FIPI

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From the Desk of the Director General

The last quarter has seen series of activities in the Oil & Gas sector in India. The policy initiatives of the government are well on their way to propel the country towards a resilient and self-sufficient economy. In a ground breaking decision, India has switched over to the Open Acreage Licensing (OAL) regime making it a part of the elite league of nations that offer areas for exploration and production of Oil & Gas round the year on liberal fiscal terms including marketing and pricing freedom. On June 28, 2017, Hon'ble Minister for Petroleum and Natural Gas, Shri Dharmendra Pradhan inaugurated India's maiden National Data Repository (NDR), state of the art primary data center (PDC) which stores information on seismic, well log, production and cultural data of 3.14 million sq. km. of sedimentary basins. Under OAL, companies can visit NDR and look at vast seismic data of currently producing fields and explored areas as also those of unexplored areas. This would enable them to carve out an area suitable to them and submit expression of interest for reconnaissance, operations and exploration operationsin the areas that are not under any licensee.

At the energy dialogue of the Organization of the Petroleum Exporting Countries (OPEC) in Vienna, our minister Shri Dharmendra Pradhan strongly emphasized on the fact that India being a large import destination and a country which has always provided timely payments and honored all its contractual commitments should be provided a discount in prices instead of the "Asian premium" that is levied on it and other Asian buyers. He highlighted that India's energy mix is transforming rapidly and over the past three years renewable energy has grown with the price of solar energy coming down to 4 cents per unit. In view of this he emphasized that the Oil Industry is at delicate crossroads and higher crude oil prices will only shift focus to solar, wind, electric vehicles and hybrid cars. It was in this context that he stressed that India should not have to bear the brunt for subsidies provided to others and a responsible pricing scheme is essential to ease supply of energy to common man. It was to provide clarity on the same that when interviewed by Rajya Sabha TV, I mentioned the dire need to bring about stability in oil prices to prevent the extreme scenarios of either lower prices resulting in low profitability or higher prices resulting in disruptive technologies and shale gas eating up the market share.

In a bid to reduce the possibility of arbitrage and improve transparency in pricing mechanism so as to offer best possible prices to the customers, daily revision of petrol and diesel prices across the country in sync with international oil prices has been introduced. This puts India in the select club of developed countries such as the US, Japan, Australia, Germany and Russia.

Under the government's flagship programme, Pradhan Mantri Ujjwala Yojana (PMUY), the state-owned Oil Marketing Companies (OMCs) have successfully released 3.25 crore new LPG connections during FY 2016-17, the highest ever number of LPG connections released in a financial year so far in the LPG history of the country. This increase in connections has resulted in a jump in the LPG coverage and as on 01.04.2017, the national LPG coverage is estimated

to be 72.8% with 19.88 crore active consumers. The latest mandate for the Oil companies is to add 10 crore new cooking gas customers between April 2016 and March 2019.

A conclave on the theme "Clean Fuels for Cooking & Transport: Social, Environment & Health Benefits" was held on April 27-28, 2017 and was attended by Dr. Pierce Riemer, Director General, World Petroleum Council; Mr. Christ of van Agt, Senior Energy Analyst, International Energy Forum; along with senior officials of the Oil & Gas Industry. The workshop was highly informative and focused on cooking fuels including penetration of PNG in India along with improving the efficiency of supply chain in LPG distribution specifically in remote / rural regions. The health impact due to switchover to clean cooking fuels was also deliberated in detail during the workshop. The workshop also delved into clean and sustainable transport needs for India and the leapfrogging from BS IV to BS VI type engines and its potential impact.

FIPI had the pleasure of hosting Mr. Bob Dudley, Group Chief Executive, BP p.l.c in an 'Energy Dialogue' series. This dialogue was attended by Shri Dharmendra Pradhan, Hon'ble Minister for Petroleum & Natural Gas, Shri Piyush Goyal, Hon'ble Minister for Power, Coal, New & Renewable Energy & Mines; Shri Rajiv Pratap Rudy, Hon'ble Minister for Skill Development & Entrepreneurship; as well CEOs of major Oil & Gas companies in the country. Mr. Bob Dudley in his speech stated that there was a need to adapt digital technologies and make things simpler and standardized to grow. He asserted that India as a large energy consumer would need all forms of energy and hence low prices would always be welcome news and emphasized the fact that energy is the most important catalyst for achieving sustained growth.

The coming couple of months will prove crucial for the Indian economy. The landmark roll out of the Goods and Services Tax from July 01, 2017 is bound to impact the Oil & Gas Industry in particular as it will have to face a severe brunt with it having to comply with both the current tax regime as well as the GST regime leading to double compliance cost because five petroleum products viz crude Oil, Natural Gas, motor spirit, high-speed diesel and aviation turbine fuel have been excluded from the GST, while other products such as LPG, naphtha, kerosene, fuel oil etc are included. It is a matter of time before the impact of actual operational issues of having a dual regime which will result in non-creditable tax costs where an Oil & Gas Company will pay the GST on procurement of plant, machinery and services, and will be unable to get credit on sale of the finished products (which are out of the purview of GST) as the input GST would not be creditable.

In view of the above concerns of the industry related to GST, FIPI continues to take up the issue with concerned authorities of the government. Several rounds of discussion have been held with various working committees and member companies have also followed up with concerned state government officials for the same. However, it seems that it will take some time before this issue is fully resolved to our satisfaction. We will nevertheless continue to take up the matter suitably.

Dr. R. K. Malhotra
Director General

International Best Practices in Operations of CNG Refueling Stations

Nitish Borthakur
7th Semester student,
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Delhi

The need for optimization of station operation

In recent years, CNG stations have witnessed long queues and inefficient operations. CNG stations are not uniformly distributed across the national capital region, with Gurgaon having less than twenty CNG station for more than sixty thousand CNG vehicles. The simultaneous queuing of private and public vehicles has further aggravated the problem. As a result, every vehicle, on an average, spends between twenty to one fifty minutes per refueling trip in NCR.

To further complicate the situation, the number of CNG vehicles has been rising gradually in NCR because of the ban on petrol and diesel run taxis, and the adoption of odd-even rule in Delhi, both incentivizing residents to switch to CNG vehicles. With the recent government push to introduce the CNG programme for two wheelers, there is a need to overhaul the existing CNG infrastructure in the state, to keep up with the rising demand.

To achieve this, there is a need to increase the number of stations and station capacity of each station. However, these solutions require long term planning for successful implementation. Apart from these, the optimization of current CNG station operations is a short term measure that can be taken to improve the congestion in stations. Any such measure must achieve a reduction in queue lengths and time spent by vehicles. Also, measures resulting in reduction of set up and operating costs also need to be explored.

Optimization can be achieved in two ways. The first is by upgrading the equipment employed at the station. A host of unconventional technologies have hit the international market over the last few years, which can be adopted by Indian gas distribution companies. The second way is by improving the physical infrastructure in stations. Countries like Argentina and New Zealand have developed innovative solutions with the help of technology experts, architects and traffic engineers to achieve this.

Improvement in technical infrastructure of CNG station

Dynamic Stage Change Compressors

Overview

In recent times, compressor systems involving dynamic changing of number of stages during operation have been developed. Such systems generally come in 4 Stage/2 Stage configurations. In the direct-fill/cascade refilling operation, it functions in 4-stage mode. While a vehicle is refueling, it automatically switches to 2-stage mode. J-W Powerfill of the J-W Power Company is one such system available in the market today.

Operation of Dynamic State Change Compressor

In a conventional CNG station, gas enters the site at a relatively low pressure from the gas pipeline network. It is compressed to a high pressure and stored in storage vessels (also known as cascade) using the station compressor. When a vehicle arrives for refueling, the dispenser connects the cascade and the vehicle fuel tank, leading to equalization of pressure between the two. However, at most times, there is a pressure drop during refueling of the vehicle and complete filling is hence not achieved. Hence, CNG from the pipeline network is compressed by the station compressor and flows to the cascade, till pressure equals that of the vehicle tank. In the dynamic stage change compressor system, during the pressure drop, there is a reversal of CNG flow from the conventional operation. CNG flows from the cascade to the compressor for compression, and then to the dispenser and vehicle.

Business Implications of these Systems

The gas pressure in the cascade is much higher than that of the network. This increases the flow rate to almost ten times of the conventional model. Hence, there is a reduction of almost 30% in the service time per vehicle. This translates to a substantial increase in the number of vehicles refueled and revenue from sales, especially during peak hours.

In addition, drawing gas from storage during refueling reduces the pressure in the cascade. When the cascade is refilled, it holds more gas, increasing storage space to a little over three times that of conventional cascade systems. This translates to decrease in CAPEX cost of cascade.

Also, frequent starts and stops of the compression cycle are almost three times lesser than the conventional compression system, because of the dynamically changing number of stages in it. This reduces the wear and tear of the equipment, and hence the maintenance cost of the compressor. This is a significant advantage, since compressor functioning is one of the costliest components of running a CNG station.

It is also important to note, however, that this technology consumes significantly higher electrical power than the conventional systems. Hence, it might not be economically feasible to implement it in low volume stations.

Adsorbed natural gas storage cascades

Overview and Functioning

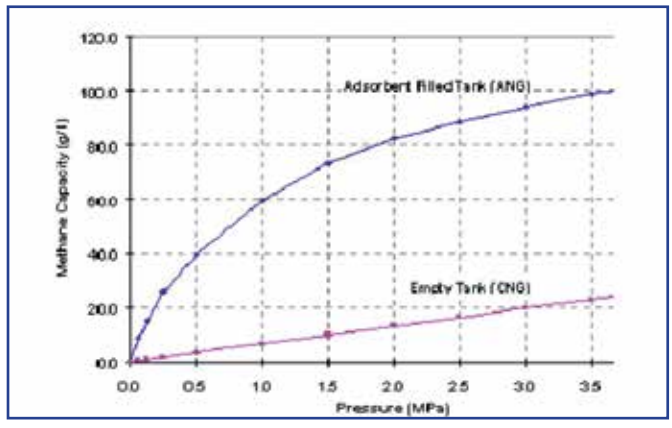
These storage tanks are made with a porous, synthetic carbon-based interior, which allows the gaseous fuels to be soaked into the “nano pores” of the material. This liquid-like state, in which the gas becomes very dense around these materials, is what is referred to as an “adsorbed state”. Usage of these systems allows tanks to be filled with lower pressure. These systems are widely in use in North America for storage purposes.

Business Implications of ANG cascade systems

Because of the adsorption of gas by the carbon interior in the cascade, more amount of CNG can be stored for the same volume of tank at a given pressure.

In conventional cascade systems, the storage tank is generally in a cylindrical shape, for maximum strength. However, this geometry puts a limitation on the CNG volume stored in the cascade. The ANG cascades however allow the gas to be filled at lower pressure, which significantly reduces the strength requirements of the cascade. Hence, a change in tank geometry is possible, leading to at most fifty per cent increase in CNG volume in tank.

In addition to it, low capacity compressors can be used to fill up the cascades due to low pressure filling characteristics of ANG cascades. This reduces the compressor cost and electricity consumed by the compressor.



Comparison of storage capacity between conventional CNG and ANG storage systems

Software Assisted CNG Compression and Storage Systems

Overview and Functioning

It has been noticed that in most stations, dispensers exceed compressor capacity, and the simultaneous use of all the dispensers leads to pressure drop at times. Although a specific number of dispensers should be kept idle at any time, for preventing this, it is often difficult to implement such optimization techniques, especially during peak hours. Often vehicles, especially autorickshaws have to leave the station without complete refueling because of this.

To address this problem, there are a number of software available made to match cascade storages and compression capacity for peak fuel demand. One such software is CASCADETM developed by the Gas Technology Institute (GTI), of the USA.

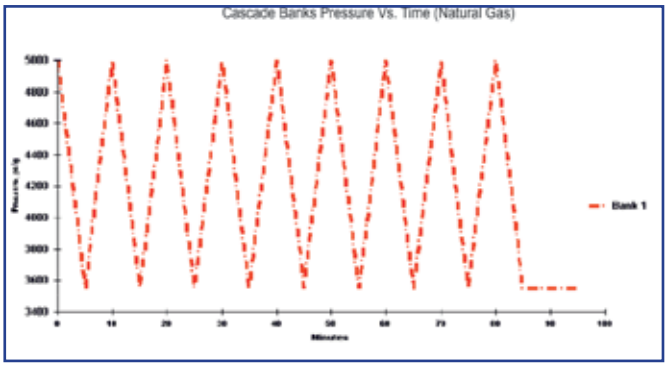
Such programs simulate vehicle fleet fueling based on data of a few vehicles being refueled. The characteristics of vehicles to be fueled and key fueling station attributes such as compression capacity, ground storage, number of dispensers, fueling pattern, and ambient conditions are taken into account during simulation.

Based on these simulations, the software infers the filling patterns of subsequent incoming vehicles. This results in the buffer storage capacity being balanced in a manner which allows vehicle filling within target time and refilling the buffer storage before the next vehicle is connected.

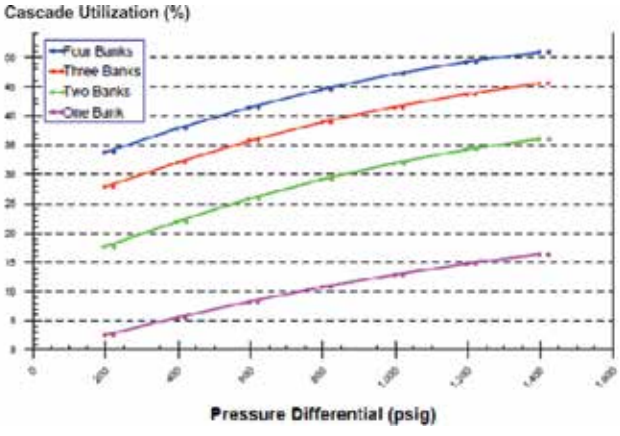
Business implications of CASCADE™ and similar software

The use of such software make it possible to use a smaller compressor to service a large fleet by allowing the compressor to run between vehicles refuels, thereby reducing its required peak flow rate. Hence, it addresses the problem of pressure drop faced during peak hours, ensuring customer retention and increased sales of CNG.

However, one negative aspect of it is its inability to operate satisfactorily after depletion, which occurs after a number of successive vehicle refueling.



Buffer storage pressure profile for a bank in CASCADE™ software system



Cascade utilization rates for different number of banks in CASCADE™ software system

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Improvement in Physical Infrastructure of CNG Station

The business implications of modifications in physical infrastructure are immense because of the relatively lower investment costs and significantly higher monetary gains. The principle aim of implementing them lie in maximizing traffic flow through the station within the fixed ground area covered by the station, resulting in increased revenues from sales.

Installation of Station Equipment on Roof

The installation of station equipment on canopy is one of the best ways of saving station area space. The additional space is used by many petrol pumps to maximize traffic flow volumes. It can lead to a substantial decrease in space requirements in CNG stations, since CNG equipment, particularly the compressor station occupy large spaces. It is widely in use in countries like Argentina and Brazil.

IGL, in 2012, introduced equipment installed on RCC canopy at its existing station in Nanglamachi on Ring Road in Delhi. In a statement, IGL had said that it resulted in nearly 40 per cent of the plot area has been saved, which was utilised for CNG dispensing.

The following considerations must be kept in mind for placing different equipment, on roof-

Compressors

The vibrations of compressor need to be transferred to canopy. Hence the strength of the canopy is crucial. Also, the height of canopy needs to be higher. Hence, capital cost of setting up the station is higher. However, if it is compensated for, by subsequent rise in revenues due to increase in traffic volumes, it will become economically feasible.

Cascades and Dispensers

Cascades can be kept on the canopy, or underground without any significant problems. Dispensers on canopy with overhanging hoses are currently in use in petrol pumps, in Delhi. If the constant maintenance requirements and safety considerations of CNG dispensers are taken care of, it can be introduced in CNG stations as well.

Overhanging hoses in a service station in Seoul, South Korea

Traffic Management Techniques

Incorporation of traffic engineering principles can go a long way to ensure optimized queuing at CNG stations. The following techniques are used in countries like Australia for this purpose-

Solid median : It is a traffic island with the function of separating different lanes of traffic.

Flush median : It is a strip in the center of the road marked with white diagonal lines within parallel lines.

Applications : They are used to accommodate U-turns safely for vehicles entering from and exiting to the other side of the main road in front of the station. It hence helps prevent delays in vehicles entering and present inside the station, vehicles exiting the station and traffic moving on the main road in front of the station.

Kerbside lane : It is the side of the road nearer to the stone edging of a pavement or raised path.

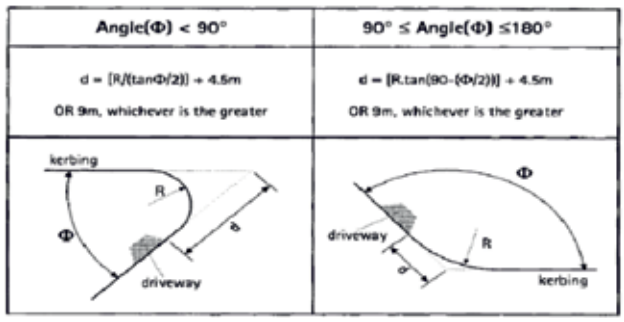
Applications : Increasing the Kerbside prevents the traffic on the main road in front of the station from slowing down due to vehicles decelerating to enter the driveway of the station, and vehicles accelerating to exit the driveway of the station.

Station Layout Design

During the construction of CNG stations, it is important to ensure that the layout design is conducive to free movement of vehicles and minimizes obstructions to ensure maximized vehicle volume, especially during peak hours. The following practices have been adopted in New Zealand to achieve this.

Distance between driveway and intersection corners

The minimum distance from the station driveway to the intersection points as shown ('d') is calculated as shown in the diagram-



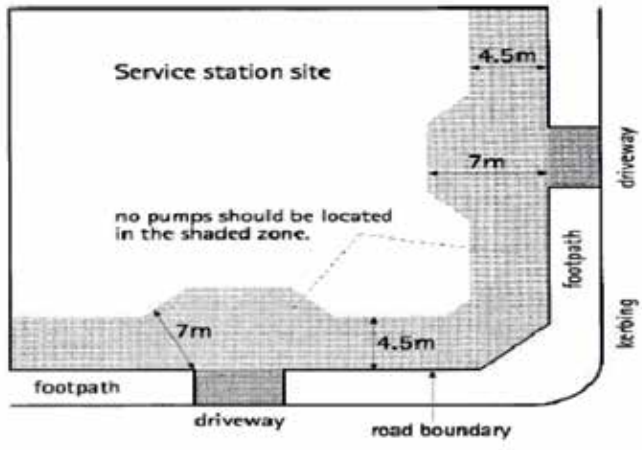
New Zealand Transport Authority

In case of T-intersections, if a seagull island is not present at the intersection, no driveway should be located at the head of the T.

Distance of dispenser from the driveway

It is important that the driveway is not blocked by incoming vehicles; otherwise the road traffic might be slowed due to vehicles entering the driveway. To achieve this, the dispensers need to be placed at a sufficient distance away from the driveway area, so that queuing takes place inside the station and not at the driveway.

To achieve this, the design requirements, as shown in the figure, have been adopted by stations



New Zealand Transport Authority

Driveway angle and width

It is important to achieve maximum visibility of station and vehicles in front of a queued vehicle for smoother flow of traffic at the driveway. One of the ways to achieve this is by keeping the angle between the driveway and the kerbside between 70 degrees and 90 degrees.

Conclusion

Innovations in the natural gas dispensing industry are evolving at a rapid rate. Although, most CNG refueling stations today do not require sophisticated improvements in their operations, the exponential rise in NGVs expected in the future justifies the early adoption of modernization measures. For policy makers, the need for setting up new stations can be offset to an extent by promoting fully optimized ones. Companies, on the other hand, can witness substantial long term profitability and competitiveness by adopting such measures.

Leveraging Gas in the Energy Mix

Sashi Mukundan
Regional President & Head of Country-India
BP Group

"I see India moving fast towards becoming a gas based economy. This will steer sustainable, efficient and responsible growth for the foreseeable future." Here are my views which I shared with a panel recently. We met to discuss on the topic "Leveraging natural resources to harness the India growth story" - It was a curtain raiser to the Global Natural Resources Conclave (GNRC) hosted in New Delhi, in March 2017.

As a representative of the energy sector, my focus is on opportunities and challenges for upstream investment, and availability of natural gas – how to boost domestic gas production and attract investments - to move India to a gas-based economy.

Before getting down to the crux of my discussion, I would like to share some major trends in the energy industry which need to be noted as context.

- The global energy demand is projected to grow by 1.0 -1.5% p.a. over the next 20 years. Virtually all this growth comes from emerging economies, with China and India accounting for over half the increase. The global demand has grown an average of 1.5 mb/d a year for the last couple of years. Nearly two thirds [66%] of the increase in global energy demand is for power generation, as electrification continues to expand in the world economy.
- As awareness of climate change grows, people are making a conscious choice to live responsibly – by opting for renewable sources of energy and low carbon fuels.
- There is a shifting pattern in the various sources of energy: natural gas is growing faster than coal and oil (1.6% p.a.), overtaking coal to become the second-largest global fuel source by 2035. As per BP Outlook, natural gas and non-fossil fuels will together supply almost 80% of the increase in energy to 2035.
- And a spot of crystal-ball gazing regarding India.
- India's economy is projected to grow at 7-8% per year until the end of this decade - energy being the key input for this growth
- Its energy consumption is likely to grow by 4-5% p.a., faster than all major economies in the world, e.g., in 2016, it was 353 kb/d vs. global growth of 1.6 mb/d. The consumption growth of fossil fuels will be the largest in the world. Despite energy production more than doubling over the next 20 years, the country will remain import dependent to help meet this vast growth in consumption.
- The good news is that India is doing this in a very responsible manner given its commitment to the COP21 targets (reduction of 33% of carbon intensity of its GDP from 2005 levels by 2030). It has been stated that India will increase its power generation from renewables by 175GW by 2022 and switch 40% of its power generation capacity to non-fossil fuels.

Given the foregoing trends and forecasts, it is heartening to observe how India has been fast off the block in relating to shifting energy patterns and leveraging its energy resources. A slew of policy initiatives taken by the Government, under the leadership of Prime Minister Modi, has the potential to bring in sweeping changes in the way energy is sourced, supplied and used in the country. Amongst these, two major ones are to reduce Oil and Gas imports by 10% and increase the share of gas in the energy mix from 6.5% to 15% by 2022.

What more can India do to actualize this? Our bucket list would be:

- Formulate a clear policy which enunciates a stable fiscal and contract regime to provide assurance to investors
- Exploration: carve large areas for PSU/IOC/Private partnerships to unlock frontier exploration
- Development: accelerate development of discovered resources
- EOR: Bring cutting edge technology to unlock reserves through EOR. [1% increase is 7% or 500 million barrels of additional reserves]
- Demand HUBS: Develop 'Demand Hubs' to promote gas with source of supply, anchor customers – refinery/petrochemical complex, power plants or fertilizer plants, pipeline infrastructure, CGD/PNG, commercial and industrial users, smart cities

To conclude, my vote and voice is for a concerted effort to move India to becoming a gas based economy that will steer sustainable, efficient and responsible growth for the foreseeable future.

For this to fructify soon, we need to bring on board a Gas Master Plan – which will help incentivize and activate investments as never before. Natural Gas should play a key role in bridging the energy gap as India transitions to affordable clean energy and renewables.

