contents and Total Acid Number (TAN) plays an important role in determining the technological changes for extraction, transportation and refining. The increasing demand of light petroleum products with less sulphur content globally has reduced the value of lower API crude (heavy crude). This is because heavy crude generally has high sulphur content and needs more conversion capacity to produce a certain yield of light products. Moreover, higher sulphur also needs intermediate process additions in the form of hydro-treating, hydrogen and sulphur recovery. Consequently, crude quality characteristics comprise an important driver of future investment requirements.

The trend discussed here will be driven by increase in medium (sour) crude production primarily in the Middle East, Latin America and Russia. Most of the light crude supply addition is expected from the Former Soviet Union (FSU) owing to the new Caspian production supported by Siberia and Sakhalin, whille the condensate expansion is envisaged to happen in the Middle East.

A similar trend of API Gravity may also be seen for sulphur content in global crude slate. Global crude slate may be projected to come down on sulphur level by 2015 and then go up to the extent of 1.3 Vol% by 2030.

Recovery estimates for heavy oils (< 22.3 deg API) range from 10 to 15% for primary, 20 to 25% with secondary and an additional 2 to 6% with EOR, for a total of 30%. The highly viscous oil needs steam injection since onset. To improve the recovery factor of heavy crude reserves, technology areas like in-situ combustion, CO_2 (miscible, immiscible) flooding techniques, Steam Assisted Gravity Drainage (SAGD) etc. are being worked upon globally.

In-situ molecular manipulation is also being explored to meet these objectives by modifying the contents of the reservoir at source so that harsh effects at consumption point are eliminated or reduced while the reservoir continues to produce efficiently.

Unconventional resources

Significant technology development in the area of horizontal drilling and hydraulic fracturing has ensured commercial viability of unconventional resources such as shale gas. Development of electromagnetic telemetry and three-dimensional micro-seismic imaging, a geological mapping technology, advanced drill bits used through tricky shale formations have been the foundation of shale gas development in the US.

The challenges in exploration of shale gas include determination of reservoir potential, understanding well placement and well architecture, reservoir characterisation which, to a fair extent, are met through reservoir analysis, geo-mechanics and formation evaluation. Hydraulic fracturing, well design, etc. are the response to development-related challenges, including minimising drilling cost and optimising fracturing design. During the production phase maintaining the production rate and minimising environmental impact are the major challenges which demands innovative fracturing and production chemicals and effective water management techniques.

R&D initiatives by Indian upstream majors

Substantial R&D efforts from Indian upstream majors are underway for the following:

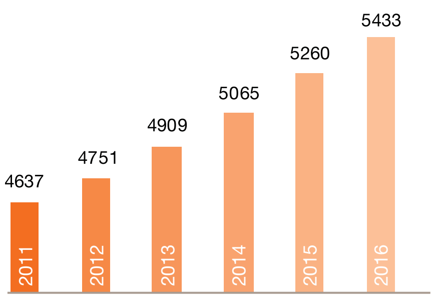
- Structural characterisation of gas hydrates using Raman Spectroscopy
- Thermodynamics and kinetics of methane hydrate formation and dissociation under varying subsurface conditions
- Soil classification and evaluation of soil design parameters using PCPT data with emphasis on application in Indian waters
- Well completion, artificial lift system, sand control, water shut off and simulation
- Deep water production and subsea technology
- Surface geochemical exploration using adsorbed Soil Gas Method
- Petroleum System Modeling through integration of geophysical, geological and geochemical data,
- Development of indigenous bacterial strains for microbial enhanced oil recovery (MEOR) process and microbial paraffin/wax remediation
- Injectivity problem in water disposal wells at a depth below 1,000 meters
- Injection water quality improvement, solvent stimulation, development of flow improver, development of EOR formulation etc.

Apart from conventional hydrocarbons Indian majors have also made foray into coal to liquids (CTL), use of tertiary coals for hydrogenation and phytoremediation of crude oil and oily sludge-contaminated soil, replacing natural gas based heating of crude at heater treater by a combination of solar and natural gas based heating combination, etc.