Future of R&D in Upstream E&P Oil & Gas Industry

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Introduction

Liquid hydrocarbons such as crude oil literally fuel the global economy. Consumption of crude oil in its various forms has grown at an average rate of 3% from 1990 to 2010 whereas proved reserves of Oil & Gas have increased at an average rate of 0.5% during the same period. More than 75% of the oil producing fields globally, have been in operation for longer than 25 years. However, the recovery factors from some of the best quality reservoirs have been in the range of 30% of original-oil-in-place (OOIP) only. These facts have several implications- Oil operators need a multi-pronged approach to sustain and enhance crude oil production that includes discovering new oil in complex basins, management of mature fields, development of unconventional resources, cost–effective development of renewable resources, operational efficiency, compliance with existing regulations and developing environmentally sound solutions, etc. Even an average increase of the recovery factor by 1% will have a major impact on Oil & Gas output. Use of polymers and surfactants to improve the efficiency of water flooding is currently a major area of investigation. Field application of yet to be commercialized technologies, like microbial EOR technology, is likely to increase the recovery factor even further.

New technologies have been traditionally been provided by global oilfield service providers.

Dedicated R&D efforts over the years have dramatically altered the way in which Oil & Gas reserves are identified, developed and produced. This includes improved subsurface imaging through the use of advanced 3D seismic acquisition techniques, geological modelling, 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. Globally, the R&D investment in upstream hydrocarbon industry is affected by economic conditions. The R&D activities in the upstream E&P sector in India has, however, exhibited a remarkable resilience to lingering effects of global economic slowdown. Encouragement by Government of India in the form of tax incentives, and focussed technology specific initiatives by pioneering and leading national oil companies has enabled India to position itself as an R&D hub. In the days to come, the upstream E&P Oil & Gas sector will face a diverse range of challenges as it tries to meet the increasing demand for hydrocarbons to fuel India's future generations. The search for new hydrocarbon resources in harsher environments, a shift towards more sustainable E&P operations and successful management of mature fields will require sustained and technology specific R&D efforts. A wide landscape full with new opportunities for multidisciplinary Research & Development initiatives is visualized for the Upstream E&P sector.

Future Thrust Domains for R&D in Upstream E&P

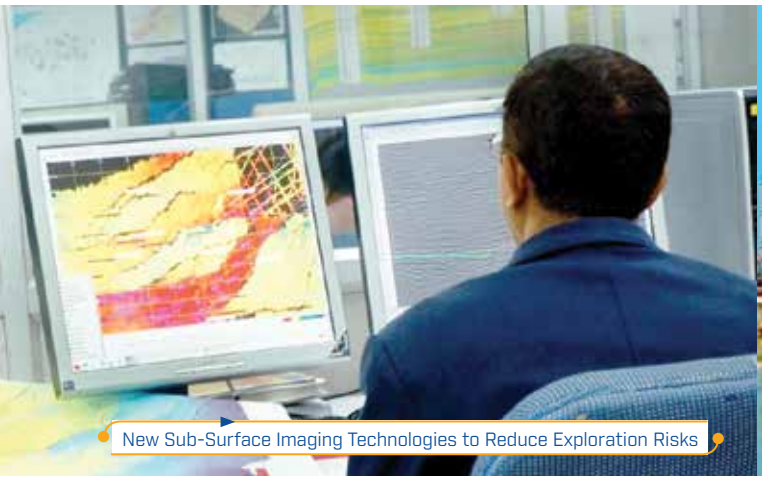
Technological innovations through sustained investments in high impact R&D will be crucial for ensuring global energy security. Although, the upstream industry involves people with diverse scientific, technical and managerial disciplines, certain thrust areas can be readily identified. These thrust areas are discussed herein.

High Resolution Sub-Surface Imaging Capabilities

Traditionally, the upstream hydrocarbon industry has relied on reflection seismic to image the subsurface layers of the earth and find the potential hydrocarbon bearing structures. The industry's target is to improve the subsurface images needed to find and produce hydrocarbons from reservoirs which could not be discovered with the legacy technologies during the golden days of 'Easy Oil'. Obstacles to this goal include limitations imposed by the physics of the rocks themselves as well as the limitations of the instrumentation and available computing power. Low reflectivity contrast between rock layers, multiple reflections from certain layers, the uneven nature of earth's surface and the resulting noise, etc. are some of the factors that hinder proper imaging of subsurface layers. On top of these are economic considerations to reduce costs of obtaining such high resolution imagery of the sub-surface in varying terrains. Over the past century, the industry has relentlessly sought ways to improve subsurface imaging of hydrocarbons. Advanced computing capabilities are now enabling us to construct more detailed models from the collection of high-quality datasets. However, there is still a great need for improved technologies that image reservoirs more accurately and make pore-filling fluids visible at high resolution within producing fields. Technologies being developed globally through Research and Development initiatives are now seeking to provide truly fit-for-purpose subsurface image at lesser costs. In the coming years with advancements in the fields of Remote Sensing, Seismic and Gravity Data Acquisition, Electromagnetics, Signal Processing and Super Computer based modelling riding on exciting new nanotechnologies will lead the way in 'Illuminating the Hidden Geological Features' that were not visible to us so far.

Management of Produced Water

Produced water or formation water, is the aqueous phase that is co-produced along with the oil and/or gas phases from a producing well during normal production operations. This includes water naturally occurring alongside hydrocarbon deposits, as well as water injected into the underground formation for pressure maintenance or secondary recovery purpose. The composition of the produced water is complex and specific to the geological formation, the oil and water (both in-situ and injected) chemistries, rock / fluid interactions, the type of production method used and the associated chemical additives. In most cases, the main constituents of concern in produced water are high level of Total Dissolved Solids (TDS), oil and grease, suspended solids, dispersed oil, dissolved and volatile organic compounds, heavy metals (including radionuclides), dissolved gases and bacteria, and chemicals (additives) used in production such as biocides, scale and corrosion inhibitors, and emulsion and reverse-emulsion breakers. The amount of produced water, and the contaminants and their concentrations present in produced water usually vary significantly over the lifetime of a field, being low initially and increasing with the maturity of the field. Currently, produced water is by far the largest volume waste stream associated with upstream E&P Industry. Shrinking global reserves and sources of potable water due to anthropogenic interventions or climate change over the years makes it essential for the E&P sector to innovate at a fast pace to incorporate sustainable technologies that re-use produced water. Technologies for Produced Water Re-Injection (PWRI) and alternate uses such as irrigating croplands, consumption by wildlife and livestock, rearing of fishes, soil-less culture of vegetables, industrial processes, dust control, vehicle and equipment washing, power generation, and fire control, need to be developed. Research and Development activity in future will also focus on treating produced water to drinking water quality levels in a cost-effective and sustainable manner. The R&D efforts at utilising produced Water for human consumption or use in agriculture has also a challenge of overcoming the issue of 'public acceptance' by generating toxicity data of the complex chemical mixtures (contaminants) on human health and the environment.



New Sub-Surface Imaging Technologies to Reduce Exploration Risks

Sustainable Management of Produced Water is a Challenge Area for the Future

Exploitation of Unconventional Resources

Resources such as heavy oils and hydrocarbon-bearing shales were not considered as feasible to exploit and were overlooked in the recent past. The primary recovery from heavy oil reservoirs was less than 10% and processes such as water flooding, gas flooding or even steam flooding were not very efficient. Shales were considered as good cap rocks for conventional reservoirs but their potential as reservoir rocks was considered as very poor due to the highly compact and almost non-permeable nature. Sustained research and innovations has made it possible to economically recover hydrocarbons from these unconventional resources. For example, the Steam Assisted Gravity Drainage (SAGD) process utilizes two parallel, horizontal wellbores placed one over the other in heavy oil reservoirs. The upper wellbore is used for injecting steam and heating up the oil, which drains into the lower producing wellbore. This innovative process, with several variants such as Solvent Assisted Gravity Drainage, has made heavy oil recovery economical. Similarly, the placement of horizontal wells in hydrocarbon bearing shales combined with hydraulic fracturing has made it possible to recover large quantities of gas and oil from otherwise difficult-to-exploit shale resources. Shale gas contributes substantially to the overall energy production in USA today, along with oil, coal and conventional gas. The production of conventional gas is on the decline, whereas the contribution of shale gas is expected to continuously rise.

Exploration data available indicate that India holds promising reserves of shale gas & oil resources. Post 2013, when the initial phase permission for shale gas and oil exploration was provided to National Oil Companies in the upstream sector by Government of India, around 56 nomination blocks have been earmarked so far. Global experiences at exploiting this unconventional resource indicate that there are major technology gaps that need to filled up to make the exploration and production process more accurate and sustainable for long term economic gains. Moreover, India has already taken a strategic leadership initiative towards exploring and economically exploiting the estimated 933 trillion cubic metres of gas hydrates available in its territorial waters through National Gas Hydrate Program. Present and future R&D efforts need to develop new multiple-application technologies that address a gamut of challenges ranging from drilling, completion, flow assurance, safety, production technologies and equipment for use in hydrate production and mitigation of environmental impacts.

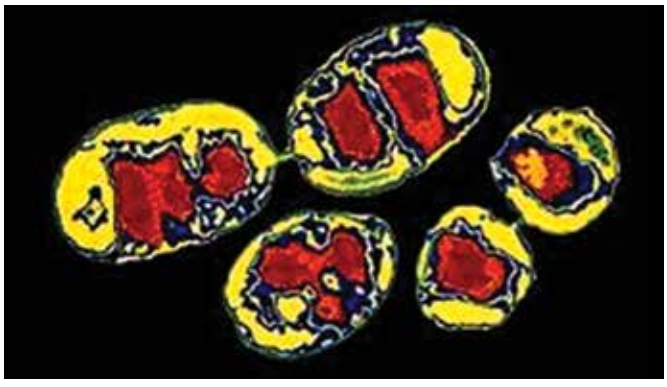
Energy Security in Times of a Rapid Shift to Clean & Alternative Energy

As we plan for the future we must learn from the experiences gained during the past and the present in the Indian as well as in the Global context. The World Wars, the race for acquiring destructive technologies in the form of Nuclear, Chemical and Biological agents of mass destruction and the present Geo-political situations prevailing in fuelled by rise of new and virulent forms of Global Terrorism will herald changes in the way 'Bottom lines' have so far been perceived and accepted in the upstream E&P sector. Historic examples of development of Synthetic Fuel production units by countries having limited reserves of Oil & Gas and the present example of some European powers like Germany starting their 'Energiewende' (Energy Transformation) just two months after the Fukushima Nuclear accident in Japan indicates a Rapid Global shift towards renewable energy. Biodegradable materials could be a significant source of energy in the coming years. Game-changing technologies that produce higher-oil-yielding bio- raw materials and microorganisms that efficiently convert biodegradable materials to biofuel could greatly benefit the industry. Research into increasing the amount of oil in a Bio-Energy source like Algae, Fungi and Biofuel plants like Jatropha plant seeds, could improve the oil yield. Improving the abiotic stress tolerance of an energy crop, such as the Jatropha plant, could make it attractive to cultivate in India's barren wastelands where they will not compete with food crops. Technologies that develop and reduce the current operational costs of Solar and Wind energy also needs to be explored to enhance India's capabilities for self-reliance in Renewable Energy sources for the future.

OIL's State-of-the-Art Petroleum Biotechnology Centre in R&D Department Duliajan, Assam

In-Situ Approaches : (The future mix-discipline game changers)

Research to understand the molecular building blocks of organisms living in diverse environments could help optimize the production of usable energy from both unconventional fossil and renewable sources. The search for microorganisms should include diverse sources, ranging from hydrocarbon reservoir to the guts of insects such as termites. Research into the molecular structure of these organisms could pave the way for improving exploration, production, and processing of fossil fuels and also help to produce usable energy from renewable sources efficiently and cost-effectively. Until only a few years ago, the majority of researchers were of the opinion that no living matter could exist in hydrocarbon reservoirs. But in recent years, a number of researchers are searching for organisms that could convert heavy oil to a lighter version or quality. In one such amazing discovery researchers have found a new species of bacteria named as Methylomirabilis oxyfera that survives by producing and "breathing" its own oxygen. The understanding of the unique metabolic pathway and the basic building blocks of this novel bacterium will pave the way for engineering of an in-situ process to accelerate naturally slow methanogenic biodegradation to recover energy from heavy oil reservoir as methane. Future game changing approach would therefore focus on 'In-situ Molecular Manipulation' of the contents of challenging reservoirs to reduce harmful products (like H_2S), generate beneficial products (like CO_2, Surfactants etc.) and reduce associated production bottlenecks. For example, converting heavy oil at its source to lighter grade oil will reduce or eliminate the need for thermal recovery, the associated capital investment, and the associated environmental issues.



Novel bacteria like Methylomirabilis oxyfera opening new vistas for In-Situ Approaches

Mature Play Management : Potential R&D Driver

The lifecycle of an oilfield is typically characterized by three main stages: production buildup, plateau production and declining production. Sustaining the required production levels over the duration of the lifecycle requires a good understanding of and the ability to control the recovery mechanisms involved. For primary recovery (i.e., natural depletion of reservoir pressure), the lifecycle is generally short and the recovery factor does not exceed 25% in most cases. Incremental recoveries in the range of 10-20% could be achieved through secondary recovery involving water or gas injection. Globally, the overall recovery factors for combined primary and secondary recovery range between 35 % and 45%. Therefore, maximising the recovery from mature fields while minimizing operational costs and keeping a low environmental imprint are other areas that are going to drive future R&D efforts in the E&P sector. One of the factors that affects the efficiency of waterfloods is the preferential flow of injected water through high permeability channels in the reservoir, which leaves a significant amount of un-swept oil in the lower permeability zones. 'Smart' waterfloods that have been designed in the recent years overcome this problem by including special chemicals in the flood water that selectively plug the high permeability zones. This causes the injected water to be diverted into lower permeability zones and the sweep efficiency is increased. Tertiary enhanced oil recovery (EOR) methods such as chemical flooding (that use a combination of alkali, surfactant and polymer for lowering oil-water interfacial tension and improving sweep efficiency of injected water) could push up the recovery factors upto 60% of original-oil-in-place, provided the chemical slug is carefully designed as per the reservoir conditions.

Emerging technologies from multi-disciplinary and R&D intensive areas such as biotechnology and nanotechnology could play big role in the near future in managing mature fields and improving recovery factors. Microbial Enhanced Oil Recovery (MEOR) involves use of bio-surfactants or injection of bacterial strains to generate chemicals (surfactants or polymers) in-situ for achieving higher recoveries. Nanotechnology is likely to find greater applications in the days to come for improvement of downhole operations, and aiding in the development of non-corrosive materials that could be used in drilling and flow assurance applications during production. Development of nano-scale devices or 'nanobots' that provide targeted delivery of chemicals (e.g., surface-active compounds) directly to the oil/water interface to modify the microscopic displacement pattern is another example by which the successful field translation of nanotechnology can help the E&P sector.

Conclusions

The India Hydrocarbon Vision 2025 enlists improvement of the quality of life by progressively improving product standards to ensure a cleaner and greener India. Continued technology acquisition and absorption along with development of indigenous Research & Development (R&D) capabilities in the upstream E&P sector would therefore have to focus on addressing national as well as global concerns for climate change, by focussing development of technologies in the area of Carbon Capture and Storage (CCS). Collaboration among industry and academia with adequate policy support from government will be crucial to meet these increasingly complex technical, economic and environmental challenges. Developments in Science and Technology and successful application of new tools generated by upcoming fields like Nanotechnology and 3D printing are going to change the way in which Exploration and Production activities are presently carried out across the upstream Oil & Gas Sector. India's large pool of skilled manpower with the requisite expertise in applied sciences and engineering disciplines is an inherent advantage that has to utilised and nurtured by Institutionalizing R&D set-ups focused on the upstream E&P Oil & Gas sector across the country. Collaborations both at the national and global level to 'Leap-Frog' into new technology areas will also be crucial in researching and developing cutting-edge technologies in pace with the rapid shifts being experienced in the Oil & Gas sector at the moment. The new breed of R&D professionals engaged in the upstream E&P sector would have to live up to the challenges that lie ahead of them and unbox the limitless opportunities that current and future challenges would bring.

(The present article elaborates the focus areas highlighted by GM (R&D), OIL during the concluding panel discussion on 'Future Roadmaps for R&D' in the recently concluded FIPI R&D Conclave 2017 with the Theme: Ideas are Here, held a Mussoorie during 16th -18th February, 2017)

Finance

Tax Considerations for Foreign EPC Contractors

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Introduction

The Oil & Gas sector is among the eight core industries in India and plays a major role in influencing decision making for all the other important sections of the economy. India is expected to be one of the largest contributors to non-OECD petroleum consumption growth globally.

India's refining capacity is estimated to reach 256.55 Million Metric Ton Per Annum ('MMTPA') by 2019-20 after completion of projects undertaken by a number of refineries which are currently undervarious stages of implementation. Globally, India is the third largest consumer of crude oil and petroleum products and second largest refiner in Asia.

India is already a refining hub with 23 refineries and expansions planned for tapping foreign investment in export-orientedinfrastructure, including product pipelines and export terminals. Indian public sector companies (PSU) are set to make massive expansions in the refinery sector by way of raising additional capacities and setting up new refinery plants to efficiently cater the demands from various geographical locations. India's three major state owned refiners viz., Indian Oil Corporation Limited (IOCL), Hindustan Petroleum Corporation Limited (HPCL) and Bharat Petroleum Corporation Limited (BPCL) intend to jointly setup India's biggest refinery on the west coast with a capacity of 60 MT and mega petrochemical complex to be setup in two phases.

In view of the above expansion and capital investment plans, the refining sector is set to attract a number of foreign players bidding for the contracts to provide and construct refineries. Such attractions could be in the form of setting up of refinery and up-keep contracts, service contracts for operation of the refineries, providing technology and crew in setting up of refineries. Taxation of such contracts have always been complex and has attracted huge litigation. Some of the key direct tax issues arising out of such contracts are discussed as under:

Taxation of Engineering, Procurement and Construction (EPC) Contract

Construction and set-up of a Refinery plant is a complex project, comprising of supply of plant and machinery, providing design and engineering services outside India, onshore supply of relevant goods and machineries and onshore services in the form of construction and installation services. The contractor bidding for such projects needs to consider the taxation aspects to enable him to bid at a competitive quote and at the same time needs to consider tax risks associated with such contracts.

Each of the income element in the EPC contract and taxability of the same is discussed as under:

- Offshore supply of material / equipment– This component of the contract is generally executed by the overseas contractor outside the territory of India. The title of the goods / plant is generally transferred outside India and the payment for such supply is received outside India. Since the income in connection with these activities does not accrue or arise in India in terms of the Indian direct tax laws, the income pertaining to such offshore supply of contract is generally considered as not taxable in India.

  The aforesaid aspect has been a subject matter of litigation in India.The revenue authorities in India in various cases contend that the offshore supply is part of the same project of construction and installation of plant and machinery and hence the offshore supply should also be taxed in India. This issue reached before the Supreme Court and the Supreme Court has held that the offshore supply of contract is not taxable in India when the contract is a divisible contract between offshore and onshore supplies and the contract provides for separate consideration for offshore and onshore component.

  Subsequent to the decision of the Supreme Court, various courts held that offshore supply pursuant to the divisible contracts should not be taxed in India. However, in cases, where based on facts it is proved that the contract is indivisible and the risk over the goods actually passes in India, then the Courts have held the income arising on sale of goods through such contracts as taxable in India.

- Offshore supply of service – An EPC contract involves providing of services by the overseas contractor in the nature of designing, planning, technical feasibility study, etc. The income received from such services are taxable as fees for technical services in the hands of the overseas contractor under the Income-tax Act. In case, India has entered into a Double Taxation Avoidance Agreement (DTAA) with the residency state of the overseas contractor, then such income may also be taxed as Fees for Technical Services (FTS) under the relevant DTAA. Certain DTAA's provide for a 'make available' clause whereby the overseas contractor does not make available any technical, managerial, know-how, skill etc., then such income may not be taxed in the source country (i.e. India in this case) in the absence of a fixed establishment in the source country. Thus, a careful analysis of provisions of the DTAA needs to be undertaken to determine the taxability of offshore supply of services.

- Onshore supply of equipment and services – Since the transaction of supply of equipment/service would take place in India, entire income pertaining to onshore supply of equipment and services shall accrue/arise in India and accordingly the same shall be taxable in India.

In view of the aforesaid discussion, it is imperative that the scope and terms of the EPC contract are considered carefully to analyse the taxability of various components of the contract, including demarcation of scope of work, terms relating to transfer of title of goods, location of payment of consideration, etc. If the contracts do not bring out actual intentions for the different scope of work, then the taxability of different component of contracts can be challenged by the revenue authorities.

Taxation of consortium formed for execution of contracts

Execution of installation and construction projects is complex exercise and on quite few occasions a single contractor does not have the skill and expertise to execute the entire contract and thus consortiums are formed by such contractors with other contractors to enable them to execute the entire project jointly. Taxation of such contracts have been complex. There is considerable litigation surrounding the issue of whether the contractors in such cases have to be taxed individually or they are required to be taxed jointly as Association of Person (AOP).

If the tax authorities treat the consortium as AOP, then the entire income earned by the AOP shall be taxed at the highest marginal tax rate. In case the consortium (having a foreign partner) is treated as AOP for tax purposes, then the entire income of the AOP shall be taxed at 40 per cent, being rate applicable to foreign company.

In absence of any specific guidelines or precedents, there was considerable litigation on the aspect relating to taxability of AOP. Recently, the Central Board of Direct Taxes (CBDT) has laid down criterion where consortium of contractors formed for executing EPC /turnkey contracts will not be treated as AOP for taxation purposes. The key essentials of the consortium contract which, if fulfilled by the consortium members, result in such consortium as not taxable as AOP are discussed as under:

- Separate scope of work – Each contractor is independently responsible for executing its part of work, through its own resources and also bears the risk of its scope of work.

- Separate consideration– Each contractor earns profit or incurs losses based on performance of the contract falling strictly within its scope of work. However, consortium members may share contract price at gross level only to facilitate convenience in billing.

- No sharing / pooling of resources – The resources (men and materials) used for any area of work are under the risk and control of respective consortium members.
- No common control / management – The control and management of the consortium is not unified and common management is only for the inter-se coordination between the consortium members for administrative convenience.

Thus, appropriate evaluation needs to be undertaken while entering into a consortium contracts by referring to the above guidelines issued by the CBDT.

Exposure of formation of a Permanent Establishment (PE)

The activity of setting up of a refinery would generally involve construction and installation activity. Taxation of non-residents having income from contracts involving construction, installation or assembly activity under the DTAA will be crystalised based on the establishment of a PE of the non-resident for such contact. Generally, a PE is established if such activity is carried on beyond a specified number of days as per the DTAA between India and the country of such non-resident contractor. In case, a PE is established for a project, then the income as is reasonably attributable to the operations carried out in India shall be taxed in India.