Downstream sector

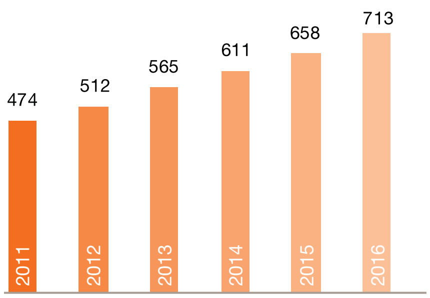
The ever-changing landscape of the upstream sector coupled with changing fuel demand patterns necessitates technological changes in the downstream sector. Therefore, refining capacity addition planned across the globe will continue to demand innovative technologies to meet the challenges.

Global refining capacity addition



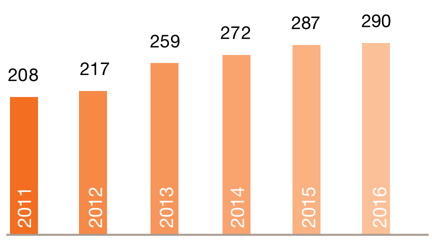
All in MMT, Source: Industry Sources

Refining capacity addition in Middle East



All in MMT, Source: Industry Sources

Refining capacity addition in India



All in MMT, Source: Industry Sources

Changing crude characteristics

From the refining perspective, most heavy crudes are hydrogen deficient and demand up-gradation in terms of improving H-to-C ratio to be useful as fuel. Currently, two major processing routes are being adopted worldwide:

1. Carbon rejection
2. Hydrogen addition

Refiners are also exploring another route of co-generation to solve the heavy crude oil processing problems.

Carbon (C) rejection technologies and thermal conversion processes are being used mainly in the form of visbreaking (both soaker and coil) and coking (delayed, fluid and flexi). Though hydrogen addition technologies have so far had a limited market (i.e., about 25% of the total conversion capacities), they have recently started gaining momentum.

Hydro-conversion processes demand much more capital and operating expenditure than coking. Therefore, economics dictates better return on investment for delayed coking than hydro-conversion processes, even though coking produces by-products like coke which has a lower market value. Research efforts and technology interventions are required to reduce the capital and operating costs of the hydro-conversion process.

Another important property of crude oil is acidity measured in terms of Total Acid Number (TAN). TAN is an aggregate index that includes various types of acid. Some of these acids have negligible impact on the refinery process. However, above a certain limit, acidity has a corrosive effect on refineries. Blending low-TAN with high-TAN crude can deal with this problem, but it increases logistical costs. New refineries constructed using special materials can tolerate higher acidity but are fewer in number, limiting the buyer group of high TAN crudes (greater than 0.5). This will necessitate R&D efforts to develop corrosion-resistant advanced equipment and materials.

To conclude, it may be said that changing crude patterns will catalyse research effort in coking, the hydro-conversion process as well as advanced materials.

Major downstream technology areas demanding innovation

The challenge	Technology area demanding innovation
Processing of heavy crude	• Hydro processing • Coker • Development of advance material
Meeting the increasing diesel demand	• Hydro processing • Catalyst development
Meet the strict product specification	• Deep desulphurisation technologies • FCC • Alkylation

Downstream

Changing fuel consumption patterns

The world is experiencing a shift in the mix of petroleum products being consumed. Demand from emerging regions such as India, China and the Middle East, along with ethanol substitution for gasoline and enhancements in engine technology, are driving higher demand for diesel relative to gasoline. This translates into continued enhancement in cracking process technology and new catalyst solutions that maximise middle distillate yields.