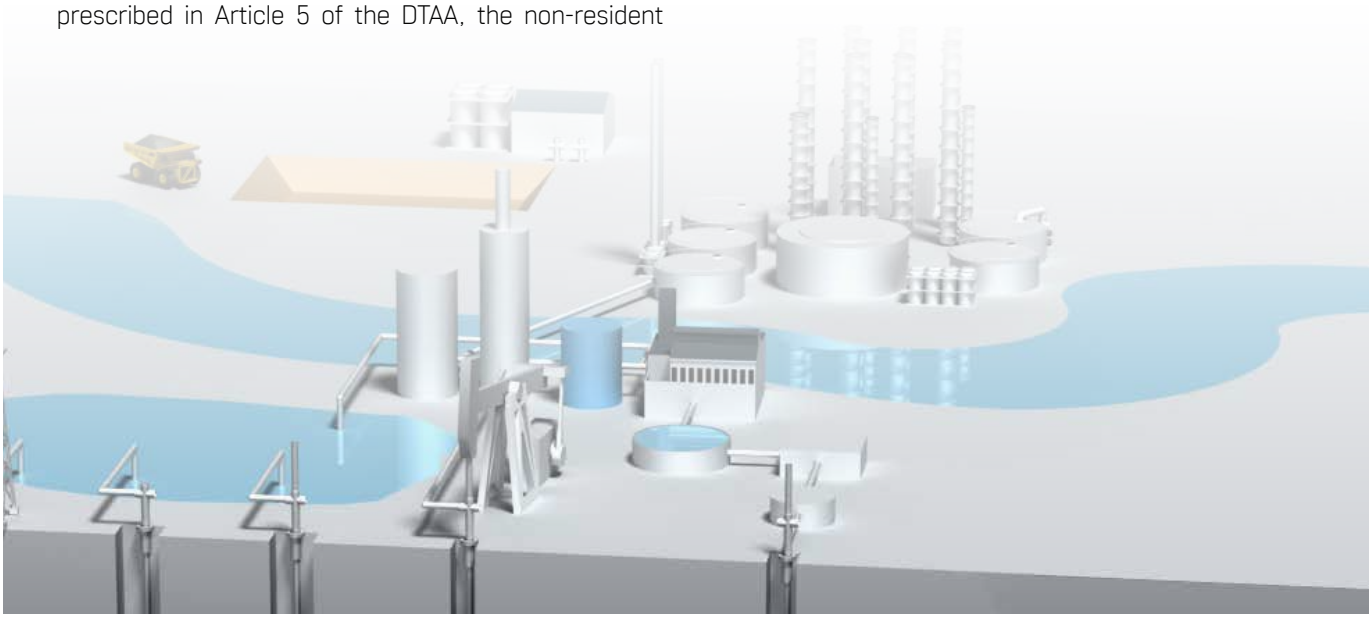
Further, for the purpose of execution of certain contracts, the contractor may also be required to provide crew to the construction / installation site. In such cases, the taxability of service fees for the supply of crew as FTS or as business profits would depend on the constitution of PE of the non-resident in India. Generally, DTAA's provide for a clause of establishment of a service PE based on the duration of days for which the crew is supplied. However, the Hon'ble Supreme Court, recently in the case of Formula One World Championship Ltd. has held that although a structure (which ispermanent in nature) may be used for a very short period of less than the stipulated time as prescribed in Article 5 of the DTAA, the non-resident would be considered to have a fixed place PE in India. In view of above, it is pertinent to evaluate the facts to ascertain the existence of a PE for determining taxability of income in India.

It may also be noted that the Base Erosion Profit Sharing (BEPS) Action Plan 7 has proposed to add the Principal Purpose Test (PPT) to the OECD Model Tax Convention, to restrict abusive splitting up of contracts in cases where contract are split between different entities for division of days of work performed for the project to avoid the establishment of a PE. In such cases, under the proposed BEPS Action Plan 7, artificial splitting of contracts shall be ignored for the purpose of calculation of duration of days for establishment of PE and entire duration of work of the contract shall be considered in the hands of the principal entity and entire income shall be taxed accordingly.

Additionally, India has implemented General Anti Avoidance Rules (GAAR) to disregard the transactions which are created only for the purpose of avoidance of tax in India. Thus, contractual structures in India needs to have bonafide commercial considerations supported by relevant documentation. This will enable the taxpayer to adopt safeguards and adequately demonstrate substance in the structure in event of scrutiny by the revenue authorities.

In view of the aforesaid discussions and considering the complex issues associated with the structuring of execution of contracts and implementation of BEPS and GAAR, it is imperative to undertake a detailed transaction structuring analysis to avoid any ambiguity and litigation regarding taxability of income earned through the contractual agreements. In certain cases, the tax payer can also opt to obtain clarity over the taxation by taking advance rulings and avoid protracted litigation.

The information contained herein is of a general nature and is not intended to address the circumstances of any particular individual or entity. No one should act on such information without appropriate professional advice after a thorough examination of the particular situation.



Environment

Soil Contamination–Environmental Concern

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Introduction

In simple terms, 'to pollute' means, to contaminate the soil, air, and/ or water with substances that are harmful to health. We should care about pollution because it affects the very existence of living beings as well as inanimate objects. The gravity of the situation resulting from pollution is hardly subject to any debate. The question is - what is our approach to dealing with the issue of pollution, particularly soil pollution and if this approach requires a shift. Speaking of the approach, we have limited ourselves to largely 'legislative approach'.

Soil is a significant part of the rural and urban environment and in both the cases; soil quality is determined by the quality of land management or the lack of it. Soil is the thin layer of organic and inorganic materials formed by the decomposition of rock and organic matter over several years that covers the rocky surface of the earth. The dark uppermost soil is organic in nature, formed as a consequence of decomposition of plants and animals. The inorganic portion at the bed is constituted of the fragments of rocks, which breakdown physically and chemically over thousands of years.

Soil properties differ from one place to another with variations in bedrock composition, climate and other factors. Sometimes, the certain soil elements may be toxic on account of mineral composition exceeding the levels recommended for the health of humans, animals or plants. Human activities may also contribute to the soil toxicity.

Soil Pollution

The soil suffers from pollution, the significant contributor being environmental pollution and more specifically the manmade waste. These waste products are full of chemicals that are not originally found in nature and lead to soil pollution. The waste produced from nature, such as dead plants, animals bodies, rotten fruits and vegetables add to the fertility of the soil.

Soil pollution is a build-up of persistent toxic chemicals and compounds, salts, radioactive materials, or disease causing agents in high concentrations that as pollutants or contaminantsmay have an effecton human and animal health, ecology and growth of plants. Soil pollution may also occur due to the levels of the contaminants in soil exceeding the levels that are naturally present in soil.

Soil pollution needs to be controlled in order to preserve the soil fertility and increase the productivity. This is essential for improving the health of all living beings as also maintaining the beautiful planet.

Main Causes of Soil Pollution

Soil gets contaminated by pollutants through seepage from a landfill, industrial wastes, contaminated water, rupture of underground storage tanks, haphazard application of pesticides, insecticides, herbicides or fertilizers, large quantities of solid waste and deforestation and soil erosion etc. The most common chemicals involved in causing soil pollution are Petroleum hydrocarbons, Heavy metals, Pesticides, Solvents etc., due to the following activities:

Industrial Activity has been the biggest contributor to soil contamination in the last century, especially with the increase in mining and manufacturing activities. Most industries are dependent on extracting minerals from the earth. The by-products of iron ore, coal, etc. get contaminated as they are not disposed of in a safe manner, thereby polluting the soil as the industrial waste remains on the soil for long.

Agricultural Activities: The use of chemicals has gone up immensely with modern pesticides and fertilizers. These chemicals, as being not produced naturally cannot be broken down by it, and tend to seep into the ground as they easily mix with water, thereby slowly reducing the fertility of the soil. These chemicals damage the composition of the soil and erode by water and air that is available in the atmosphere. The plants absorb the pesticides and they cause soil pollution upon decomposition.

Waste Disposal: A growing cause of concern is how we dispose of our waste in addition to the industrial waste which in any case is sure to cause contamination. Domestic garbage, municipal sewage and industrial wastes when left in heaps or improperly disposed seriously affect health of human beings, plants and animals. These wastes contain borates, phosphates and detergents in large amounts and if untreated, they affect the vegetative growth of plants.

Other liquids wastes like sewage, sewage sludge, etc. are also important sources of soil problems. While most of the personal waste produced by humans by way of urine and faecesis disposed into the sewer system, a large amount gets dumped directly into landfills in the form of diapers. The toxins and chemicals present in our bodies into the land as biological waste at the landfill, thus causing soil pollution.

Heavy Metal Pollutants: Heavy metals are elements having a density greater than 5 in their elemental form, created upon weathering from their parent materials and are widely distributed in the environment, soils, plants, animals and in their tissues. They mostly find specific absorption sites in the soil where they are retained very strongly either on the inorganic or organic colloids. Heavy metal pollution is mainly caused by urban and industrial aerosols, combustion of fuels, liquid and solids from animals and human beings, mining wastes, industrial and agricultural chemicals, etc.

Accidental Oil Spills: Oil leaks happen during storage and transportation of chemicals, as seen at most of the fuel stations. The chemicals when present in the fuels deteriorate the quality of soil and make them unsuitable for cultivation and upon ingress in the groundwater, make it undrinkable.

Acid Rain: Acid rain is initiated when pollutants present in the air mix with the rain and fall back on the ground. The structure of the soil gets changed when the polluted water dissolves in the soil by taking away some of its important nutrients.

Effects of Soil Pollution

Effect on Health of Humans: The contamination of soil has major consequences on our health. Crops and plants grown on polluted soil absorb much of the pollution and then pass these on to the consumers which is manifested by the sudden surge in small and terminal illnesses. Long term exposure to such soilscan affect the genetic temperament of the body, leading to congenital illnesses and chronic health problems which are nor easily curable.

Effect on Growth of Plants: The contamination of the soil leads to disturbed ecological balance of any systemas the plants are unable to adapt to the chemistry of the soil changes in a short period of time. Fungi and bacteria in the soil begin to decline, which creates an additional problem of soil erosion. The fertility of the soil slowly weakens, rendering the land unsuitable for agriculture, thereby restricting the growth of any local vegetation that may sometimes lead to famines.

Decreased Soil Fertility: The presence of toxic chemicals in the soil decreases soil fertility, thereby decreasing the soil yield. The contaminated soil is then used to produce fruits and vegetables which lack quality nutrients and may contain some poisonous substances that may cause serious health problems in people consuming them.

Toxic Dust: The emission of toxic and foul gases from landfills pollutes the environment and adversely affects human health.

Changes in Soil Structure: The death of many soil organisms e.g. earthworms in the soil can lead to alteration in soil structure. Earthworms which inhabit soils and litter layers in most landscapes play an important role in environmental transformations and impacts. Cleaning the environment and curbing the current rate of pollution require plenty of time and resources.

Measures for Decontamination

Numerous attempts are being made to decontaminate polluted soils, including an array of both in situ (on-site, in the soil) and off-site (removal of contaminated soil for treatment) techniques. None of these are ideal for remediating contaminated soils, and often, more than one of the techniques may be necessary to optimize the efforts for cleaning.

The most common decontamination method for polluted soils is to remove the soil and deposit it in landfills or to incinerate it. These methods, however, often exchange one problem for another: landfilling merely confines the polluted soil while doing little to decontaminate it. In the case of incineration, although toxic organic chemicals get removed from the soil, but these get released in the air thereby causing air pollution.

Various physical as well as chemical soil washing techniques have been developed for removal and recovery of heavy metals such as attrition scrubbing, wet-screening, treatments with organic and inorganic acids, bases, salts and chelating agents. However, the problem with the chemicals which are strong acids or bases used to extract radionuclides and toxic metals is that they generate secondary waste products that may require additional hazardous waste treatments.

In contrast to these methods, in-situ methods are used directly at the contamination site, wherein soil does not need to be excavated and therefore the chance of causing further environmental harm is minimized as it involves enhancement of naturally occurring micro-organisms by artificially stimulating their numbers and activity. The micro-organisms then assist in degrading the soil contaminants. A number of environmental, chemical and management factors affect the biodegradation of soil pollutants, including moisture content, pH, temperature, the microbial community that is present and availability of nutrients. Of all the decontamination methods bioremediation appears to be the most environmentally acceptable and the least damaging technique.

Ecological Risk Assessment (ERA)

ERA is a process of collecting, organizing and analysing the environmental data to estimate the risk or probability of undesired effects on organisms, population or ecosystems caused by the stress associated with human activities, associated with uncertainties, predictability, utility and costs.

There are typically two major types of ERA, the first is 'predictive' and is often associated with the authorization and handling of hazardous substances such as pesticides or new and existing chemicals in the European Union, ideally done before environmental release and the second is 'descriptive' which involves the assessment of changes in population or ecosystem in already polluted areas. While the predictive method is based on more or less generic extrapolations from laboratory or controlled and manipulated semi field studies to real-time situations,the descriptive method determines and monitors the changes in contaminated soils in specific areas/ domains.

Regulatory and Legal Framework

The legislative approach with respect to addressing the issue of soil contamination may be understood from the prevailing laws.

Environment Protection Act, 1986 and Environment (Protection) Rules, 1986

India adopted the Environment Protection Act, 1986 (Act) pursuant to certain decisions taken at the United Nations Conference on the Human Environment held at Stockholm in June, 1972. It provides for prevention, control and abatement of environmental pollution. Section 2(a) of Act defines 'environment' to include water, air, land and the relationship which exists amongst these and also between water, air and land and human beings other living creatures, plants, micro-organism and property. The term 'environmental pollutant' as defined in section 2(b) of the Act means any solid, liquid or gaseous substance present in such concentration as may be, or tend to be, injurious to environment.

The Environment (Protection) Rules 1986 have been issued by the Central Government in exercise of powers conferred by sections 6 and 25 of the Environment (Protection) Act, 1986. These Rules provide for the standards for emissions or discharge of environmental pollutants and protecting and improving the quality of the environment and preventing and abating environmental pollution.

The Act and the Rules provide for the thresholds for emissions or discharge of environmental pollutants from industries, operations or processes as specified in Schedule I to IV of the Rules. The statute provides for penal consequences in case such emissions or discharge of pollutants are in excess of the threshold. It requires mention here that irrespective of level of such emission or discharge, the adverse impact of it on the soil cannot be ignored.

- **Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2016**

  These Rules have been issued by the Central Government in exercise of powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986 and in supersession of the Hazardous Wastes (Management and Handling) Rules, 2008. The said Rules apply to the management of hazardous and other wastes as specified therein. They also provide for the procedure for management of hazardous and other wastes; the import and export of hazardous and other wastes; and the treatment, storage and disposal facility for hazardous and other wastes. The objective of setting forth methods of management of hazardous wastes and other wastes is to minimise its contribution towards pollution of the environment.

- **Manufacture, Storage and Import of Hazardous Chemical Rules, 1989**

  These Rules have been issued by the Central Government in exercise of powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986. They provide for amongst

other things preparation of an on-site emergency plan by the occupier detailing how 'major accidents' will be dealt with on the site where the industrial activity is carried on.

The term 'major accident' as defined in section 2(j) of the Rules means an occurrence including any particular major emission, fire or explosion involving one or more hazardous chemicals and resulting from uncontrolled developments in the course of an industrial activity or due to natural events leading to serious effects both immediate or delayed, inside or outside the installation likely to cause substantial loss of life and property including adverse effects on the environment.

It is not clear if soil pollution issues are particularly required to be effectively handled in case of occurrence of any major accident.

- **The Chemical Accidents (Emergency Planning Preparedness and Response) Rules, 1996**

  These Rules have been issued by the Central Government in exercise of powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986. They provide for constitution of a crisis alert system by the Central Government and constitution of Central, State and District Crisis Groups to deal with 'major chemical accidents'.

  The term 'major chemical accident' as defined in 2(f) of the said Rules means occurrence of including any particular major emission, fire or explosion involving one or more hazardous chemicals and resulting from uncontrolled developments in the course of industrial activity or transportation or due to natural events leading to serious effects both immediate or delayed, inside or outside the installation likely to cause substantial loss of life and property including adverse effects on the environment.

  It is not clear if soil pollution issues are particularly required to be effectively handled in case of occurrence of any major chemical accident.

- **Rules for the Manufacture, Use, Import, Export and Storage of Hazardous micro-organisms Genetically engineered organisms or cells**

  These Rules have been issued by the Central Government in exercise of powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986 and with a view to protect the environment, nature and health, in connection with the application of gene technology and micro-organisms. These Rules require use of pathogenic micro-organisms or any genetically engineered organisms or cells for the purpose of research in controlled environment, and prohibit deliberate or unintentional release of genetically engineered organisms/hazardous microorganisms or cells to the environment or nature. In case of any interruption or operations or accidents that may lead to discharges of genetically engineered organisms or cells which may be harmful to the environment, nature or health or involve any danger thereto, the person responsible is required to try effectively to minimise or prevent the effects of interruptions of operations or accidents.

  It is not clear if soil pollution issues are particularly required to be effectively handled in such cases.

- **The Bio-medical Waste Management Rules, 2016**

  The said Rules have been issued by the Central Government in exercise of powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986 and in supersession of the Bio-medical Waste (Management and Handling Rules), 1998. These Rules apply to all persons who generate, collect, receive, store, transport, treat, dispose, or handle bio-medical waste in any form, and provide for amongst other things, the procedure for treatment and disposal of Bio-medical waste without causing any adverse effect to human health and the environment.

  The statute provides for penal consequences in case of damage to the environment due to improper handling of bio-medical waste. It is not clear if soil pollution issues are specifically addressed in the assessment of damages.

- **The Plastic Waste Management Rules, 2016**

  The said Rules have been issued by the Central Government in exercise of powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986. These Rules apply to every waste generator, local body, Gram Panchayat, manufacturer, importer and producer, and provide for amongst other things, plastic waste management and extended producer's responsibility.

  The term 'extended producer's responsibility' as defined in section 3(h) of these Rules means the responsibility of a producer for the environmentally sound management of the product until the end of its life.The objective of setting forth methods of management of plastic wastes is to minimise its contribution towards pollution of the environment.

- **The Solid Waste Management Rules, 2016**

  These Rules have been issued by the Central Government in exercise of powers conferred by sections 3, 6 and 25 of the Environment (Protection) Act, 1986 and in supersession of the Municipal Solid Waste (Management and Handling Rules), 2000. They Rules apply to every urban local body, outgrowths in urban agglomerations, census towns as declared by the Registrar General and Census Commissioner of India, notified areas, notified industrial townships, areas under the

control of Indian Railways, airports, airbases, ports and harbours, defence establishments, special economic zones, State and Central government organisations, places of pilgrims, religious and historical importance as may be notified by respective State government from time to time and to every domestic, institutional, commercial and any other non-residential solid waste generator situated in the areas except industrial waste, hazardous waste, hazardous chemicals, bio medical wastes, e-waste, lead acid batteries and radio-active waste, that are covered under separate rules framed under the Environment (Protection) Act, 1986. The Rules contain extensive provisions with respect to categorisation of waste and disposal thereof in an attempt to eliminate or minimise pollution to the environment.

- **The Construction and Demolition Waste Management Rules, 2016**

  These Rules have been issued by the Central Government in exercise of powers conferred by sections 3, 6 and 25 of the Environment (Protection) Act, 1986 and in supersession of the Municipal Solid Waste (Management and Handling Rules), 2000. These apply to every waste resulting from construction, re-modelling, repair and demolition of any civil structure of individual or organisation or authority that generates construction and demolition waste such as building materials, debris, rubble. The Rules contain provisions with respect to each person in the link starting from the generator of the waste to the regulatory authorities.

- **Batteries (Management and Handing) Rules, 2001**

  These Rules have been issued by the Central Government in exercise of powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986. They apply to every manufacturer, importer, re-conditioner, assembler, dealer, recycler, auctioneer, consumer or bulk consumer involved in manufacture, processing, sale, purchase, and use of batteries or components thereof, the battery. The term 'battery' as defined in section 3 of the Rules means a lead acid battery which is a source of electrical energy and contains lead metal.

  It is not clear if contamination caused in the process of dealing with batteries is specifically addressed.

- **E-Waste (Management) Rules, 2016**

  These Rules have been issued by the Central Government in exercise of powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986 and in supersession of the E-waste (Management and Handling) Rules, 2011. They apply to every manufacturer, producer, consumer, bulk consumer, collection centres, dealers, e-retailer, refurbisher, dismantler and recycler involved in manufacture, sale, transfer, purchase, collection, storage and processing of e-waste or electrical and electronic equipment listed in Schedule I of the Rules, including their components, consumables, parts and spares which make the product operational. The Rules provide for amongst other things, 'environmentally sound management' of e-waste.

  The term 'environmentally sound management' as defined in section 3(o) of the said Rules means taking all steps required to ensure that e-waste is managed in a manner which shall protect health and environment against any adverse effects, which may result from such e-waste.

- **The Wetlands (Conservation and Management) Rules, 2000**

  These Rules have been issued by the Central Government in exercise of powers conferred by section 25 read with sub-section (1) and clause (v) of sub-section (2) and sub-section (3) of the Environment (Protection) Act, 1986. They have been issued for the conservation and management of wetlands. The said Rules specify activities which are restricted within wetlands such as industrialisation, construction, dumping of untreated waste and any activity likely to have an adverse impact on the ecosystem of the wetland, reclamation of wetlands.

- **Forest (Conservation) Act 1980, issued by Ministry of Environment and Forests**

  This Act provides for the conservation of forests and for matters connected therewith or ancillary or incidental thereto. Following this enactment, no reserved forest or any portion thereof shall be de-reserved or no forest land shall be used for non-forest purposes except with prior approval of the Central Government.

- **The Biological Diversity Act, 2002**

  This Act came into force in 2003, subsequent to the coming into force of the United Nations Convention on Biological Diversity in 1993, to which India is party. India, as a country is rich in biological diversity and associated tradition along with contemporary knowledge system. It provides for the Central Government to develop national strategies or plans for the conservation of biological diversity, specifically, where the Central Government has reason to believe that any area rich in biological diversity, biological resources and their habitats is being threatened by overuse, abuse or neglect. This allows the Central Government to issue directives to the concerned State Government to take immediate beneficial measures, offering such State Government any technical and other assistance that is possible to be provided or needed.

India has a non-lapsable corpus, National Clean Energy Fund (NCEF), under the Public Accounts of India. NCEF was formed after the Finance Act, 2010 which imposed a clean energy cess on goods listed in the Act which are produced in India and in certain cases, imported to India. The primary purpose of this fund is to fund research and innovative projects in clean energy technologies which includes projects related to environment management particularly in the geographical areas surrounding the energy sector projects . NCEF requires the participating organization to invest at least 40% of the project cost and the fund shall provide a loan or gap funding of no more than 40% of the same project cost. While NCEF intends to invest in research and innovative technologies, there are certain drawbacks to its implementation, such as;

- Under-utilization,
- Inconsistencies in project appraisals like exceeding the fund investment limits and involvement of other branches of the Government,
- Absence of an evaluation framework which not only lays emphasis on the financing but gives importance to the project's ability to promote development of clean energy technologies and use of innovative methods, and
- Limited awareness amongst Indian research institutes and industry on the NCEF funding opportunity.

In addition to the above rules and regulations, the Central Government launched a voluntary initiative in 2014 -'Swachh Bharat Abhiyan', which is a massive mass movement that seeks to create Clean India, as a tribute to Mahatma Gandhi. Through this Abhiyan, one can challenge maximum nine persons and similarly the chain of challenges follows wherein one can share the experiences and pictures of cleanliness 'before' and 'after'as the drive proceeds in a particular area or locality.

Approach

It is clear from the foregoing that the legal and regulatory framework is fairly comprehensive and closely follows the 'Precautionary Principle' and the 'Polluter Pays Principle'.

The Polluter Pays Principle ('PPP') establishes that the absolute liability of harm to the environment extends not only to compensate the victims of pollution, but also to the cost of restoring environmental degradation. The Precautionary Principle implies that any lack of information or knowledge will not justify the absence of management measures and efficient management measures should be established in order to conserve the resources.