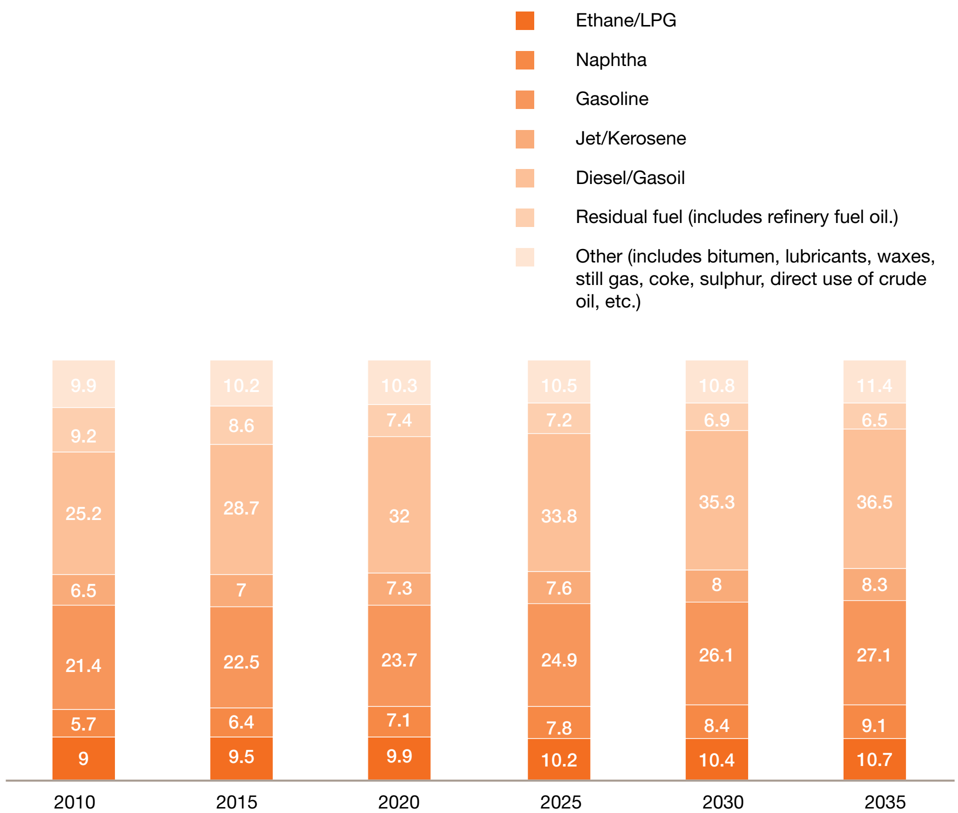
The shifting demand pattern of petroleum products will not only necessitate increase in refinery throughput but also a change in refining configuration. Considering the need for enhanced middle distillate demand, there is a need to emphasise efficient distillation and component separation (in crude distillation and conversion units), optimisation of Fluid Catalytic Cracking (FCC) feed and operations, hydrocrackers in maximum middle distillate mode (wherever applicable), optimum hydrotreater operations, and cutting-edge catalyst for maximum middle distillate production.

Market changes will lead to a shift in technology trends. For example, hydro-cracker may be preferred over FCC, hydrotreating will assume greater importance, blending opportunities for low-cetane, high-sulphur stock into fuel oil will decline, and increased residue conversion may bring more cracked middle distillate into the diesel pool.

Growth in diesel demand shall require increasing diesel yield from existing as well as new installations. This may catalyse the refiner's interest in hydrocracking and catalysts favouring the production of middle distillates. Increasing yield of diesel shall also demand investment in the desulphurisation process. The following table summarises the options for increasing diesel yield.

Technologies that mainly produce the product whose demand is dwindling shall be discouraged, e.g. visbreaking, which mainly produces furnace oil (FO).

Global product demand, shares and growth, 2010–2035



Source: World Oil Outlook 2011, OPEC

Options for increasing distillate yield

Nature of opportunity	Example	Expected yield increase*
Immediate, Non capital	• Optimisation of distillation cut points • Re-routing of intermediate streams and tank optimisation	+2 to 4%
Non-capital taking <1yr	• FCC catalyst change • HCU catalyst selection	+1 to 2%
Capital project, taking <1 yr	• Minor hardware change (tower internals, reactor distribution, etc.) • Hydraulic debottlenecking	+1 to 2%
Capital project, taking >1yr	• Install/expand distillate draw capacity on fractionators • Additional fractionators • New HCU	+3 to 5%
Total		+ 7 to 13%

Source: PwC analysis based on discussion with industry experts
**This yield is expected from a fairly complex refinery*

Changing fuel-quality norms

Tightening of fuel-quality regulations around the world, including reductions in benzene, olefins and aromatics in gasoline and the global movement towards ultra-low sulphur fuels, will require refining industry to undertake upgradation.

After a gradual shift to unleaded gasoline, though the worldwide completion is yet not achieved, the focus turned towards sulphur content in fuels in the mid-1990s, especially in Europe, Japan and the US. This shift, combined with the growing importance of diesel oil and gas oil, especially in the road transport sector, resulted in the tightening of quality requirements for these products, too.

Now the regulatory focus has shifted to produce transportation fuels that have a sulphur content below 10 parts per million (ppm). The next step, which has already begun in a number of countries, is the extension of stricter sulphur specifications beyond on-road transportation to other products, particularly fuel oil, marine bunkers and jet fuel and to continue tightening other specifications, such as the cetane number, aromatics and benzene content.

Sulphur reduction seems to be the near-term task of countries lagging behind on this count. Deep desulphurisation technologies have already reached an advanced stage; however, they require investment from the countries which need to catch up.

The long-run focus may shift to the reduction of benzene content and improving the octane number in gasoline. The table below illustrate the benzene and octane contribution in gasoline by various processes.

Illustration of the source of benzene in gasoline for a typical refinery producing gasoline with 2 vol % Benzene

	%vol in the total pool of gasoline	Bz content in the pool (%vol)	% Bz contribution in the pool	% Bz in Gasoline	% Pool RON
Naphtha	11	0.6	0.066	3%	8.8
FCC Gasoline	46	0.8	0.368	18%	42.6
Reformate	35	4.5	1.575	78%	40.1
Alkylate	8	0	0	0%	8.4
	100		2.0 vol %		100

Source: PwC Analysis based on discussion with experts

From the table above, it may be noted that that maximum benzene is contributed from reformate and FCC gasoline however, both of these are major octane boosters, too. Hence, research activity on FCC and reformer needs to be emphasised. Alkylates contribute a low volume in total pool. However, technology to convert alkylatebenzene to ethylbenzene or propylbenzene is at the nascent stage and continues to demand research efforts.

Progressive shift to tighter standards for diesel include constraints on aromatics, gravity, cetane etc. although in the near term, the main focus is on sulphur content. Currently, hydrocracking, hydrotreatment and aromatic saturation are becoming popular as methods for producing diesel, reducing its sulphur content and reducing its aromatics contents, respectively. Research efforts in these areas are desired to reduce the cost thereby, leaving significant room for incremental research.

Cetane index specification can be met by a combination of cetane improver additive and increasing gasoil hydrocracking stocks. Hence, with the new specifications, the emphasis will be on existing hydrocracking capacity and the extent to which a revamp (e.g. increased reactor volume) is possible or practicable. To further reduce this sulphur content to 10 ppm, which is the current diesel specification in Europe, refineries need to review the marginal economics of adding low or high conversion hydrocracking rather than hydrotreatment. In carrying out such a study, the refiner will need to carefully consider the future role of the catalytic cracker and the future product slate objectives.

Increasing demand for middle distillates and stringent environmental laws aimed at improving diesel quality has spurred active developmental work to improve the processing technology and the catalysts used for gas oil hydrotreating over the past decade. The classical gas oil desulfurisation catalysts are capable of producing diesel fuel to the required specifications. However, the catalysts deactivate rapidly due to high severity of operations.