The PPP has been imbibed by India in the law of the land. It was recognized for the first time by the Indian Courts in the case of Indian Council for Enviro-Legal Action and Ors. vs. Union of India (UOI) and Ors. , wherein the Hon'ble Supreme Court while questioning the liability of the respondents to defray the costs of remedial measures stated that:

The polluter pays principle demands that the financial costs of preventing or remedying damage caused by pollution should lie with the undertakings which cause the pollution, or produce the goods which cause the pollution.

Under the principle, it is not the role of government to meet the costs involved in either prevention of such damage, or in carrying out remedial action, because the effect of this would be to shift the financial burden of the pollution incident to the taxpayer. Thus, according to this principle, the responsibility for repairing the damage is that of the offending industry."

The establishment of the NCEF reflects a pro-active approach in as much as projects related to environment management particularly in the geographical areas surrounding the energy sector projects are eligible for funding.

It is well acknowledged that in the present stage of economic and industrial development, soil pollution continuously occurs despite all precautionary measures that one may take. The soil is quite literally the 'universal sink'- absorbing the good and the bad alike.

In addition to implementation of the 'Precautionary Principle' and the 'Polluter Pays Principle', a collaborative approach amongst the stakeholders will make a significant difference. The stakeholders may collectively formulate pro-active plans for soil remediation. Soil remediation techniques include bioremediation, thermal soil remediation, encapsulation, air sparging, etc. Remediation of damaged environment is part of the process of sustainable development.

Corporates may consider allocating a part of their CSR (Corporate Social Responsibility) Expenditure on soil remediation. A collaborative approach amongst corporates appears to be a necessity given the diverse known and unknown contaminants of the soil and grave consequences thereof.

Renewable Energy

Power of the Seas

Capt. Sekhar
Founder Director
AlphaMERS Ltd.

Renewable energy from the seas is relatively unexplored as compared to the Solar and wind. That there is plenty of energy in the seas was never in doubt. These energy come in various forms - Tidal energy, wave energy and kinetic energy of water currents. While they all come from water i.e rivers and seas, they are different forms of energy that have different challenges, yields and viabilities.

Tidal energy refers to energy in the rise of water caused by tidal variations. If trapped and stored, this can provide a potential source of energy to be harnessed when you need. Locations like Bhavnagar in Gulf of Khambat, have a tidal range of over 9 Meters. This is nature's bounty of energy, given to us every few hours. While trapping the rise of tidal waters is potential energy, there is another form of energy that is closely associated with it and more abundantly so. These are the tidal streams with kinetic energy. Understandably, locations with large tidal variations will also have strong tidal streams associated with it. However unlike a river flow, the tidal streams are not steady unidirectional streams. They change in strength and direction almost every six hours. Harnessing this kinetic energy requires turbines that can operate in both directions i.e flood and the ebb tidal streams. Combining the rise of tide with the stored waters of tidal streams make a good hybrid model of plant.

Rivers on the other hand provide unidirectional flow and a rather steady seasonal stream. This kinetic energy can be harnessed by micro turbines at certain locations without necessarily being a large dam project. The main challenges are - spots which have sufficient head, also which have perennial flow and relatively free of siltation problem. This form of energy lends itself to micro plants located close to riverside consumers.

Wave energy is harnessed from the waves on the surface, the same force that causes boats to roll and pitch in a storm. If this movement can be converted to a rotation of a shaft, useful energy can be harnessed. There are perhaps over 50 designs around the world to do just that. Of these, less than five are operational. The authors firm has developed three such designs of different sizes and one of them is under prototyping. India is blessed with a large fetch on both the west and east coast for waves to build up before it hits our coast. Not a good feature for coastal erosion, but great for wave energy yields.

India has been slow to go down the road to renewables but enjoys the advantage of worldwide industry wisdom in hindsight. Meanwhile, technology and infrastructure is improving fast. Lidars have replaced traditional masts with half cup anemometers, for measuring wind resource when planning the location of a wind farm. Floating Lidars are successfully replacing such expensive masts at sea. We have an increasing inventory of ports on our coast to support offshore wind farm development. The country's need for energy is ever increasing. Governments across the world and in India are increasingly weaning away from use of fossil fuels. Solar and wind have already achieved economies of scale. As fossil fuels become dearer, society will turn to the sea for more power in future.

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Impact – Flexural Optimization in Polypropylene

Narattam Chakraborty
Manager – Technical Sales
Mangalore Refinery and Petrochemicals

Polypropylene (PP) is one of the most widely used commodity polymers in today's world. Homo-polymer, Random – Co - polymer and Polypropylene Block Copolymer are normally three versions in which PP's are commercially available in market. Amongst different usages of PP, a considerable percentage falls under Molded Items which are processed through Injection Molding operation.

The most common problem customers face with PP injection molded parts is Part Breakage in finished items due to inferior Impact or drop strength. Even quality inconsistency and property variation in different specimens of same sample are also not unknown in PP, mainly in case of items made of block co-polymers.

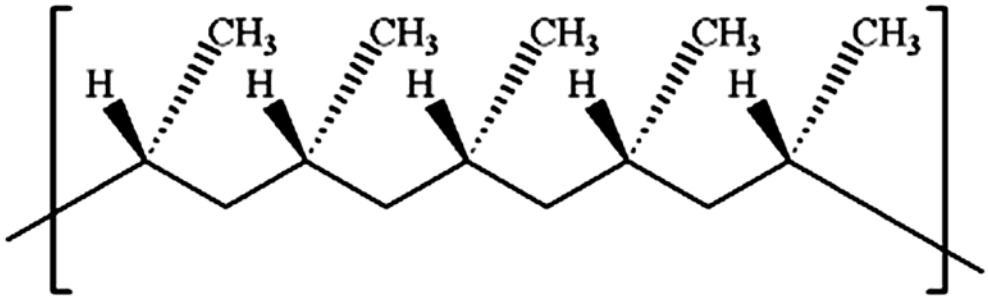
Pic 1: Part Breakage in Items made of PP

Hitherto, many initiatives have been taken for improving mechanical property of Polypropylene. However, precise care needs to be taken in modifying impact strength of PP, as any endeavor to upgrade

Impact strength leads to a counterproductive effect in stiffness / flexural value for PP. Additionally, rate and degree of crystallization, Spherulite size, transparency, dimensional stability of end articles, product cycle time, etc. are also influenced by initiatives for Impact-Flexural modifications in PP and hence, utmost care needs to be taken.

Brief Idea about Polypropylene

The Polypropylene of most commercial importance is Isotactic Polypropylene Homo-polymer. Like HDPE, catalyst used for polypropylene is predominantly Ziegler Natta Catalyst and the reactor condition are maintained which, overwhelmingly conforms formation of Isotactic polymer.



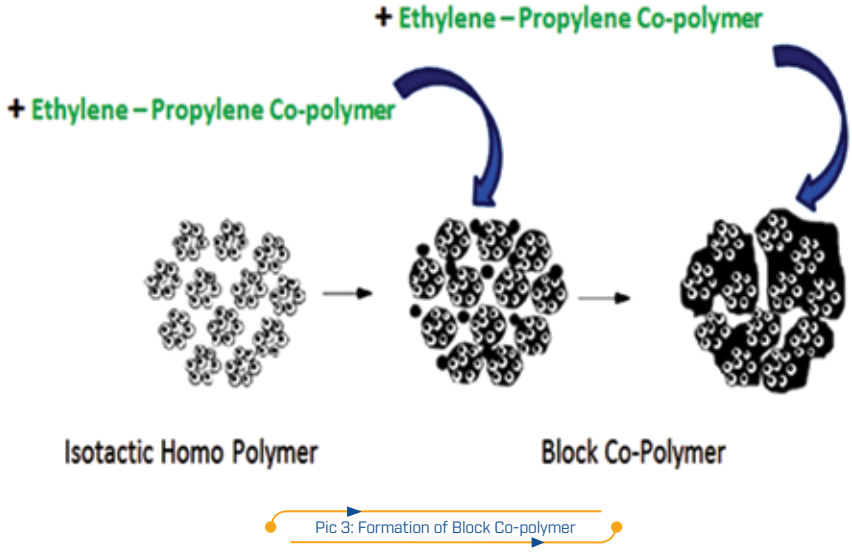
Pic 2: Isotactic Polypropylene

Though Polyethylene and Polypropylene share many of the common properties, however, the presence of Methyl (-CH3) groups in each of the alternating carbon atoms of polypropylene backbone makes it to behave other than polyethylene in a number of circumstances.

One unfortunate characteristic property of PP is, it slow Impact strength as well as brittle point. The polymer becomes brittle with lowering in temperature and its impact property suffers drastically even in room temperature, making it unsuitable for various products, even if other of its properties are conducive for those applications. Random and Block Copolymers offer the option to improve upon the impact strength of polypropylene homo-polymer.

Impact Modification in PP

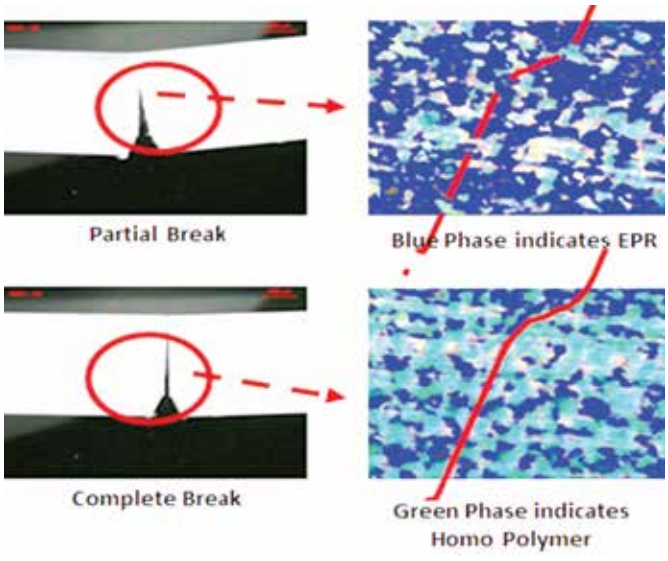
To improve this low temperature impact property and lower brittle points, Random PP co-polymer were invented and introduced in market and this is done by incorporating small percentage of ethylene in the backbone of polypropylene homo-polymers. For further improvement of Impact property, Heterogeneous PP Block co-polymer was invented where an amorphous Ethylene-propylene rubbery (EPR) phase was made to disperse in continuous homo - polymer matrix.



Pic 3: Formation of Block Co-polymer

In case block co-polymers, the homo-polymer produced in reactor is routed through an additional Gas Phase reactor along with fresh propylene, ethylene and hydrogen. Percentage of ethylene that can be incorporated in Homo - polymer matrix is much higher in block co-polymer than in random co-polymer.

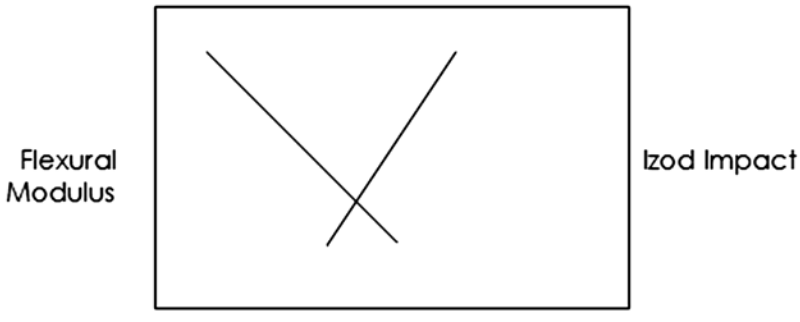
Impact performance in finished products is normally gauged by Izod or Charpy Impact testing of representative samples. The Ethylene-propylene rubber (EPR) phase is mainly responsible for enhancing impact strength of PP block co-polymer. With increase in rubber content, as well as ethylene to propylene ratio in EPR phase, impact property increases and reaches its maximum. After this threshold value, the adhesion between Homo- polymer matrix and rubber phase decreases drastically and impact strength also falls. In both cases of Izod and Charpy testing, sudden loads are applied on specimens and Breakage Analysis is carried out to judge their performance.



Pic 4: Morphology of PP Block Co-polymer

Specimen fractures are classified in four categories; complete break, partial break, hinge break and no break. From above depiction (refer Pic: 4), it is clear that Partial Break sample contains much more rubber phase compare to Complete Break sample.

The percentage of EPR (and its composition) in block co-polymer is very much important in maintaining Impact – Flexural balance for Polypropylene block co-polymers.



Pics 5: Izod –Flexural correlation with EPR %

Whenever a co-polymer shows low flexural modulus and high impact, probably too much of a rubber phase has been produced. During production, homo-polymers are actually responsible for conferring stiffness to final product, whereas, it is EPR phase, produced in gas phase reactor, controls the impact strength of end article. Proper weight balance between homo-polymer and rubber phase is essential to control the Izod – Flexural optimization in finished product. For Polypropylene Homo-Polymer it has been observed that high molecular weight chains does not crystallize so easily as lower molecular weight fraction and it differences the degree of crystallization which affects the bulk properties.

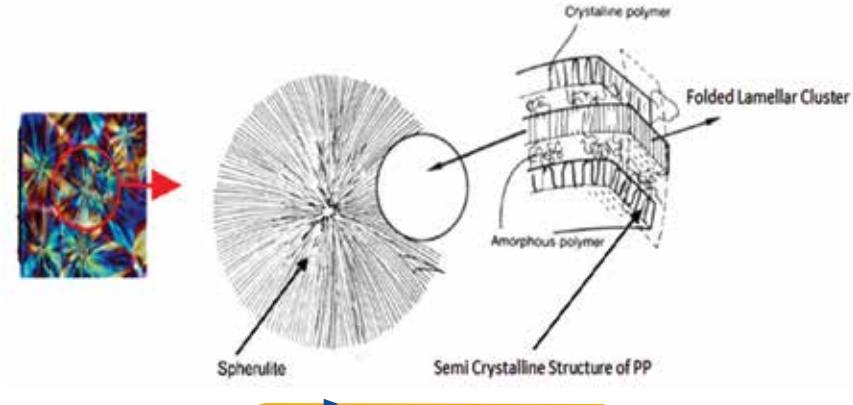


Fig 6: Semi Crystalline Structure of PP

In case of block co-polymers, improvement in low temperature impact property is also associated with a high degree of toughing. The area under a Stress-Strain graph gives a measure for toughness. The toughening mechanism is related to the generation of many small crazes or voids and thus interruption of the propagating fracture within the matrix, when under load. It has been observed that when the ethylene-propylene rubber (EPR) particles are of size of about 0.4m, they initiate many sub-critical crazes that absorbs significant energy during the stressing of PP.

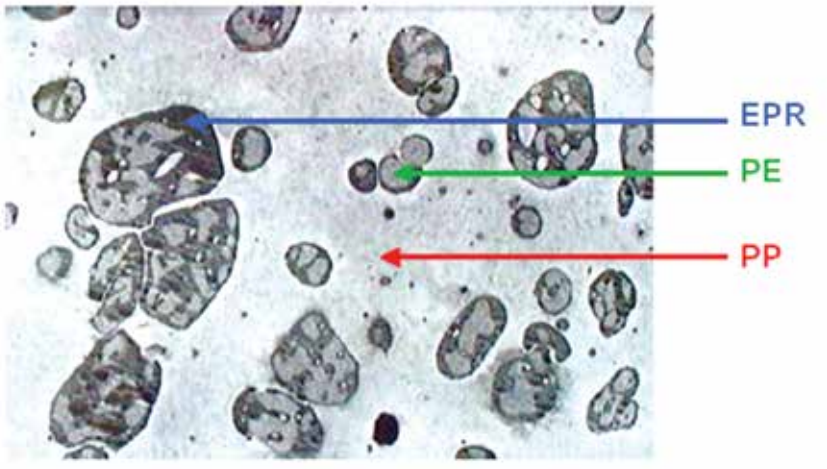


Fig 7: Dispersion of EPR phase on Homo Polymer

With much higher particle size of EPR phase, chances for their particle coagulation increases and the dispersion of rubber phase in homo-polymer matrix becomes unstable. Consequently Impact falls as adhesion between continuous phase and disperse phase is lost.

The composition of ethylene propylene rubber (EPR) phase also plays a determining role in controlling the impact property of final polymer. As percentage of ethylene in the EPR phase increases, polyethylene crystallization begins to appear within the rubber phase. As a consequence the rubber particles shrink more during cooling, and it matches with the shrinkage of PP matrix in case of melt cooling. This in turn, reduces stress build up in the matrix and the adhesion between the rubber phase and homo-polymer matrix increase and impact values reach a maximum. At still higher ethylene content, the rubber becomes stiffer, the dissimilarity between the EPR phase and the PP matrix increases, adhesion is lost and impact falls. The optimum rubber composition for impact modification has been reported to lie between 50-60 % of ethylene percentage in EPR.

Another import concern which processors frequently face is property variation in different specimens of same sample. No doubt, the EPR phase and its composition are the key instrumental in deciding the impact strength in PP block co-polymer. However, in order to have uniform impact strength all through of the sample, equal dispersion of rubber phase all through the homo-polymer matrix is essential.

There are a number of ways to control the flexural property of block co-polymer. Structure of homo-polymer chains mainly controls the stiffness of product. It has been observed that small chain molecules orient more than longer chains during cooling and hence exhibit higher degree of percentage Crystallinity.

Another property, Intrinsic Viscosity (IV),is also found to have a huge influence in controlling the mechanical properties of PP block co-polymers. As a general rule, higher is the IV of the rubber phase, the better is mechanical characteristics of the final co-polymer. However, this number divided by the homo-polymer IV should never be greater than 2, as at that point the difference of viscosity between the homo-polymer and EPR phase will be so large that it will be very difficult to blend these two products under normal processing conditions.

Conclusion

Though Impact Strength and Flexural Modulus are the two most important properties for deciding the usage of Polypropylene (mainly PP Block Co-polymer) for a particular application, stringent care needs to be taken in product design and recipe formulation in order to have an optimum balance between these two properties. Any initiative to increase the impact strength shows a counter effect on flexural modulus. Generally, product designs are executed based on final Impact-flexural balance intended in end product. However, manufacturers need to work smart in optimizing stiffness- toughness relationship in case of Polypropylene.

Special Feature on Refining & Petrochemicals

Accessing The Viability of Coal As An Alternate Feedstock for Petrochemical Import Substitution

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Abstract

Role of the chemical industry for development of our nation's economy is paramount, occupies a pivotal position in meeting basic needs and improving quality of life. While India has achieved self sufficiency, and is an exporter of refining products, the petrochemical industry has shortfall in capacity that is made up by imports. The total petrochemicals import in the country stands at more than 30%. Alternate options need to be explored do exist to cut down these petrochemical import and move towards self-reliance. For a nation importing more than 30% of total petrochemical products to meet the domestic demand, slated to grow more, it's imperative that all the feedstock options are exploited to identify the most economical option to achieve self-reliance.

One option to enhance availability of feedstock to increase production of petrochemicals in the country by use of coal. This paper provides a holistic view on Coal as an alternate feedstock options for chemical & petrochemical generation in India. It touches upon the challenges faced by an owner in today's scenario, the options to improve margins, incentives & challenges for gasification. Justification of coal gasification, via case study, is brought out by the competitive cost of production of chemicals/ petrochemicals of national importance, thus leading to import substitution, from coal gasification vis-à-vis conventional route. Generation of fertiliser post gasification, along with other chemicals offer true sequestration of CO_2. Chemicals in short supply are targeted through coal gasification route, which otherwise find hard to compete due to high cost of production, and nation ends up importing them.

1. Burgeoning Chemical Import for India

In India, we may be more than self-reliant in terms of refining products, however, in case of petrochemicals, ~ 30% are imported. The following are the major Petrochemicals and chemicals which are imported:

TABLE – 1.1: Petrochemical Import by Inda -2015-16

Major Petrochemicals	Import Value INR Crore	Quantity deficit, KTPA	Remark
(source: MOC&F, GOI/ EIL Analysis)			
PVC	8756	1493	Can be addressed by investing in PVC value chain
VCM	1672	350	All technologies are available for licensing
EDC	1019	584	PCPIR is the best suited location for this
CAUSTIC SODA	925	402	
METHANOL	2771	1668	Next Gen fuel. Technology is available for licensing
ACETIC ACID	2011	784	Apart from a Chinese licensor, M/s Beijing Zenhua, none available for licensing
PHENOL	1403	242	Technology is available for licensing
ACETONE	797	128	Surplus Benzene~ 915KTPA exported in 2015-16
POLYCARBONATE	2032	134	Can be addressed by investing in Phenol value chain
LLDPE	4453	574	Technologies are available for licensing
HDPE	7011	806	
LDPE	2870	351	Same value chain
EVA	1605	164	All technologies are available for licensing
VAM	869	140	Upcoming RIL plant of 400 KTPA LDPE/250 EVA
STYRENE	5159	717	Technologies are available for licensing
SBR	1316	142	
MEG	4876	1040	Upcoming RIL & IOCL plants
ACRYLONITRILE	1196	158	Technology is available for licensing

As is evident from above, immense opportunity exists to set up competitive domestic facility for these petrochemical generation, and go for import substitution.

2. Feedstock Options for Chemical & Petrochemical generation:

» **Steam Cracking**
- Produces olefins and some aromatics.
- Processing feedstock including ethane, LPG, naphtha and Gas oil from Crude / NGL (inc. Condensates)

» **Fluidized Catalytic Cracking**
- Produces C3= & lot of C2= in off gases

» **Catalytic Reforming**
- Produces Aromatics

» **Alternate Feedstock Options**
- Coke / Coal Gasification: Syn-gas to Chemicals
- On-Purpose Olefin technologies like PDH / BDH
- Underground Coal Gasification
- From Natural Gas via Methanol: Methanol to olefins(MTO)
- Coal Bed Methane

The major factors governing the choice of feedstock in petrochemical plants:

1. Availability: assured continuous availability
2. Cost of Feedstock
3. Product slate/ configuration type
4. Downstream requirement including Aromatics

Cost competitiveness is key to petrochemical success. Further, It is worth noting that logistics cost can be a source of advantage or disadvantage:

TABLE – 2.1: Feedstock & Logistic cost

Physical State	Feedstocks	Petrochemicals	Transportation Costs
Gas	Ethane, LPG	Olefins	High
Liquid	Naphtha, Gas Oil	Aromatics / Olefins	Low/ High
Solid	Coal, Coke	Plastics	Medium

India lacking a feedstock advantage wrt conventional feedstocks for petrochemical industry, i.e Oil & Gas, it becomes paramount to exploit the abundant coal reserves for petrochemical generation.