Besides gasoline and diesel, other fuels are also being subjected to stricter quality specifications, e.g. FO is being subjected to MARPOL. However, in the near term, it doesn’t seem to attract the focus of refiners. In the medium term, sulphur reduction shall attract the focus with catalysed interest in the long term.

R&D initiatives by Indian downstream majors

R&D in downstream sector in India has transcended beyond its infancy; however, it is yet to achieve adolescence. In-house developed technologies are testimony of its growth and commitment to oil and gas sector.

INDMAX technology developed by IndianOil is capable of converting heavy distillate and residue into LPG/light distillate products and it has been implemented successfully at Guwahati and Bongaigaon Refineries. This technology is under implementation in Paradip refinery for production of petrochemical feedstock viz. ethylene, propylene from vacuum gas oil (VGO).

Technology developed by Indian downstream majors include hexane hydrogenation process for production of food-grade hexane (WHO grade quality) with indigenous catalyst, diesel hydrotreatment technology and isomerisation technology Isomerisation Technology for meeting gasoline quality requirements etc.

Currently, development of refinery process technologies, catalysts development for refining processes, refinery process modelling, optimisation in refineries, material failure analysis, corrosion and remaining life assessment, etc. Are the major R&D focus of Indian refiners.

Major attention of R&D within lubricant technology includes development of lubricants, greases and specialties, as well as boundary lubrication, metal working tribology, specialty bituminous products, and fuel additives.

Besides, significant research efforts are underway for alternative fuels – hydrogen, hydrogen-CNG, bio-diesel, second and third generation bio-fuels, solar energy, biotechnology, nanotechnology and petrochemicals & polymers.

Energy efficiency

With the onset of stricter environmental norms and process improvements, energy efficiency in the refining process has gathered momentum. It has the potential to delink industrial growth with environmental impact.

Petroleum refining is the most energy-intensive manufacturing industry. Refineries use various fuel sources and refining by-products for energy. These include refinery gas, petroleum coke and other oil-based by-products. Energy consumption and losses together constitute the major portion of a refinery's cost. Due to the increased complexity in refining configuration for meeting challenging product specifications, energy consumption is envisaged to increase further. Thus, in the near future, existing processes are likely to be replaced with alternatives that are more energy-efficient and environmentally sound.

By the year 2020, processes are expected to be characterised by a high degree of flexibility for handling crudes of variable quality, as well as entirely new feed stocks. Refineries will be tightly controlled to increase performance and efficiency, and will require less maintenance and laboratory services. Costs would be minimised by operating with minimal inventory, using completely automated processes wherever possible. Plant engineers would be able to rely on demonstrated, reliable process models to optimise plant performance, and existing processes would be replaced with alternatives that are more energy efficient and environmentally sound (e.g. ionic liquids in place of solid phase catalysts).

The efforts for process intensification are also underway. This can lead to energy, capital, environmental and safety benefits through dramatic reductions in plant size. Process intensification enhances the mass transfer coefficients and improves areas with the help of new design and advanced materials. Some of the developments include the rotating packed column with foam metal packing that has the potential to reduce size of a crude column by up to 1,000 times.

Energy efficiency may be achieved by either replacing or retrofitting the existing equipments. More often, retrofitting the existing equipment with more energy-efficient substitutes commands better economic support than replacing the existing equipment altogether. Towards this end the refining processes which are more energy intensive, may be more because of processing volume than the energy intensity of the processes (e.g., furnaces, distillation towers), demand technology interventions.

Bureau of Energy Efficiency (BEE) and Petroleum Conservation Research Association are the agencies responsible for promoting energy efficiency across the sectors in India.

Midstream – pipeline transportation

Globally it is observed that oil reserves close to refineries are depleting. Newer, more remote sources of oil and gas are being discovered. Pipelines, as the cheapest source of transportation, have and are envisaged to have a significant role in linking production centres with consumption centres for crude oil, natural gas and finished petroleum products.

The challenge pipeline industry is facing, is different for oil and gas owing to its characteristics. Gas pipeline transportation involves technical issues very different from those of oil. The environmental threats from oil and gas pipelines differ significantly. The challenges of pipeline industry include damage detection and prevention, corrosion managment, integrity management, etc.

The performance of pipeline transportation is limited by the ability to detect corrosion, protect it from damages, corrosion and manage the integrity of the pipeline. The remote and inexpensive monitoring and pipeline integrity management will certainly provide a major boost to operational reliability due to the increased ability to predict the service life and detect the defect. The challenges of enhanced pipeline safety and reliability can be met by developing and integrating new technologies. Technologies providing enhanced capability at low cost shall be adopted.

The areas demanding technology intervention to improve business performance include pipeline monitoring for real-time warning of proximity, inspection tools to detect and characterise corrosion (Stress Corrosion Cracking and Microbially Induced Corrosion), non-intrusive methods for coating and external pipe condition assessment, non-destructive evaluations of unpiggable lines, development and evaluation of new materials for pipeline, and pipeline coating and security.

R&D in the area of hydrocarbon pipeline has also attracted the attention of Indian downstream majors and the current activities includes development of intelligent & caliper pigs for transportation of crude and petroleum products through pipelines, pipeline monitoring, corrosion inhibition etc.

Major pipeline technology area demanding innovation

The Challenge	Technology area demanding innovation
Pipeline Monitoring & Inspection	• Cost effective remote monitoring • real-time warning of proximity
Corrosion Inhibition	• inspection tools to detect and characterize corrosion • Development of advance material • Pipeline quoting including Nano-coating

Midstream

Treading on the alternative route

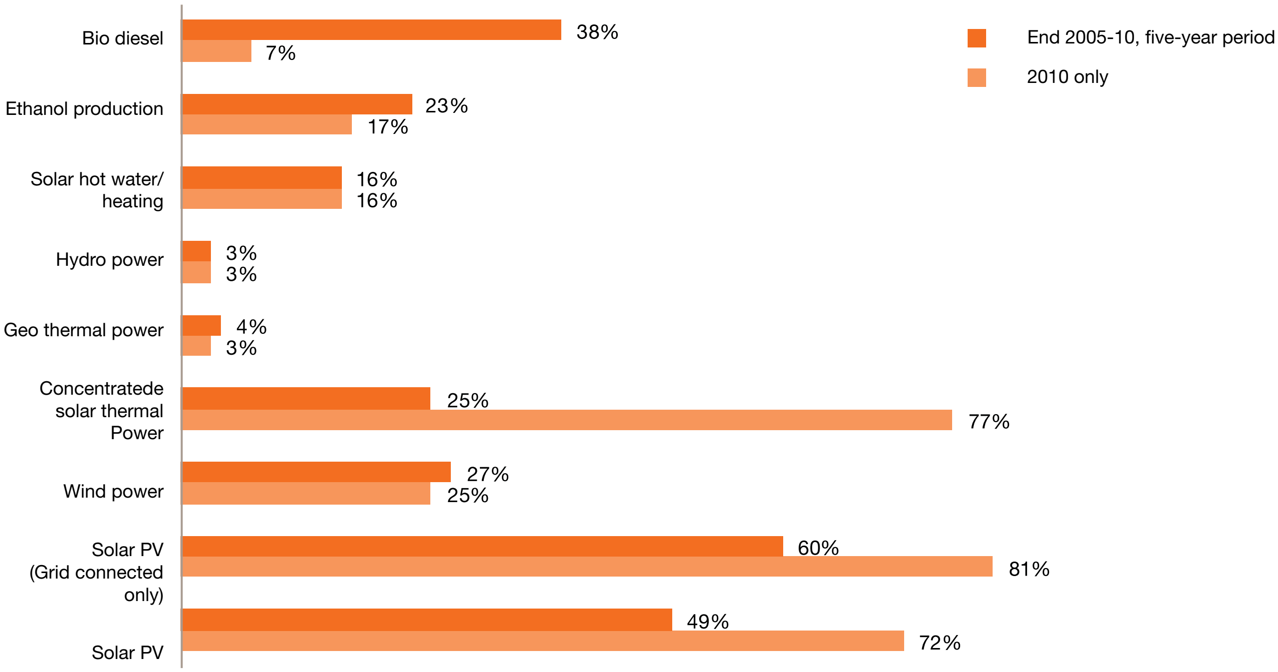
Increasing the share of renewable energy