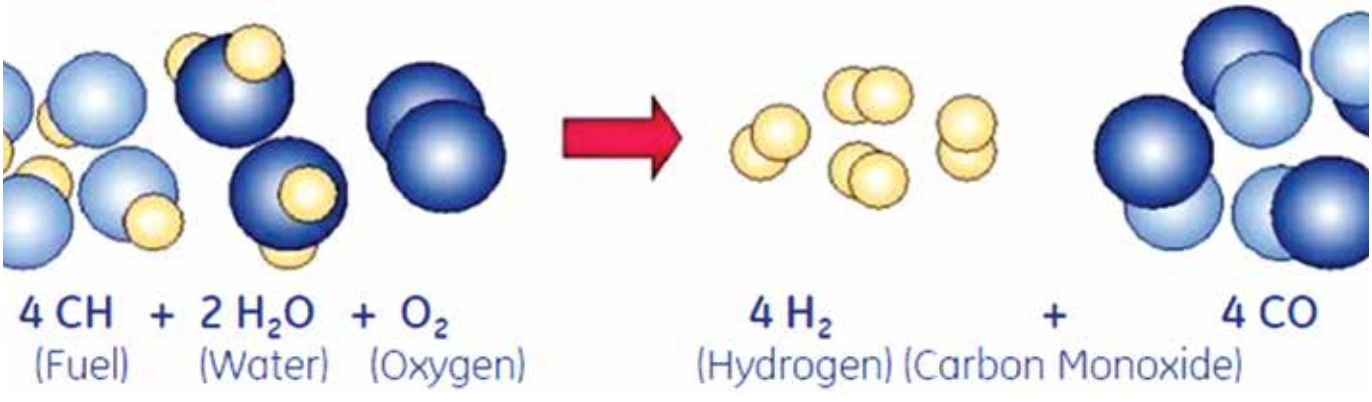
3. Gasification Route For Exploiting Coal

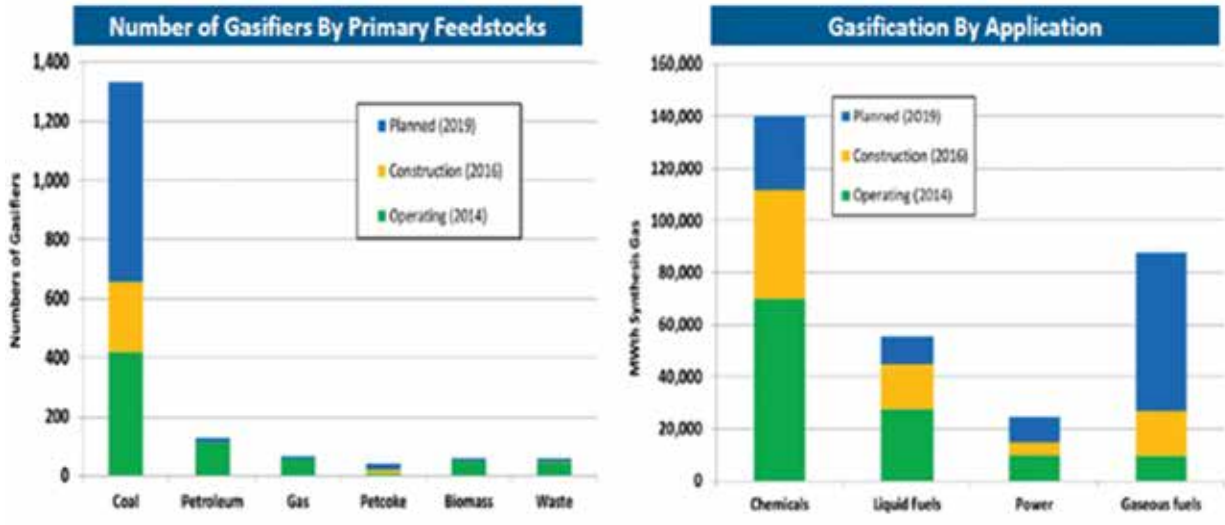
Considering the current crude & gas price scenario these options (esp. coke gasification) has been found to be challenging in terms of investment required. However, considering nation's energy security these are the tried and tested options which cannot be overlooked. Past couple of years, even the government has been promoting Coal gasification/ UCG as the alternate feedstock for the fertilizer industry, for developing self-reliance, apart from the domestic gas. Globally, syngas is also being used to make valuable chemicals at competitive price.

A commercially proven partial oxidation process, Gasification, is available that converts Hydrocarbons, such as heavy oils, petcoke, and coal into H_2 and CO (Syn Gas)

A summary of application of gasification process by feedstock & end product is depicted in Figure 3.1

Figure-3.1: Global Feedstock & Application Scenario





Source: Gasification Technology Council

» Globally, there are 618 operating gasifiers and the number will increase to 1740 by 2019.

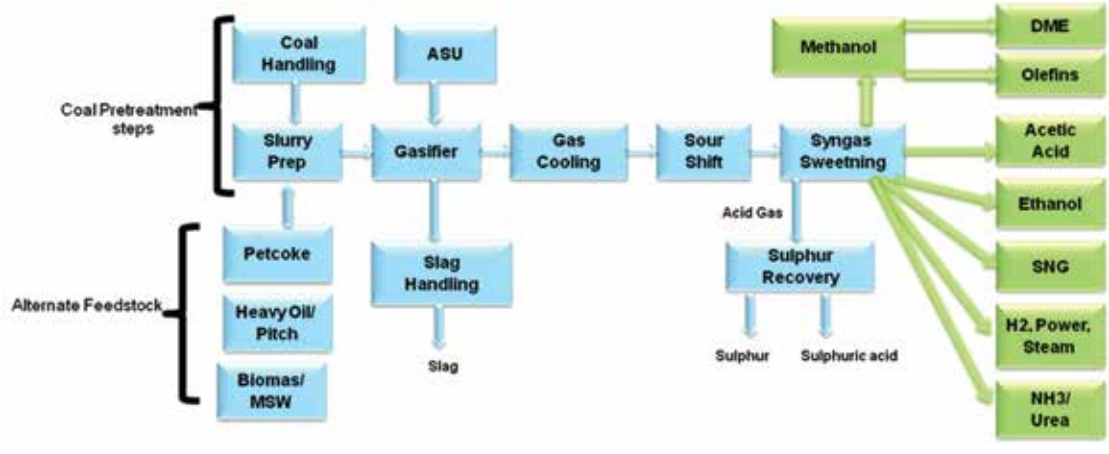
» 35% of Methanol & 25% of Ammonia produced globally is through coal gasification route.

As can be seen above, coal gasification is a proven technology, and enough references exists for the same.

3.1 Syngas Processing

The various steps involved in feed preparation, syngas generation & its treatment are depicted in Fig.3.2 below:

Figure-3.2: Typical Gasification Scheme



3.1.1 Gasification Technologies

The commercially proven gasification technologies are listed below:

TABLE – 3.1: Gasification Types: Proven Technologies Available

MOVING BED	FLUIDIZED BED	ENTRAINED BED
• Dry ash : Lurgi	• Bubbling : Winkler-Uhde, GPE	• Slurry feed type: GE(Texaco), CB&I(E-Gas)
• Slagging : BGL	• Circulating : FW, U-gas • Transport gasifier: TRIG- KBR	• Dry feed type: Shell, Uhde-Prenflow, Noell.

For Coal, so far, the fixed bed technology is the most reliable & commercially used technology, whereas entrained bed type have most references for petcoke.

3.2 Syngas Treating & Application

Various Syngas processing steps are as follows:

» Reducing syngas temperature
  - Extract valuable energy

» Removal of chemical species that:
  - Foul, corrode, or erode system components
  - Poison or deactivate chemical processing agents

» Target Syngas purity
  - H_2S / CO_2 concentration

» Adjustment of H_2 / CO ratio : H_2 / CO adjustment via water Shift Gas reaction is required for:
  - Hydrogen production
  - SNG production (H_2 / CO ~ 3)
  - Ammonia production
  - Methanol production (H_2 / CO ~ 2)

4. Case Study to Establish the viability: Coal to Chemical route

A case study has been performed to establish the viability of "Coal to Chemical route" using Indian coal as the feedstock. The product slate, of chemical/petrochemical being generated from coal gasification, has been finalized keeping India's import requirements in mind. Ash percentage in the Indian coal typically varies between 32- 43%. For the purpose of case study, a conservative figure of 43% ash, has been considered with GCV~ 3300 Kcal/hr, AFT.~1200-1400 deg C & 0.5 wt.% S. Fixed bed technology basis has been considered for analysis.

4.1 Overall Material Balance

1 Tonne of Indian Coal (having 43% ash, GCV~ 3300 Kcal/hr, Ash Fusion temp. ~ 1200-1400 deg C & sulphur ~ 0.5 wt %), post coal washery can make around 1150 to ~ 1400 Nm3/hr of Syngas depending upon the type of gasifier chosen, having typical composition as depicted below: ~ 60-61% (CO + H_2)

TABLE – 4.1: Typical Syngas Composition

S. No.	Composition	mole%
1.	CO	23.71
2	H_2	37.3
3	CO_2	27
4	CH4	11.7
5	AR + N_2	0.32
6	H_2S + COS	
	Total	**100%**

This gas has the potential to make the following:

1. 3850 TPD UREA UNIT, via 2200 TPD AMMONIA UNIT
2. ~ 3.42 MMSCMD Methane rich gas (incidental generation)
3. 4.3 MMTPA of Methanol.
   I. Around 1 MMTPA of METHANOL FOR SALE
   II. 3.3 MMTPA of Methanol to be utilised for Olefins via MTO Unit

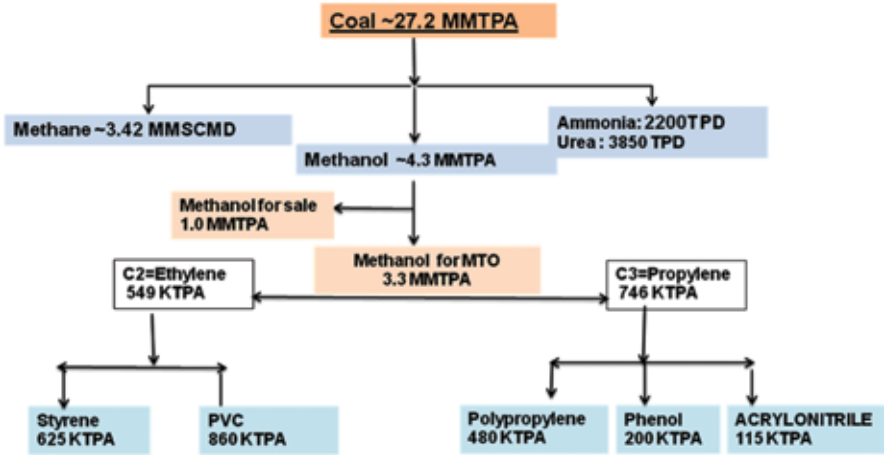
3.3 MMTPA MTO unit, is used to generate olefins for the following petrochemical via downstream derivative units:

a) Ethylene (C2=) derivatives:
  - 625 KTPA styrene using ~ 490 KTPA of benzene
  - 2 X 430 KTPA of PVC using ~ 875 brine solution

b) Propylene (C3=) derivatives :

- 480 KTPA Polypropylene
- 200 KTPA Phenol
- 115 KTPA of Acrylonitrile

Figure-4.1: Case Study Feed & Product Schematic



The following assumptions have been made for the study:

1. The price of coal is based on its Calorific value.
2. ROM Coal shall be sourced from a nearby location (5-10km) through conveyors. ROM Coal is fed to the coal washery for the production of crushed coal of size (+)5 to (-)50 mm, which is further fed to Gasification unit while fines, middling and rejects are used for power generation in Captive Power Plant.
3. Coal washery Unit is provided in the upstream of Gasification Unit to reduce the ash content of ROM coal from 43% to 33% ash.
4. The CPP for Steam & power requirement for the Gasification & associated facilities, CO shift, Acid gas removal, Methanol, Ammonia & UREA. Part U&O shall use Coal as fuel.
5. The CPP for steam & power requirement for MTO, and other downstream petrochemical units shall use LNG/ Methane rich gas generated as fuel.

4.2 Price Basis for Economics:

The following current prevailing prices for feedstock & products have been considered for the base case to evolve the economics of the proposition:

TABLE – 4.2: Price used for Evaluation

Feed	**Price**
ROM Coal (Note-1)	780+450 = 1230/ MT
Raw water	10 /m3
Benzene	Rs. 71370 / MT
Brine	4050 / MT
Product	
Urea	Rs. 22633 / MT
Methanol	Rs. 25125 / MT
Styrene	Rs. 100299 / MT
PVC	Rs. 68704 / MT
PP	Rs. 95810 / MT
Phenol	Rs. 109000 / MT
Acrylonitrile(AN)	Rs. 115000 / MT
Methane Gas/ NG	10 USD/MMBTU

Byproducts	
Acetone	Rs. 73000 / MT
Caustic	Rs. 28963 / MT
Acetonitrile	Rs. 85000 / MT
HCN	Rs. 105000 / MT
Toulene	Rs. 63700 / MT
C6+(Gasoline Blend ~ 98 ron))	Rs. 54223 / MT
Gasification Oil	Rs. 26000 / MT
Clear Tar	
Rs 17500 /MT	
Liquid Ammonia	Rs. 32500 / MT
Phenolic Pitch	Rs. 10000 / MT
Rectisol Naphtha	Rs. 26900 / MT
Solidified Sulfur	Rs. 7000 / MT
Nitrogen	5.00 / Nm3
Argon	1.78 / Nm3

NOTES:

1. A Conservative Price considering G-14 grade coal (GCV between 3100-3400 Kcal/kg) has been considered as basis with a coal price of INR 780/ MT, further an additional charge of INR 450 has been levied on the same. Thus, base case prices come to be INR 1230/ MT.

4.3 Capex & Irr

Considering 2:1 Debt: Equity, and other consideration of above assumptions and feedstock and product prices, the CAPEX(+30%,) and IRR is as follows:

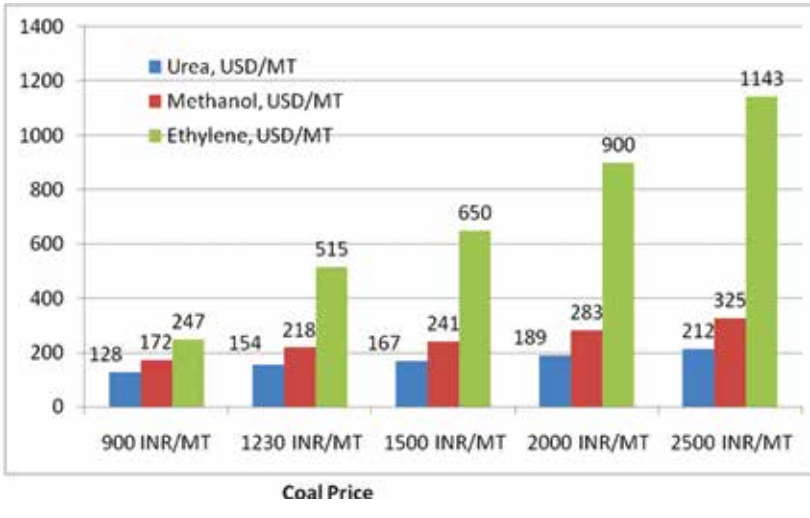
TABLE – 4.2: Project Economics

S. No.	Description	Amount, INR Cr.
1.	Project Capex, (2:1 Debt : Equity)	~ 13 Billion
2.	IRR After Tax	>15%

4.4 Cost of Production & Sensitvity at Varying Coal Feed Price:

For the base case, with the estimated CAPEX and OPEX worked out above, the cost of production of clean syngas works out to be ~ 7.99 USD/MMBTU. In order to check the robustness of the project economics & our competiveness, a sensitivity analysis has been done for the cost of production of clean syngas & select products/ intermediates over a range of coal price. The results are presented in Fig-4.2.

Fig 4.2: Cost of production of chemicals/ products



We can see that the above Cost of Production(COP) is competitive vis-à-vis global trading price of :

1. Urea trading price 338 USD/MT (2013-2015 avg.) & 190-240 USD/MT (2015-16/17)
2. Methanol trading price ~350 USD/MT(2013-2015) & 250 USD/MT (2015-16/17)
3. Ethylene trading price 1250 USD/MT (2013-2015) & 850-1150 USD/MT (2015-16/17)

Worth mentioning that Economies of scale & Advantageously priced feedstock are very essential for any Coal to Chemical Product to be comercially viable. Thus, it can be seen that for a hydrocarbon resources deficit nation like ours, Coal to Chemicals can be a viable option to fulfill the deficit in Chemicals & petrochemicals if the feedstock is available at competitive price and supply of feedstock is secured.

Conclusion and Way Forward

From the case studies above, It can be seen that for a energy deficit nation like ours, Coal to chemicals can be a viable option for import substitution of chemicals / petrochemicals. Further, besides the usage of alternate feedstocks, an important aspect is the need to revisit the existing strategies for gas and coal usage in India. It's imperative that apart from Thermal value of coal, the chemical value is also exploited.

Also worth mentioning are India's commitment to UNFCCC via INDCs. GOI's 2 Major INDCs to UNFCCC at COP-21:

- To adopt a climate friendly and a cleaner path than the one followed, hitherto, by others at corresponding level of economic development.
- Reduce emissions intensity of its GDP by 33 to 35 percent by 2030 from 2005 level.

In order to stand our commitment, usage of technologies like gasification cannot be over looked. A fertilizer complex downstream of a Gasification complex offers perfect synergy for CO_2 sequestration Further, the gas, SNG and methanol made from gasification can be used in power plants, and fuelling the automotive and power industry. GOI has been advocating the gas based economy, and is expected to come out with a mandate for methanol usage alongwith natural gas for transportation as well as for marine fuel also. Further to this, Methanol, as demonstrated above via case studies, can further be value-added and serve as an attractive feedstock to petrochemical industry. The Methane rich gas generated can be hooked to the natural gas pipeline of planned regional grid or routed for CGD for nearby customers. The strategic location of the proposed complex, near eastern coal field would also help evacuating the chemical product via port at the eastern coast. Some challenges do exist for gasification esp. with respect to hight. cost and quality of coal, these are listed below:

» Energy price fluctuation wrt Crude Oil & Natural Gas

» A capital Intensive complex project (Gasification/ASU/AGR etc), Large Land requirement & solid handling

» High R&M cost, and additional gassifier for reliability

» Economics favorable for large scale gasification

» Environmental issues need to be addressed, one should target for very low fly ash. Bottom ash in the form of solidified slag

» Government's support for CCS development to maximize profit from "Green technology"

» Availability of coal through long term allocation of Coal block

However, these can be overcome or minimised by adopting the following success mantras:

- The project needs to be conceived with adequate capacity to harness the advantage of economies of scale
- Incase of planning gasification facility for an existing hydrocarbon complex by using syn gas & displacing erstwhile fuel, then exploiting the displaced fuel's potential for further value-add is a must
- Until technologies & market for CCS matures, integration with Fertilizer complex offers perfect synergy for CO_2 disposal. Other being downstream Acetic acid / Ethanol units.
- Solutions like washing / blending coal with biomass / petcoke for tackling problems related to high ash content.
- SNG from gasification is another attractive option provided prevailing natural gas / LNG prices are high.
- Initial capital investment can be managed by considering BOO option for ASU.
- Utilization of Clean energy cess being imposed on Coal producers & users for partially funding the high CAPEX involved in gasification projects. Offlate project developers investors in coal based projects are also lobbying for usage of fund collected via National clean energy cess to be partly used for funding of these capital intensive gasification based projects. Worth mentioning that around 26000 INR Cr. was collected under National Clean energy cess.

Special Feature on Refining & Petrochemicals

Improving FCCU energy efficiency through synergies with upstream and downstream processes

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Greenhouse gas (GHG) emissions have become a growing concern for many industrialized countries over the past few years and confirmed with the Paris Agreement signature in December 2015.

Beyond the specific issue of GHG and general environmental considerations, there is a global tendency for improved energy efficiency. Indeed, whether the price of energy is high or low, controlled and reduced energy consumption will naturally improve operators' margins.

In the particular case of Russia, Presidential Executive Order number 752 was passed in September 2013, stating that the volume of GHG emissions will have to be reduced by 2020 to 75% of the baseline set in 1990.

As indicated in the 2015 World Energy Outlook (Special Report on Energy and Climate Change) [1], Russia has indeed already drastically improved energy intensity between 1990 and 2014 (see Figure 1). Yet, there is still a large potential for improvement in general and more particularly in the refining industry which represents about 5% of the total energy use (including industry, transport and buildings) [1].

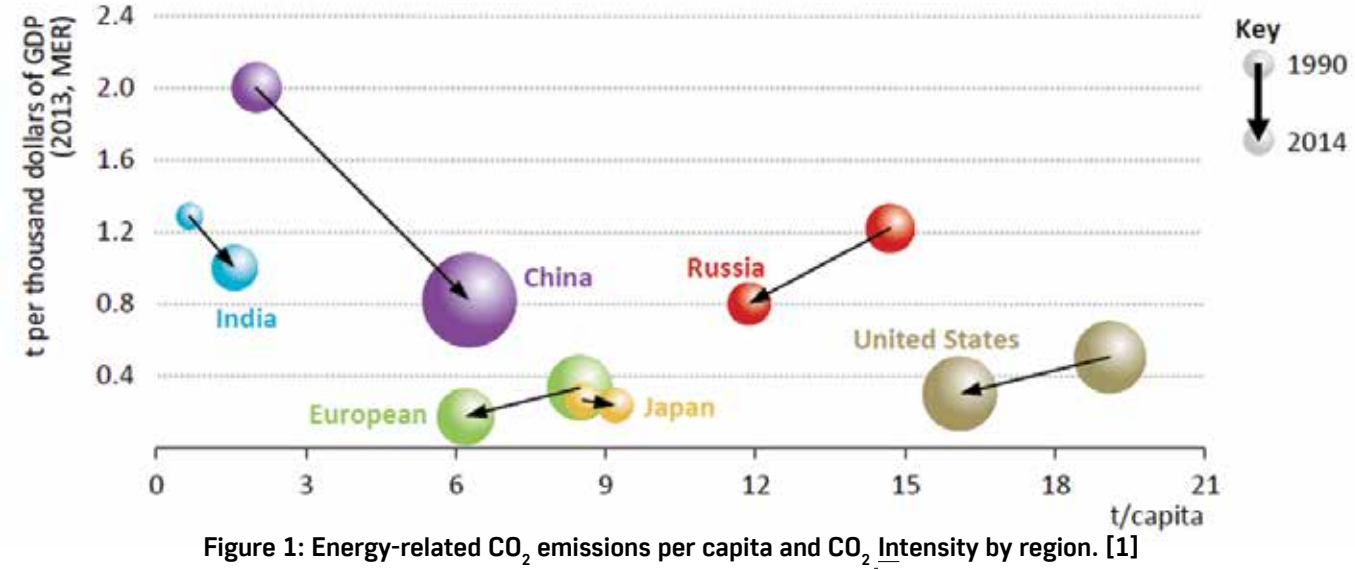


Figure 1: Energy-related CO_2 emissions per capita and CO_2 Intensity by region. [1]

Bubble area indicated total annual energy-related CO_2 emissions. MER = Market Exchange Rate.

This paper will deal with the methodologies available to refiners to assess their process thermal efficiency, focus on the case of fluid cat cracker (FCC) and its pre- and post-treatments and finally cover one revamp case of a refinery in CIS area.

Energy efficiency evaluation

Pinch analysis is a systematic methodology for energy saving based on thermodynamic principles developed by Linnhoff March in the 70's. It needs limited information about material (flowrate) and heat balance (temperature T, specific heat capacity Cp and enthalpy H). This method is useful to compare two networks, identify inefficient exchangers or assess the minimum energy (cold/hot utilities) required by the system, thus the maximum potential for improvement of a given scheme (the target). Pinch analysis never provides a solution but ways of improvement. Moreover, this methodology cannot take into account specific process or operating constraints. As such, no optimised heat exchangers network (HEN) is obtained.

Pinch analysis involves a graphical resolution, through the building of "composite curves". Composite curves consist in aggregating, on an enthalpy/temperature graph, all the heat availability in the process ("hot" curve) on one hand and all the heat demands or heat sinks ("cold" curve) on the other hand. The cold and hot composite curves shall therefore run more or less parallel. At the point where they are the closest to each other, the "pinch" temperature is defined and the difference in temperature at this point is called the ΔTmin (see Figure 2).