Increasing dependency on fossil fuels raises concerns over energy security and environmental sustainability. To address these issues, significant developments in renewable energy technologies are vital. Though various governments around the world are promoting renewable energy technologies through various programmes and policies, which have generated significant investments and growth in the renewable energy market, technological advancements are necessary for rapid adoption of renewable energy technologies.

Currently, renewable energy accounts for nearly 16% of the global primary energy demand including biomass and waste. Rapid changes in renewable energy markets, increased investments and government policies so far has led to rise in the share of renewable energy. It is expected that the contribution of renewable energy in the future commercial energy mix across the world is set to increase further.

During the last five years, various renewable energy sources have witnessed a high growth rate, especially wind, solar power, bio-diesel, ethanol etc. However, the current share of renewable energy in the total commercial energy mix is still quite low. Hence, incremental technological developments would be required for a rapid growth in renewable energy technologies.

Average annual growth rates of renewable energy capacity and bio-fuels production, 2005-10



Power and transport sectors, being major energy-consuming sectors, must incorporate renewable energy sources, towards which major technological developments would be necessary. Power generation capacity additions planned worldwide indicate that the share of renewable energy in the total power generation mix is expected to increase. Wind power and solar power are the main renewable sources for electricity generation.

The oil and gas industry is undergoing a tectonic shift making established technologies being repeatedly outpaced. The survival of the business will severely depend on an organisation's ability to question the status quo. The most visible changes continue to demand innovative approaches and technologies.

Despite the steady progress in the technology, significant challenges in wind energy technologies such as complexities in grid integration, reliability issues due to uncertainty in wind flow and land use issues may prevent broader usage of wind power. Similarly, solar power generation technologies also remain one of the most expensive technologies. Solar photovoltaic technologies face cost-related challenges, since there are a very versatile source of power and can be used independently from a grid. Concentrated solar thermal technologies which are, comparatively expensive technology, also pose challenges in terms of cost and land requirements. Though reliability issues prevent broader usage of these renewable energy technologies, addressing cost related challenges through technological advancements will accelerate the growth in renewable energy.

Alternative energy technologies, such as bio-fuels and hydrogen, catering to the demand of transport sector are also demanding significant technological advancements. Bio-fuel alone or bio-fuel blended with gasoline and diesel can cater to the demand in transport sector. Biomass availability is a significant challenge that this segment faces. Production of higher yield biomass and development of cheaper bio-fuel production technologies needs technological advancements. Similarly hydrogen, as a transport fuel, faces major challenges due to higher costs associated with hydrogen storage, transportation and utilisation, which are the main barriers for acceptance of hydrogen fuel. In the transport sector, alternative technology options faces many barriers to the uptake of alternative fuels and vehicle technology. This includes their applicability to various road transport modes, the need to develop vehicle drive-trains to accommodate the specific properties of the fuel, their cost competitiveness and their environmental performance relative to oil. Breakthrough technological advancements would be required to address the abovementioned challenges, for replacing oil based fuels in the transport sector.

Development of alternative sources of energy is undertaken by various Indian academic and commercial research centres. Various academic institution viz. IIT (Rajasthan and Mumbai) have developed dedicated centre to research on specific renewable energy sources. Among various renewable energy sources solar and bio-fuel have attracted the major focus.

The road ahead

Conclusion

The oil and gas industry's ever-increasing need for innovation will compel companies to invest in technology development, and the pace of innovation will differentiate companies from each other. Emerging economies are envisaged to accord higher priority to innovation and R&D. Furthermore, commercialisation of technologies developed in-house developed may be the prime focus of developing countries in the short to medium term.

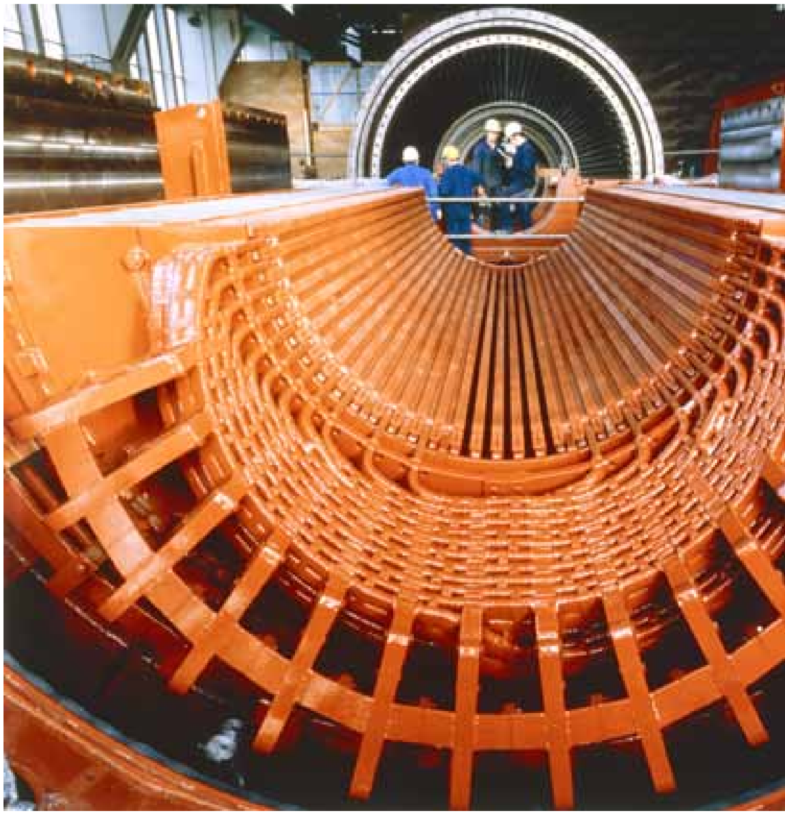
The upstream sector demands major technology intervention for discovering new reserves, improving the recovery factor of existing fields, extraction of heavy crude and unconventional resources. To overcome these challenges, geological modelling, improved subsurface imaging, directional drilling, data acquisition and simulation, various IOR and EOR techniques etc. are envisaged to witness major innovations.

In the downstream sector, catalysts and processing technologies need to continuously evolve to enable processing and purification of the most difficult crudes, and to transform them into the desired fuels and petrochemical intermediates. Further along the value chain, in all the sectors, technology solutions are needed to improve energy efficiencies, allow the incorporation of non-conventional fuels and moderate the climate-change impacts.

Evolution of alternative energy sources is necessary to meet future energy demand. However, considering the progress made so far and efforts on the anvil it is believed that alternative energy sources shall continue to have a smaller share relative to oil and gas. A gradual substitution of fossil energy sources by renewable energy is expected on the horizon beyond 2030.

Innovation and R&D is envisaged to become more complex, thereby demanding more investments. Therefore, organisations may opt to continue sharing experiences and commitment to similar objectives and should leverage opportunities for regional integration. The government plays a key role in facilitating technological breakthroughs. We have, in fact, witnessed the miracle of public private partnerships in the US, where the joint efforts of the government and the private sector revolutionised domestic shale gas resources.

About PwC India



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Deepak Mahurkar
Leader-Oil and Gas, PwC India
T: +91 124 3306027
M: +91 9818670797
Email: deepak.mahurkar@in.pwc.com

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