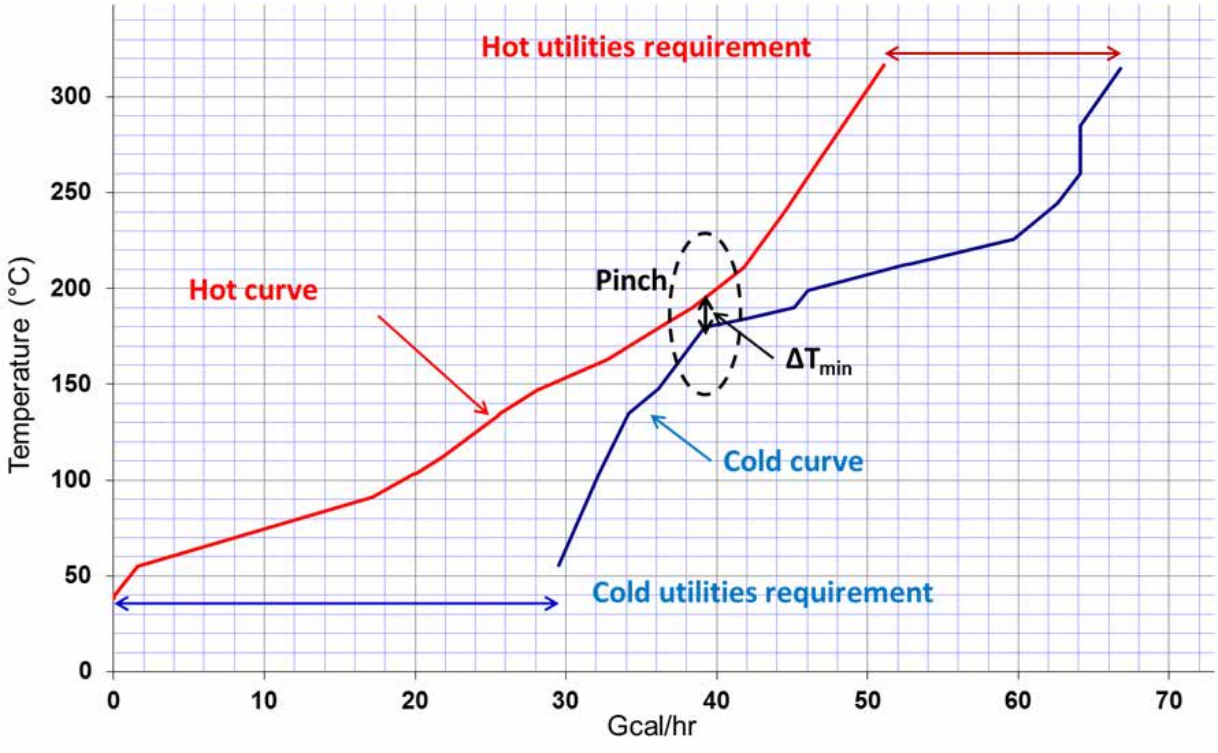


Figure 2: Example of composite curves.

With such a graphical representation, it is easily possible to identify design issues or poor exchanges. Indeed, thermal transfer will be impossible for instance if the cold curve is above the hot curve. In addition, three "golden" rules have been defined to ensure the best efficiency:

- No external cooling above the pinch
- No external heating below the pinch
- No heat transfer across the pinch

Properly integrated process units routinely exhibit ΔTmin in the range 30-40°C (this can vary depending on the process considered, site utilities conditions, etc.). A target can be set with a lower ΔTmin, targeting thus a better efficiency. The cold composite curve is therefore translated until this new ΔTmin is reached. The new relative position of the cold and hot composite curves will then define the minimum hot and cold utilities consumptions necessary, and therefore the ultimate potential for energy savings. The optimum ΔTmin is a trade-off between investments (low ΔTmin) and operating expenditures (high ΔTmin), yet the Pinch methodology will provide neither the optimum ΔTmin feasible, nor the associated most optimised HEN possible.

Indeed, as previously indicated, Pinch methodology provides only indications, for a given situation, that some exchanges are to be reviewed, not taking into consideration potential impossibilities due to technical limitations or process constraints. It is therefore necessary to use more sophisticated tools and that's why an in-house tool has been developed with IFP Energies nouvelles (IFPEN) in order to generate optimized HEN.

This advanced tool needs much more data than Pinch analysis and can be coupled directly with process simulators such as PRO/II. It is therefore possible to evaluate large-scale units with added features:

- Bypass requirements can be set, in case the process needs to be run under different operating modes (seasonal operation, varying objectives of feed cocktail, etc.) or to take into account transient phases.
- Restrictions on approaches can be set.
- Some exchanges can be forbidden (high pressure fluid exchanging against low pressure fluid, very low duties, etc.).
- Number of exchanges can be limited to limit complexity of the scheme (and associated capital expenditures!).
- The target is generally defined as an energetic optimum but can be tweaked to take into account unit costs (OPEX), GHG regulations, investment (CAPEX) minimization, reduction in the consumption of a particularly expensive utility, etc. or any combination of the above.

Consequently, the more data is available, the larger the number of possibilities are offered and ultimately the better the HEN optimisation. This methodology has been applied to a FCC complex and the results are developed here after.

The "FCC Complex"

Nowadays, a Fluid catalytic Cracker (FCC) unit can be thermally integrated to a deep extent, especially when this unit is designed with a Propylene Recovery Unit (PRU), which will allow making good usage of low heat level streams to reboil columns such as Depropanizer and Deethanizer (see Figure 3).

As such, it becomes fairly common to reach ΔTmin under 30°C while the industry standards are in general in the range 30-40°C. This seems to be the best performance achievable with conventional process equipment. Therefore, in order to go around such limitation and seek even better performance, we have to either consider unconventional process or heat exchange equipment (generally available at a higher cost or with limited warranty due to reduced operational feedback) or expand the boundaries of the study. The latter will allow including more fluxes, thus a larger potential for a further improved thermal integration as previously indicated.Therefore, instead of focusing only on the FCCU, we shall have a look at the "FCC Complex".

The "FCC Complex" can for instance be defined as the chain of processes involving the FCC feed hydrotreatment (CFHT, standing for Cat Feed HydroTreater) and any or all of the post-treatments of the FCC effluents. Each element constituting this chain is presenting specificities:

In terms of flexibility:

- The FCCU can be operated under different modes, resulting in fairly different yields, eg. Maxi Gasoline and Maxi Propylene modes of operation,
- The hydrotreating catalysts will age over time and exhibit different performances between start and end of run (SOR, EOR).
- In terms of operating conditions, tweaked to maintain optimal catalyst activity or adapt to the desired mode of operation, resulting in turn in different demands for utilities consumptions.

A proper thermal integration should take into account those specificities and no compromise should be envisaged in order to ensure process integrity at all times and the requested level of flexibility intended for each process. The starting point for our case study is an FCC including propylene recovery section for polymer grade propylene production with limited complexity with regards to energy efficiency. Moreover, in the chosen example:

- The pre-treatment CFHT is operating into mild hydrocracking service, which increases middle distillate production through VGO hydroconversion while improving the quality of the VGO feeding the FCCU,
- the post-treatment includes a gasoline hydrotreatment unit (GHT), in that case the well-known Prime-G+™ process enabling deep FCC gasoline desulphurisation with maximum octane retention,

Two different thermal integration options have been considered for this chain of processes:

- Option 1 with a deep thermal integration of each process separately, using pinch analysis and linear programming tool,
- Option 2 with a thermal integration allowing exchanges between process units. The balance between pre- and post-treatment was also slightly adjusted in order to maintain products qualities for a fair comparison.

The exchanges have been limited in order not to jeopardize the operability of the units, including the possibility to start up and shut down properly. Moreover, neither breakthrough nor unconventional technologies have been envisaged.

As expected, important gains were obtained versus the reference case.

Some points were noticed (see Table 1):

- The FCCU efficiency for the reference case is already good but is yet improved through an increase of its heat exchangers network complexity.
- While the FCCU efficiency seems to be the same (no variation on FCCU ΔTmin between Phase 1 and Phase 2), the global thermal integration was nevertheless also improved when exchanger between CFHT and FCCU/PRU are allowed.
- While the ΔTmin improvement could seem marginal, whether looking at FCCU alone or the whole complex, large gains were obtained in terms of OPEX or GHG emissions for a limited increase in complexity and CAPEX (limited number of additional process/process exchanges).

It appears clearly that tracking ΔTmin alone will not allow assessing fully the performance of a scheme, as variations in ΔTmin do not reflect directly variations in reduction of OPEX, GHG emissions or specific utility consumption... As such, setting clear objectives is of paramount importance to ensure the best scheme will be offered.

Scheme	Reference	Option 1	Option 2
Optimization	Limited	Independent units	Global
Complexity	Low	Normal	Limited complexity
CAPEX (MUSD)	REF	REF + 3%	REF + 6%
OPEX (MUSD/yr)	REF	REF - 5%	REF - 21%
Pay out time (yr)	-	2	1
ΔT min Complex	53°C	33°C	30°C
ΔT min FCCU	25°C	16°C	16°C
GHG (teqCO_2/h)	REF	REF - 4.1%	REF - 7.3%

Table 1: Case study around the "FCC Complex"

Obviously, resorting to non-conventional technologies, while certainly more expensive to install or more complex to operate, will further boost the energy efficiency of such a complex. We can name, in decreasing order of contribution to the reduction of GHG emissions (see Figure 4):

- Organic Rankine Cycle (ORC), consisting in heat recovery from lower temperature, converted into useful work that could itself be converted into electricity thanks to an expansion device such as an expander.
- Dividing Wall Columns, their optimal application being limited to spare applications in the FCC Complex. Indeed, all fractionation services are not suitable for such a technology.
- Use of side-reboilers: this is limited to a handful of applications for minor gains throughout the FCC Complex.
- Advanced heat exchangers: usage of advanced technologies will be envisaged only in specific cases (e.g. retrofit where plot space or pressure drop are issues).
- Hydraulic Power Recovery Turbines can be considered whenever a high pressure to low pressure let down is considered.

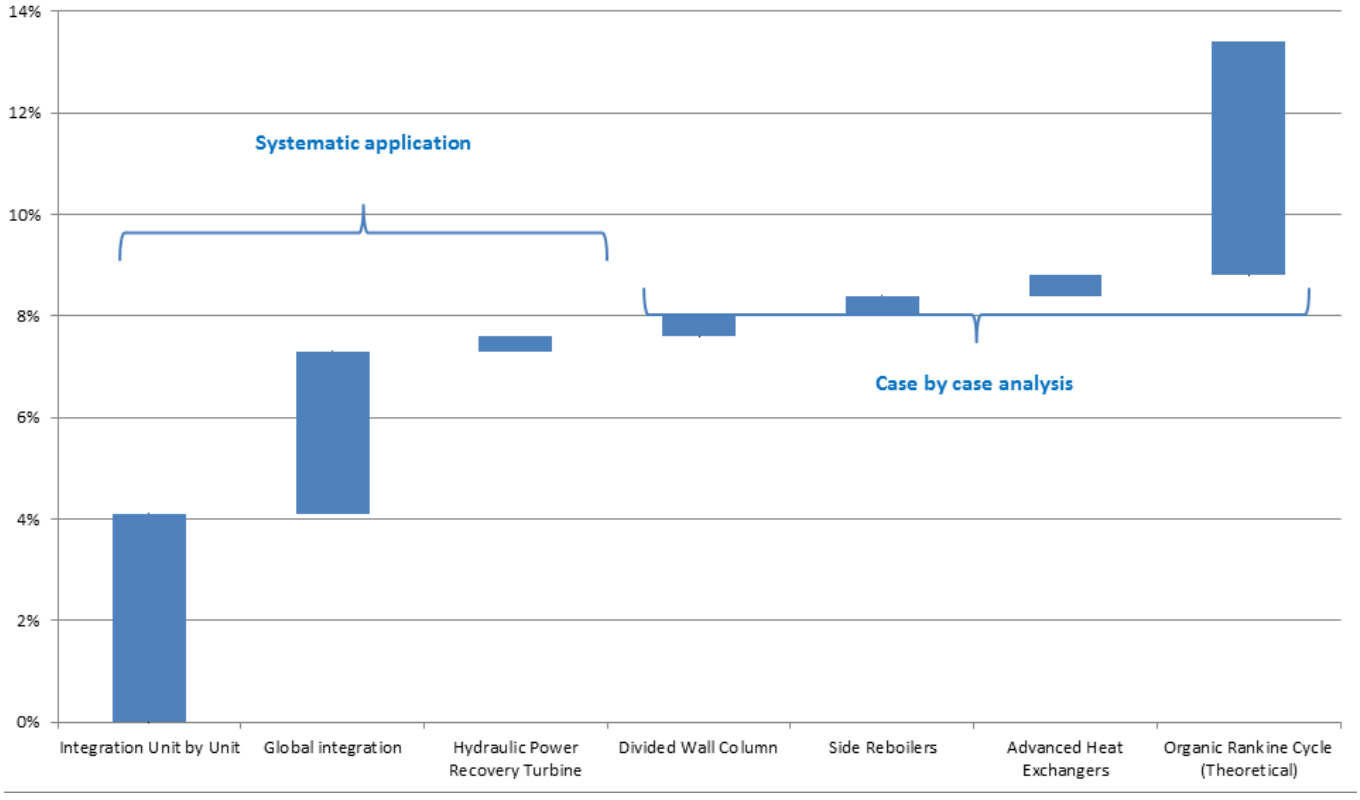


Figure -4: Further reduction of GHG emissions with non-conventional Solutions

All of the above will contribute separately to GHG emissions reduction above and beyond the intra or inter thermal integrations. A better level of performance of the above solutions is expected, as more and more operators will resort to their usage.

CFHT and FCCU revamp case in the Gazpromneft Moscow Oil Refinery Plant (MNPZ)

Axens managed recently a revamp case in MNPZ refinery consisting in debottlenecking the capacity of a train composed of a CFHT and FCCU, along with a better performance and improved energy efficiency.

As part of the FCC Alliance, Axens and its partner Technip Stone & Webster Process Technology have an outstanding trackback record of FCC grass-root designs and revamps.

This project went through different steps, under initial management by Performance Programs, Axens' unit in charge of consulting services [2], in order to ensure a proper execution and fulfilment of Gazpromneft expectations at the lowest possible cost:

» **Feasibility study, consisting in**

- Identification of main bottlenecks
- Proposing incremental capacity increases vs. cost
- Selection of the (economical) optimum capacity for the complex (CFHT+FCCU)

» **Scoping study with higher level of precision**

- Focusing on selected case (CAPEX / OPEX)
- Confirmation of the profitability of the case
- Full site survey and thermal integration study aiming at identifying one preferred scheme taking into account process and site constraints

» **Process Data Book production**

Beyond the expected improvement of the energy efficiency and increase of capacity, a technological upgrade was performed on, the FCCU involving among others the installation of new impact-type feed injectors to ensure intimate contacting of feed molecules with catalyst particles, replacement of the riser termination device with RS² in order to limit dry gas production due to thermal degradation of the products, and addition of a new Stripper Packing for enhanced recovery of hydrocarbons.

Concerning the CFHT operated in mild hydrocracking service, a new reactor distribution tray was installed using EquiFlow™ technology. Moreover, a new fractionator aiming at removing diesel from FCCU feed was added in the plant.

A preliminary Pinch evaluation of the existing configuration hinted at different potential improvements. Indeed, not only the ΔTmin at 68°C was probably too high with regards to current industry standards but different breaches of the aforementioned Golden Rules were also identified (see Figure 5), namely:

- 7 exchanges across Pinch
- 8 exchanges with cold utility above Pinch
- 1 exchange with hot utility below Pinch

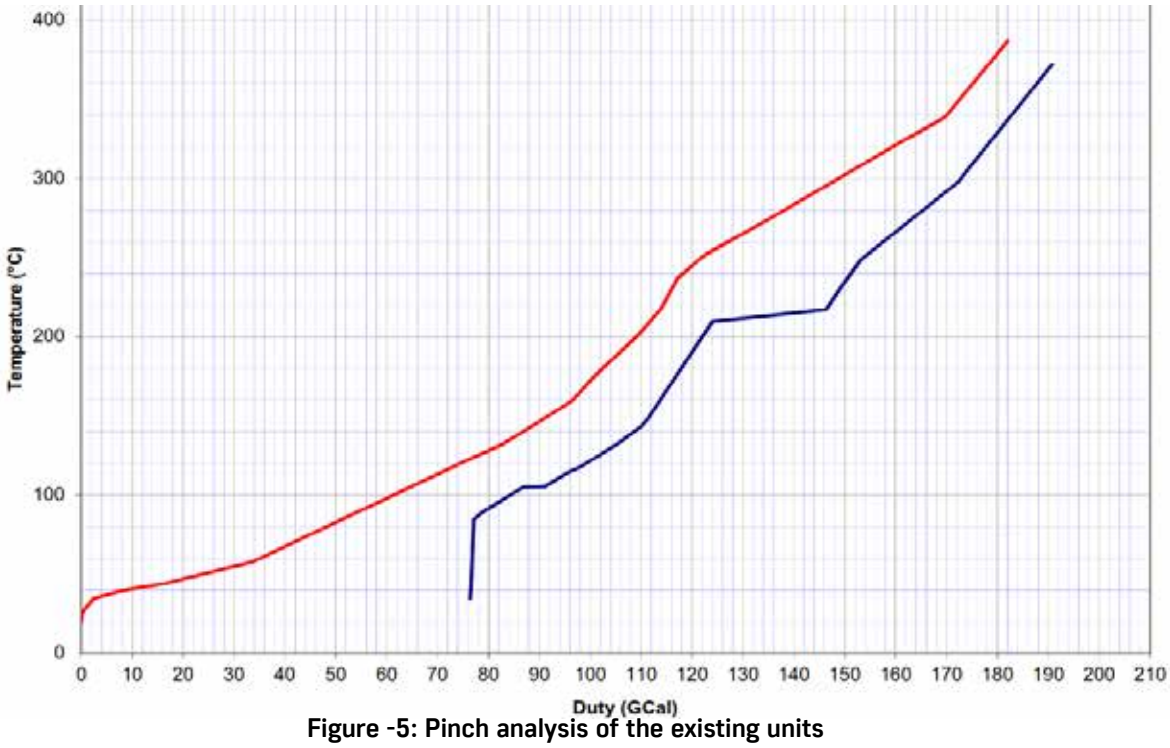


Figure -5: Pinch analysis of the existing units

Further to the Pinch analysis, the in-house HEN optimization software was used to produce different solutions:

- Case 1: No constraints provided. This case was set to allow defining the ultimate potential gains possible for benchmark of the other cases.
- Case 2: Process / Process exchanges allowed only for duties higher than 0.5 Gcal/h. This case was targeting at limiting the overall capital expenditures yet resulted in achieving about two thirds of the maximum potential energy consumption reduction.
- Case 3: Full flexibility to account for transient phases and refiner's preferences. For instance, exchanges between high and low pressure fluids were banned, as well as exchanges between CFHT recycle gas and any FCCU streams. In addition, a minimum bypass of 10% was asked in order to maintain unit controllability. Obviously, each demand aiming at increasing operation safety / reliability or reducing operation complexity would be made at the expense of the final energetic performance of the process units.

Case 3 was retained as the basis for further steps, in spite of a preliminarily moderate improvement in energy requirements (about one third of the maximum potential energy consumption reduction), as this was a very realistic basis with reduced number of modifications, above all in line with refiners' budget.

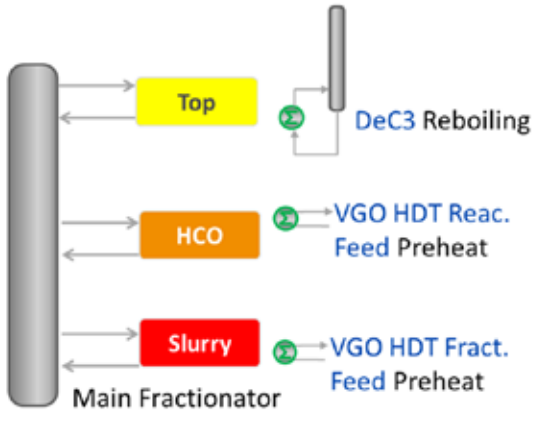
After a careful examination of the units' performances and behaviour through a site survey and check-run, the thermal integration study was finalized and data sheets produced. The following modifications in the heat exchange equipment were performed:

» **CFHT:**
- 1 fired heater modified
- 1 air cooler deleted
- 6 new heat exchangers and 2 new air coolers corresponding to addition of a fractionator aiming at removing diesel from FCCU feed

» **FCC:**
- 1 heat exchanger removed
- 2 air coolers and 2 exchangers replaced for larger capacity
- 3 reboilers modified to improve performance

Among those modifications, we can in particular detail rearrangements around FCCU main fractionator column (see Figure 6):

- Depropanizer is now reboiled with Top Pumparound (P/A) instead of HCO P/A,
- The subsequently heat available in HCO P/A is now used to preheat CFHT feed instead of using Slurry P/A,
- The subsequently heat available in Slurry P/A is now used to preheat new CFHT fractionator feed.



Finally, the following results were obtained (see Table 2), where utilities consumptions have been averaged between summer and winter operations in order to account for seasonal variations of air/water cooling breakpoint:

Figure 6 : New arrangement around FCC Fractionator

	CFHT (Old)	CFHT (New)	FCC (Old)	FCC (New)	Complex (Old)	Complex (New)
CW consumption, Gcal/h	0.2	3.7	26.5	22.1	26.7	25.8
FG consumption, Gcal/h	25.3	19.4	-	-	25.3	19.4
Added steam production, Gcal/h	-	8.0	-	-	-	8.0
Throughput, T/h	254	300	246	275	254	300
Efficiency, Gcal/T feed	0.10	0.05	0.11	0.08	0.21	0.12
		(-50%)		(-27%)		(-43%)
ΔOPEX, MM USD/yr						**3.3**

Table 2: Energy efficiency improvement in MNPZ refinery

Added electrical consumption of rotating machines was not taken into account to focus on improvement of energy efficiency rather than on capacity increase. Added electrical consumption of air coolers was considered as negligible.

Global revamp investment for capacity increase, technology upgrade and thermal efficiency is 52.8 MMUSD. Looking only at air cooler and heat exchanger investments (not pertaining only to energy efficiency), this corresponds to 13.5 MMUSD, thus a Pay Out Time (POT) of 4 years in spite of a significant capacity increase.

Globally, the impact of the revamp is detailed in Table 3.

	Before Revamp	After Revamp	Delta
CFHT Flowrate	254 T/h	300 T/h	+ 18%
FCC Flowrate	246 T/h	275 T/h	+ 12 %
Catalyst Cycle Length	2 years	2 years	-
Extra Diesel Production Flowrate	0	19 T/h	+ 19 T/h
Gasoline Production	130 T/h	162 T/h	+ 25%
LCO Production	27 T/h	23 T/h	- 15%
Utilities Consumption (Gcal/T feed)	0.21	0.12	- 43%

Table 3: Global improvements of MNPZ CFHT and FCCU

All of the objectives set to Axens were met with outstanding improvement of energy efficiency for a limited added level of complexity, without impacting the operability of the unit or the CFHT cycle length in spite of strong constraints imposed due to plot plan limitations.

Conclusion

The growing scarcity of resources, climate change and growing of population on one hand and a fluctuating market with tightened refining margins on the other hand are defining a new context imposing more energy efficient plants.

Considering only pinch ΔT as an indicator for process unit efficiency is not sufficient to compare solutions: taking into account client's objectives and site specificities is paramount and imposes a tailor-made solution. Such solution must not impair the reliability or the flexibility of the involved processes to cope with varying feedstocks and evolving process objectives. Moreover, ensuring operability on a daily basis is crucial.

Broadening the vision around main process units such as FCCU to include surrounding process units will offer better opportunities for global energy efficiency improvement, whether non-conventional solutions are considered or not. As such, management of the FCC train for instance by a single licensor can help reduce drastically GHG emissions and/or utilities consumptions.

As illustrated in this article, Axens is developing sustainable offers that minimize environmental footprints through tailor-made solutions. Axens' experience as technology licensor shows that, due to tight schedule and lack of time, energy efficiency and water footprint as well, are not sufficiently customized and this can be improved with the innovation approach called CEED™, standing for Custom and Efficient Early Design. During this new phase, taking place before the beginning of the basic engineering, Axens and the customer work together, in close collaboration. In addition to the base case, alternate schemes are defined and carefully evaluated according several criteria defined by the customer (CapEx, OpEx, IRR, NPV, energy efficiency, water footprint, unit flexibility, unit operability...). At the end of the CEED phase, Axens provides a powerful decision-support tool that allows the customer to select the most appropriate scheme for the basic engineering phase.

As a technology licensor, Axens ensures that the proposed optimal scheme is robust and safe considering all the flexibility needs such as various operating modes, start-up needs and specific catalyst treatment steps. Therefore additional scrutiny by another layer of experts is not warranted, potentially saving our clients significant cost and schedule impacts.

Special Feature on Refining & Petrochemicals

Modern Trend In Catalysis

Ritwik Kumar Hatial

Mangalore Refinery & Petrochemicals

Dedicated to : Honourable H.Kumar, A.K. Sahoo, M. Venkatesh

Abstract

This article explores the interesting development in the catalysis domain in Refining & Petro Chemical Industries since middle half of the 20th century to contemporary era & also it explores the futuristic growth & changes in catalysis. The primary reason for the need of advanced & efficient catalyst is due to stringent fuel emission standard that imply huge investment in Refinery & Auto Mobile Sectors. Although the reduction of Carbon-di-Oxide will eventually require the decarbonisation of energy carriers, oil will still remain the principal source of liquid motor fuel for a long time as long as the hydrolysis generating hydrogen is becoming the most sustainable & economic technology. This paper brings about salient features of the futuristic plan to replace carbon with hydrogen as main energy element. The use of biomass will generate a modest level. Within this frame work catalyst will play a significant role in technical & economic development in the 21st century in energy sector.

Introduction

The 21st century is known for the eerie development in catalysis from the point of view of fundamental knowledge and its applications. Ultra fine spectra, use of nano particle, rare earth elements, membrane technology etc. make this domain of chemical engineering more challenging competitive. The present & futuristic growth of catalysis can be depicted by the catalysis sustainability diagram as :

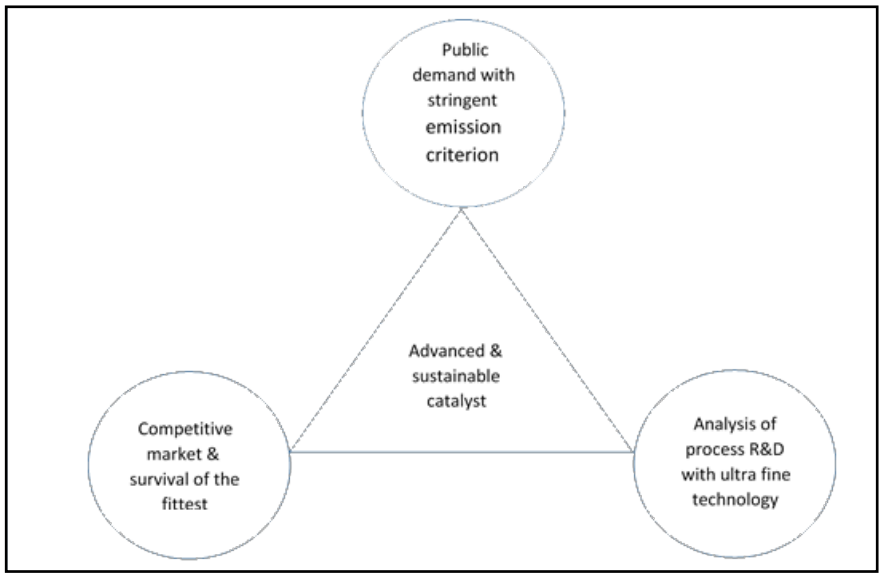


Fig-1: Catalysis sustainability diagram

Although the environmental norms are the major factor in the background to this article, the paper will analyse the technology to generate the less polluting fuel in refining & petrochemical sector. Lastly, an attempt will be made to bring some light in future catalysis to regenerate carbon with hydrogen as energy element.

Salient feature of catalysis life cycle

The development of industrial catalysis is specially influenced by a series of geo-political contexts as :

- 1970 world oil crisis & realization of limited fuel oil resources leading to search for substitute for it : sill oil the most strategic energy source in power & transport sector
- Increasing demand of heavy fractions in refining into lighter products leading to resid catcracking & hydroconversion
- Need to protect environment against noxious emissions produced from power & automobile industries. Since 1968 to 2000 , primary concern-lead out of gasoline. Since 2000: sulphur leads. Refer Table-1/2
- Greenhouse gas effect & realisation of CO_2/SOx as one of the greenhouse gases in 1990s , leading to demanding HDS-hydro-desulfurization technology
- Growing completion in petrochemical industries to increase predictive yield.

Table-1: Changes in fuel specifications on global perspective

Fuel	1994	1995	1996	2000	2005	2020
Unleaded gasoline 95/85						
Sulphur, vol% max	1000	500		150	50/10	10
Benzene, vol% max	5			1	1	
Aromatics, vol% max				42	35	
Olefins, vol% max				18		
Oxygen, Vol% max		2.7		2.7		
RVP, kPa, max	80			60		58
E100, vol%, min	40/43			46		
High speed diesel						
Cetane index, min	46			46		
Cetane number,	49			46		51
Sulfur, ppm mass,max	2000		500	350	50/10	10
Recovery@95%	370			360		
HPA, mass%, max				11		

The mass emission standard for low sulphur grade fuel i.e. Euro-V/VI is as shown in the Table-2

Table-2: Limit values for M & N categories category vehicles fitted with SI&CI engine

			Mass of CO		Mass of total hydro-carbons (THC)		Mass of non-methane hydro-carbons (NMHC)		Mass of oxides of nitrogen (NOx)		Combined mass of hydrocarbons & oxides of nitrogen		Mass of particulate matter (PM)		Number of particles(PN)	
			L1 (mg/km)		L2 (mg/km)		L3(mg/km)		L4 (mg/km)		L2+L3 (mg/km)		L5 (mg/km)		L6(numbers/km)	
Category	Class		PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI	CI
M(M1 & 2)	-	All	1000	500	100		68		60	80		170	4.5	4.5	$6X10^{11}$	$6X10^{11}$
N1	I	RM≤1305	1000	500	100		68		60	80		170	4.5	4.5	$6X10^{11}$	$6X10^{11}$
	II	1305<RM≤1760	1810	630	130		90		75	105		195	4.5	4.5	$6X10^{11}$	$6X10^{11}$
	III	1760≤RM	2270	740	160		108		82	125		215	4.5	4.5	$6X10^{11}$	$6X10^{11}$
N2	-	All	2270	740	160		108		82	125		215	4.5	4.5	$6X10^{11}$	$6X10^{11}$

Source: Gazette of India: extraordinary

Development of catalysis in refining and petrochemicals:

Catalysis played a very important role during second half of the 20th century in the development of the refining and petrochemical industries. Fig-1 indicates some of the important dates that marked their history to contemporary trend with some extrapolation to future :

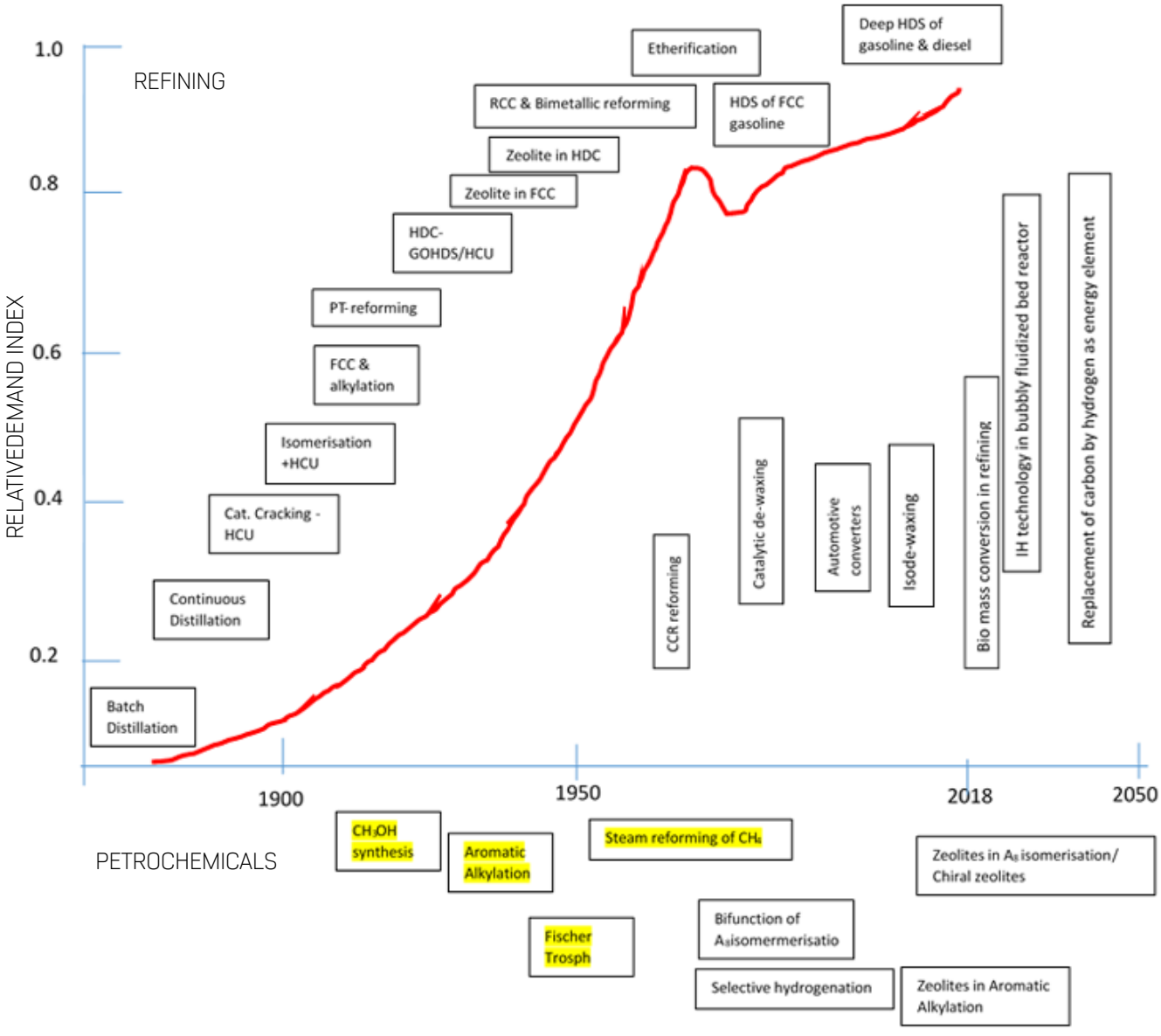


Fig-2: Important development in catalysis

The growing aspects in micro chemicals has prompted much work on catalysis by impregnated metals to the crystal voids.

Present & future zeolite based catalyst:

In refining, one of the most important process is catalytic cracking. Started in 1930, the Use of γ-zeolite containing rare earth element to maximise gasoline yield invented in early 1960. In 1980, gain in octane number were obtained with the ultra-stable-γ (USY) & then by the use of ZSM-5 zeolite as an octane booster. The recent development in zeolite catalysis is encaging quasi-homogenous catalytic reaction into a zeolytic microcapsular reactor. The nano-palladium entrapped zeolitic catalyst is very much selective in halide removals from organic compounds eg: Heck coupling reactions. Moreover due to antileaching effect of surrounding zeolitic shell towards entrapped homogeneous Pd-species the catalyst shows outstanding stability & reusability even in leaching prone reaction system containing reaction systems. Alkylation process for upgrading low value naphtha fractions to diesel. Recently a new zeolite catalyst formed by intergrowth of three different polymorphs with interconnected large and medium pore channels. As the pore channels are becoming more and more dense, the effectiveness of the catalyst is getting increased. The HR-TEM images with the yield pattern of the four graded zeolite catalyst of hierarchical porosity are as follow:

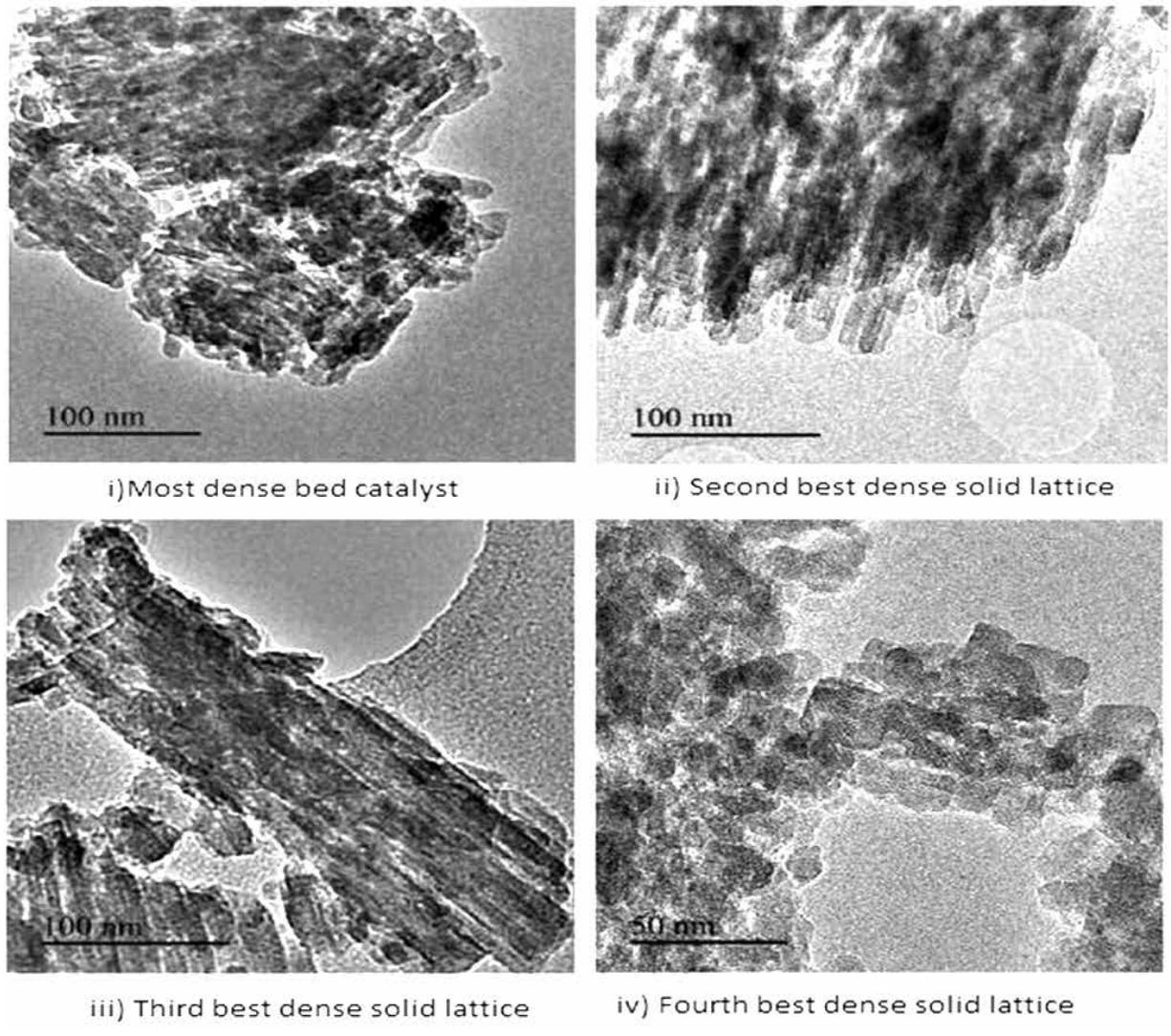
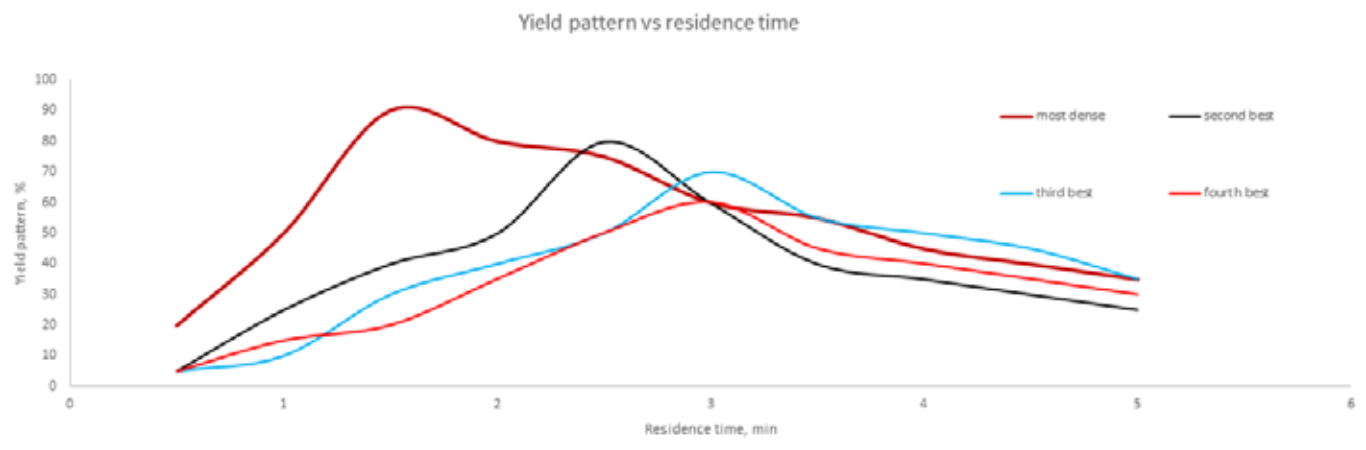


Fig-3: Hierarchical catalysis & respective yield pattern



As the catalyst is getting denser, optimum yield pattern is achieved faster & at longer residence time, yield is decreasing due to formation of coke in the catalyst bed.

As the frame work aluminium content decreases the ratio of de-alkylation to cracking decreases. Recent development of well dispersed Fe_5C_2 nano-particles within ordered mesoporous carbon & their successful application of high temperature Fischer-Tropsch syn thesis showed higher CO conversion and good selectivity for gasoline range hydrocarbon. For sulphur removal of gasoline, Zn, Na and F-doped γ-Al2O3 is very much effective especially in tetra hydrothiophene (THT) species. Partially sulfided oxidic as well as reduced and passivated Al_2O_3-supported nickel catalysts for pyrolysis gasoline hydrogenation is a well-known industrial practice. The commercial catalyst for isomerization of light straight run gasoline to branched chain to boost up octane number is Pt on chlorinated alumina and Pt Hmordenite. Pt-on chlorinated alumina allows to carry out the

reaction at lower temperature (180^{0}C) but the reaction is very much sensitive to water and sulphur at low concentration (10 ppm); Pt-mordenite requires higher temperature (250^0). Recent development of nano-crystalline Beta (BEA) zeolite is much more effective to carry out the reaction at lower temperature and it is not hindered by traces sulphur or water species present in the system.

In near future chiral zeolite i.e. chiral ordered porous material for enantioselective adsorption is utter importance. It is having the future potential to have enantio pure compounds. However, computational methods have been used to predict feasible chiral layered zeolites with desired channel geometries. Experimental analysis could be an aid for futuristic research to tally the computational results.

Colloidal zeolites, delaminated zeolites (i.e. particles with desired topology with tremendous aspect ratio) synthesis by a single hydrothermal crystalline stage without lamellar precursor is a worth importance for futuristic catalysis. In a nut shell, following are the aspects of futuristic catalysis:-

- Reproducible defect free oriented (anisotropic structure) zeolite membranes
- Commercial asymmetric γ- Al_2O_3, TiO_2 membrane
- Self supported membrane i.e. geometrically homogenous porous supports

Renewable energy source and catalysis:

In this section the renewable catalyst is divided into three categories:

A. Catalyst & adsorbent by design:
   - Electro catalysis: Core shell MoO_3-MoS_2 nano wires are highly stable & active hydrogen evolution catalysis. $W_{1-x}IrxO_3$-δ as acid stable OER catalysis; IrO_2/RuO_2 are stable OER catalysts in acidic electrolytes. Recent development revealed that doping of 10 mol% of Ir into WO_3 Lattice decreased over potential from 1.87 to 0.5 V.
   - Ultra deep hydro-sulfurization: ZnO NW powders as supports for advanced ultra deep desulfurization catalyst
   - CO_2 Adsorbent: Lithum ceramics having the CO_2 adsorbent as :

$$Li_x MO_y + CO_2 = Li_2CO_3 + MO_{(y-2)}$$

CO_2 chemisorption occurs in a wide range of temperature from room temperatures to 650-710^{0}C at atmospheric pressure; it is having high CO_2 capacity & easy regeneration compared to conventional wet scrubbing agents; however, core shell morphology accounts to slow adsorption kinetics and it is very much susceptible to impurities present in the system. In recent times, Li_4SO_4 adsorbent having nanowire morphology is very much effective in the process.

B Nano wire based material: Nano wire based materials are much more active compared to nano powders; they are having application in fluidized bed reactor, bubbly flow reactors with high attrition index giving extra stability to the catalyst. They are synthesised in
   - Plasma flame production of nanowires:
   - Slovo plasma synthesis of nano wires

C Compositionally controlled synthesis of mixed metal oxide alloy: The metastable phase and solid solution of the metal oxide alloys are having the potential of high active catalysis as:

Table 3: Modern structure & usage of catalysis

Usage	Symbol	Structures
Super conductors	$Cd_2Re_2O_7$	Pyrochlores
Photocatalysis	$AgGaO_2$	Delafossite
Lithium ion battery	$LiMn_2O_4$	Spinel
	$LiNi_{0.33}Mn_{0.33}Co_{0.33}O_2$	Layered rhombo
Electro catalysis	$Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_3$	Perovskite
	$Co_xMn_{3-x}O_4$	Spinel
Heterogeneous catalysis	$La_2Zr_{2-x}Rh_xO_7$	Pyrochlore
	$Na_6Al_6Si_{36-n}O_{192}$. 16 H_2O	Zeolite 0<n<27

Future energy source and catalysis :

Next generation energy source and replacement of carbon by hydrogen as energy element is quite certain; as of now the future catalytic energy map can be depicted as :

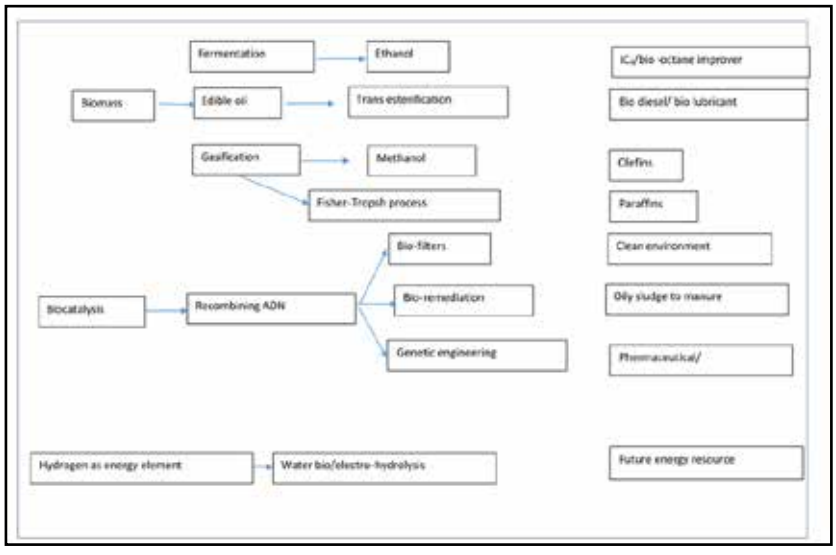


Fig-4: Future catalytic energy map

There are fundamentally three ways to convert biomass into an energy source:

- Anaerobic pyrolysis transform lignocellulosic biomass into coal, gas or pyrolytic oil containing oxygen compounds
- Catalytc decomposition of biomass into biofuel, bio lubricants or biogas
- Fermentation by enzymes in anaerobic conditions into methane of alcohols

Bio catalysis to produce sun gas or hydrogen having futuristic growth potential. Hydrogen is a complex & promising energy carrier offering high energy yields and limiting all secondary yields. The fuel cell to produce electricity for propulsion from hydrogen appears to be promising technology. In near future Pt-free fuel cell development is the prime challenge. In 2020-30 all automobiles vehicles would be equipped with autonomous hydrogen production unit fuelled by hydrocarbons, ethanol or even methanol. Another long term option is the direct use of methanol as fuel cell fuel. A major technological break through would be expected to replace at least primarily noble metals of electrodes.

IH^R technology: alchemy to modern era:

The IHR technology to convert carboniferous waste like MSW(municipal sewage waste) into gasoline by digestion with hydrogen is one of the turning point for future catalysis. The bubbly fluidized reactor with nano porous catalyst help to convert carboniferous waste into value added products is invented by M/S CRI groups.

Conclusion: impact on applied catalysis to fundamental catalysis:

The above discussion decipher on the primary concern & challenges in future catalysis research. In a summery, in the following areas, catalysis research is having bigger scope & need prime focus of advanced research:

- New micro-mesoporous catalytic material, catalytic membrane or membrane reactors for hydrogen storage
- To replace Pt & other noble metals in the diffused activities i.e. fuel cell
- Development of bio catalysis in refining and petrochemicals, biomass application
- Optimization of use of catalysis in new industrial implementations
- Advanced knowledge in reaction mechanism and reaction pathway i.e. the computational chemical method to predict the catalysis behaviour with the experimental validation

White Goods Industry Overview and Use of Polyolefins

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Indian Oil Corporation Ltd., Panipat

Consumer Durable Market in India

The Indian consumer durables market has traditionally been a "high spend" priority sector. Consumer durables account for more than 40% of end consumer spending in India. The Indian Consumer Durables segment can be categorized as below:

Consumer Durables

Consumer Appliances

- Air conditioners (AC)
- Refrigerators
- Washing machines
- Sewing machines
- Electric fans
- Cleaning equipment
- Microwave ovens
- Other domestic appliances

Consumer Electronics

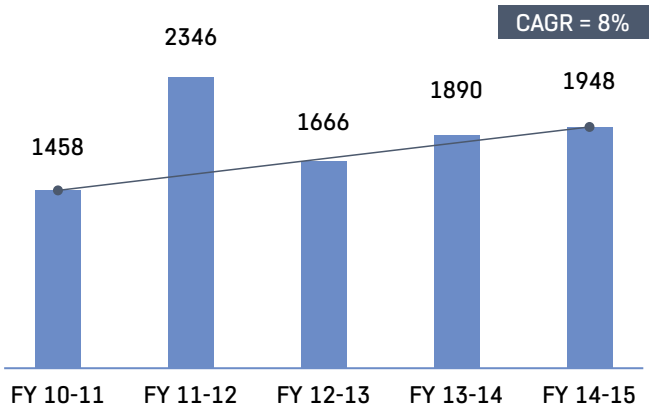
- TVs
- Audio and video systems
- Electronic accessories
- CD and DVD players
- Digital cameras
- Camcorders

AC, Refrigerator & Washing Machine segment is referred as white goods and Polyolefin's are mainly used in Washing Machines & Refrigerator. ABS is preferred material for AC.

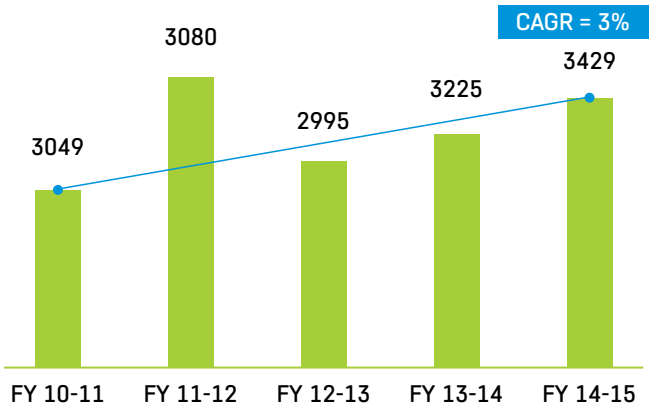
Domestic Production Of White Goods

Overall, growth in manufacturing over the 5 year period of FY10 - FY14 remained fairly moderate. Most manufacturers in India have been running their plants at ~80% capacity. With growing demand, domestic production has also been on a rise.

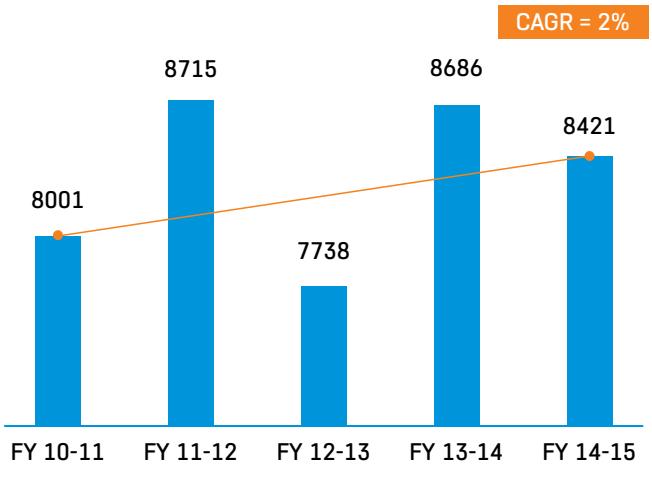
AC Production ('000s)



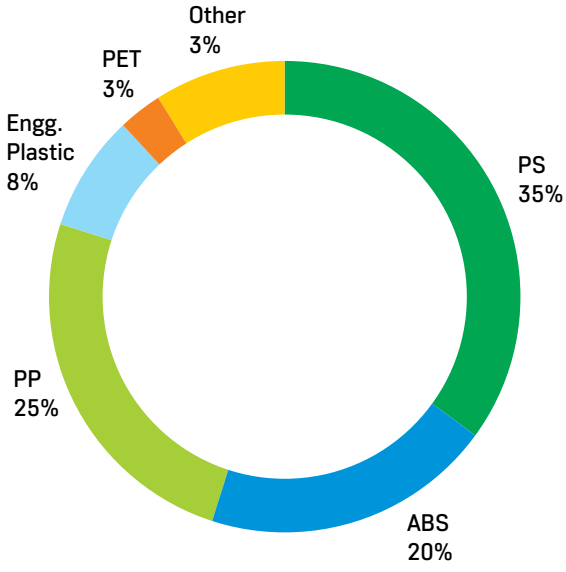
Washing Machine Production ('000s)



Washing Machine Production ('000s)



Raw Materials –Usage in White Goods



Traditionally, PS, ABS & PP are dominant material in White Goods: 80% of total plastics used

Material Properties Comparison Matrix

Parameter	PP	HDPE	ABS	PS
Max Service Temperature (°C)	135	120	80	65
Min. Service Temperature (°C)	0	-100	-20	- 50
Process Melt Temperature (°C)	185 - 230	180 - 215	225 - 265	200 - 250
Sterilization	Yes	No	No	No
UV Resistance	Poor	Very Good	Poor	Poor
Hardness	R 65–70	SD 55–65	~ R 110	~ R 75
Specific Gravity	0.90	0.95	1.04	1.05
Mould Shrinkage (%)	0.8 – 1.4	1.1 – 1.7	0.2 – 0.6	0.2 – 0.6
Hygroscopic	No	No	Yes	No

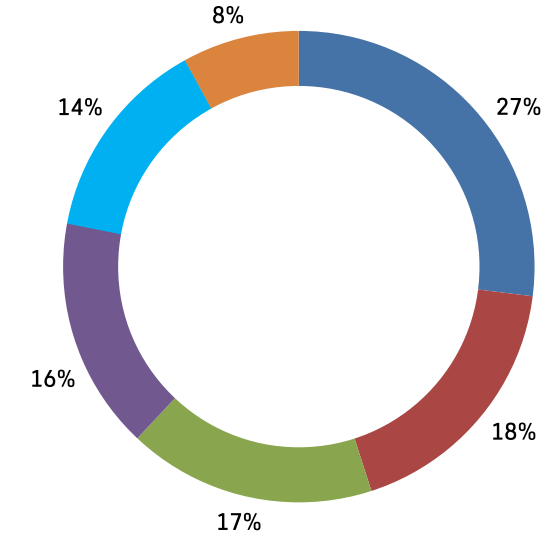
Plastics Used In Refrigerator:

Plastics in Refrigerator: ~10 Kg Plastics / piece (~6 Kg molded & ~4 Kg Liner)

PP & PE in Refrigerator: 2 - 3 Kg/ piece

Per annum domestic consumption of Polyolefin's in Refrigerator components is around 21 KTA, wherein PP consumption is about 98%.

Break-up of cost, by key components (Refrigerator medium range, 200 L)



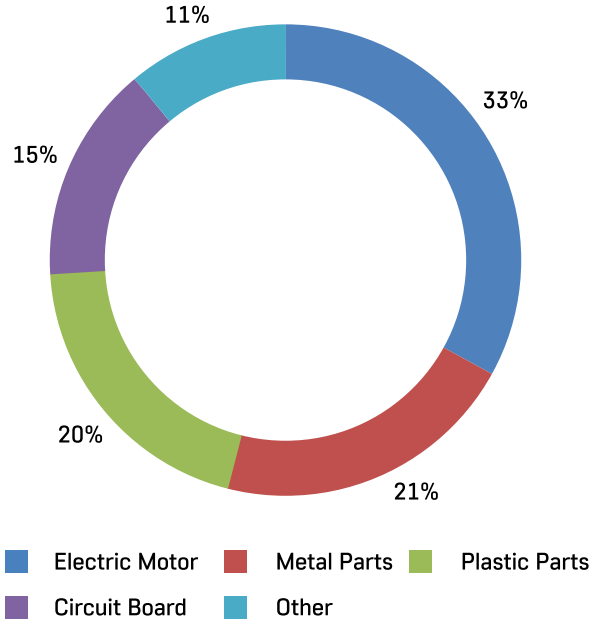
Plastics Used In Washing Machine top loading:

Plastics in washing machine: ~10 Kg Plastics / piece

PP in washing machine: 7-8 Kg/ piece

Per annum domestic consumption of PP in washing machine components is more than 30 KTA.

Break-up of cost, by key components (Washing machine medium range, top loading, fully automatic,



Raw Material Challenges & Opportunities

- Demands are moving towards clear, transparent material and with metallic finishes–Solutions are needed for aesthetics improvement.
- Currently, only neat materials are used, developments are needed for compounding material for strength and lower cost.
- There have been many advances in the development of polypropylene compounds such as high gloss, rigidity and heat performance gained through new filler and polymer technology. Flow and shrinkage analyses have now provided appliance designers with the freedom to use polypropylene compounds as a cost effective alternative in applications that were previously only deemed suitable for amorphous thermoplastics. Non-yellowing properties means polypropylene compounds often replace traditional styrene-based polymers.
- Special effect master batches to replace printing / coating.
- Innovation required in replacement of sheet metal parts with viable plastics solution.
- Key properties improvement required in PP like scratch resistance, high melt strength & printability for material replacement.
- Replacement of GPPS in Refrigerator tray with PROPEL PP 2120MC grade

It is a significant cost effective application development with transparent Random Co-polymer Polypropylene (RCP-PP) grade 2120MC.

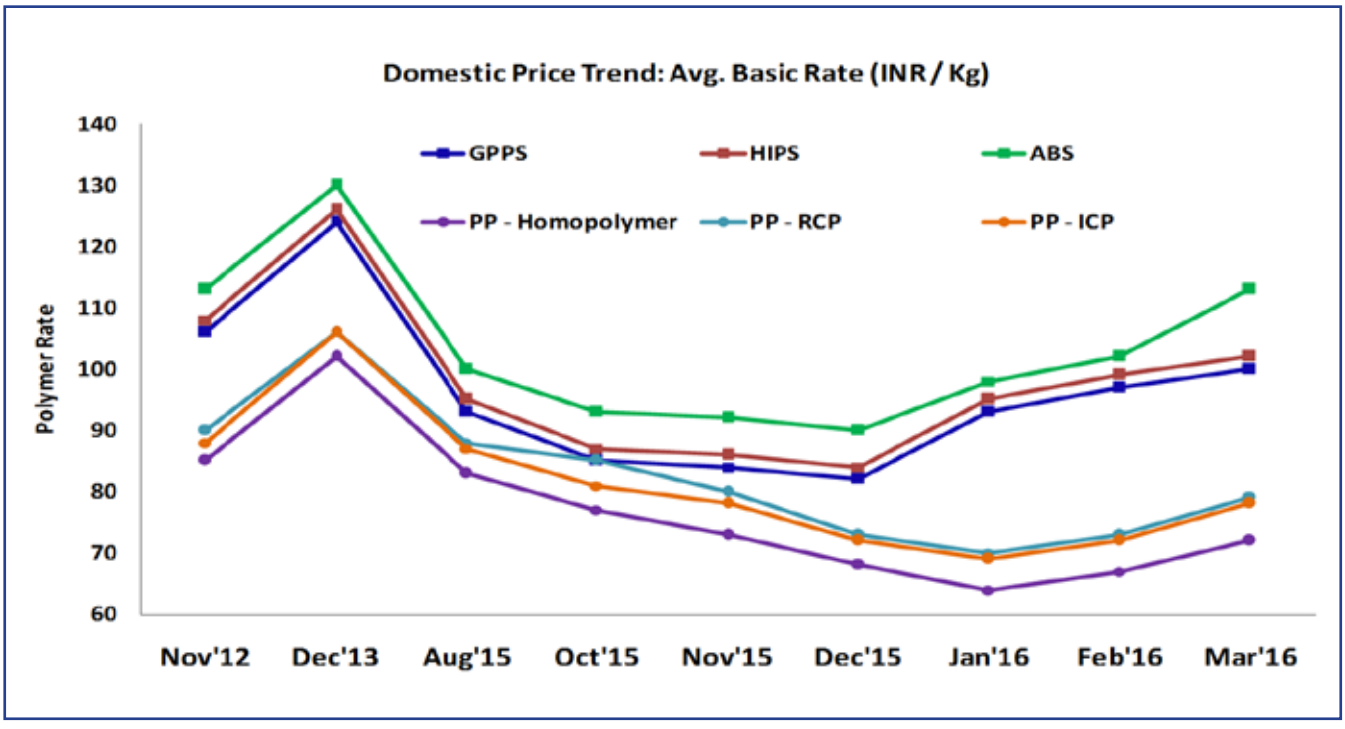
More than 15000 MT/ annum GPPS is consumed by OEM'S for refrigerator crisper tray applications.

Advantage of RCP-PP tray over GPPS tray

» ~18 % weight reduction with RCP-PP over GPPS due to lower density of PP.

» RCP-PP refrigerator single tray is ~11% cheaper than GPPS refrigerator tray because RCP-PP is cheaper material than GPPS.

Refer Fig: Domestic Price Trend.



» Lower in-transit breakages with RCP-PP. Around 5 % in-transit breakages observed with GPPS Crisper tray. GPPS is a brittle material whereas RCP-PP is having a balance of impact & stiffness properties.

» No extra mold cost with RCP-PP. As same mold can be used for making refrigerator vegetable tray.

Replacement of ABS/ HIPS with high melt strength PP grade for Refrigerator Liners:

At present, PP is not being used in deep draw thermoforming applications like refrigerator liners, etc. due to poor melt strength. ABS & HIPS are preferred material for deep draw thermoforming and currently being used in refrigerator liner applications.

Development of high melts strength polypropylene will probably open an opportunity for new applications like refrigerator lines.

Refrigerator liner is one of the major potential sector and annual consumption of polymer is this application is more than 25,000 MT.

Replacement of ABS with High Gloss & Scratch Resistance PP grade for Refrigerator door end caps:

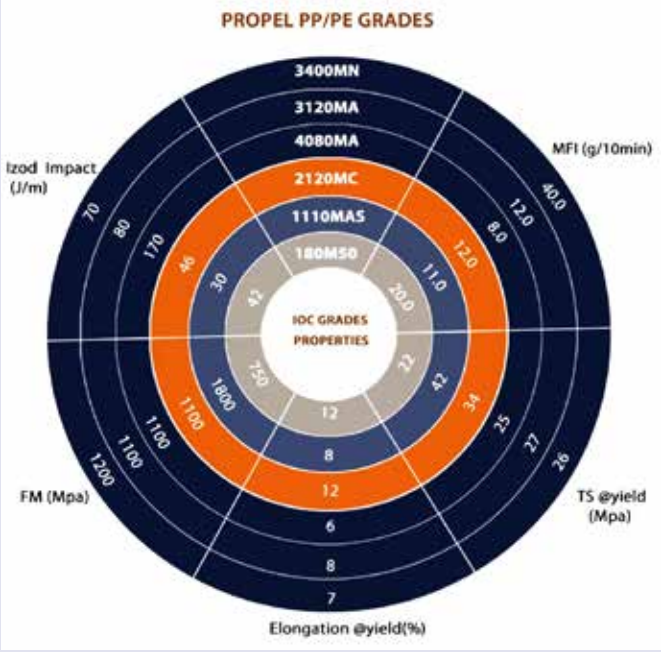
Refrigerator liner is one of the major potential sector and annual consumption of polymer is this application is more than 25,000 MT.

Changing price gap between Polyolefins and other polymers and further properties enhancement will likely push Polyolefin's in new application segments of white goods.

Refer Fig: Domestic Price Trend.

Indianoil's PROPEL Grades for White Goods:

Products	Parts	PP	HDPE
Refrigerator	Vegetable Tray	2120MC 3120MA	-
	Door tray separator / connector	1110MAS	
	Defrost Water Tray	3120MA	-
	Ice Tray	-	180M50
	Padestrial Tray	3120MA	-
Washing Machines (WM)	Top Control Panel	3120MA	-
	Tub	3400MN	-
	Washing Machine Base	3400MN	-
	Pulsater	3120MA 4080MA	-
	Spin Basket	3120MA	-
	Spin Safety Cover	2120MC	-



Washing machine parts made with PROPEL Grades

Top Control Panels: 3120MA

Washing Machine Tub : 3400MN

Washing M/c Pulsater : 3120MA

Spin Basket : 3120MA

Washing M/c Base: 3400MN

Spin Safety Cover: 2120MC

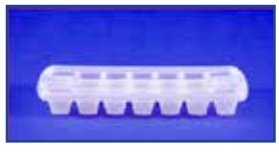
Refrigerator parts made with PROPEL Grades

Vegetable Tray: 2120MC

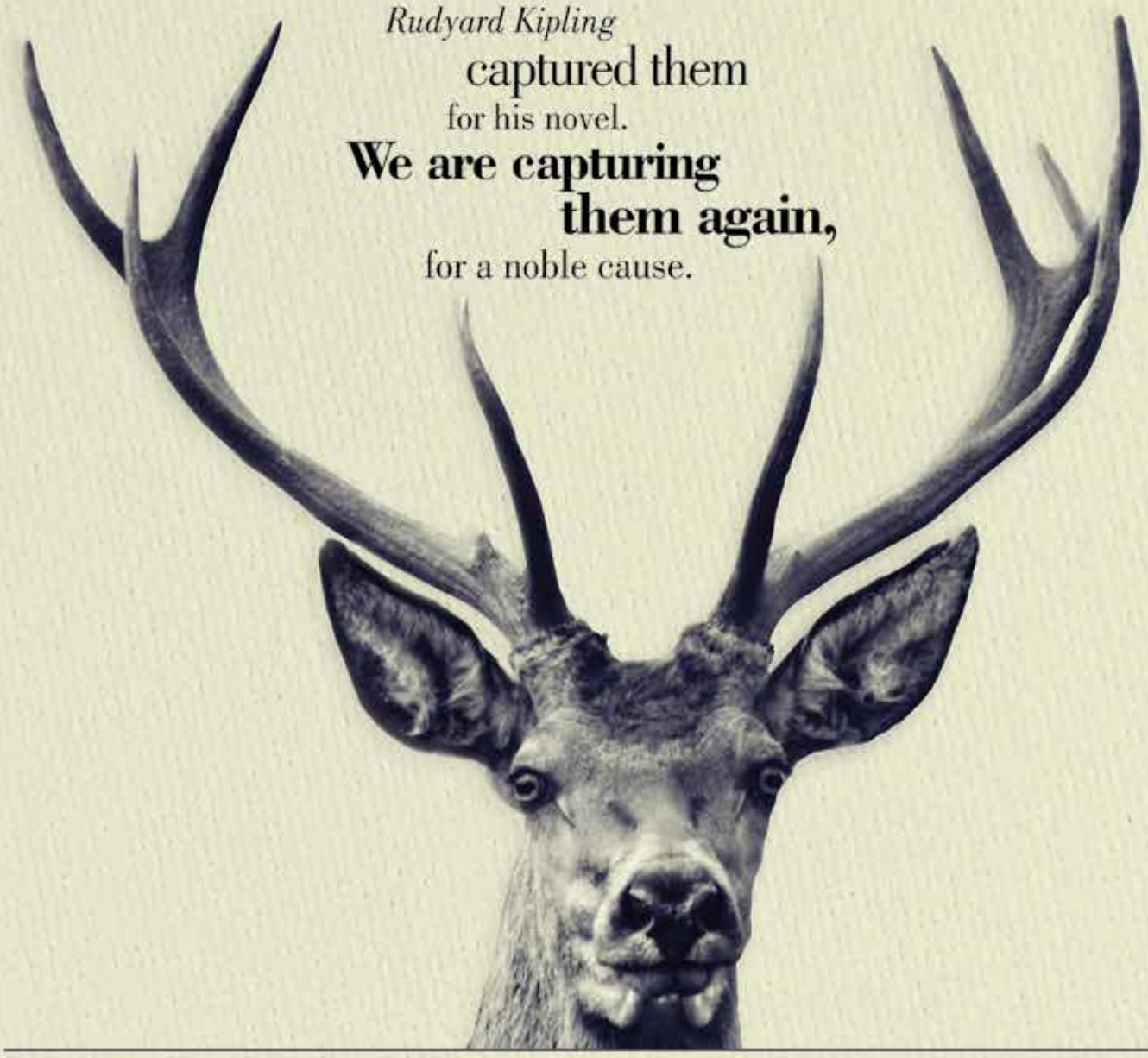
Defrost Water Tray: 3120MA

Padestrial Tray: 3120MA

Freezer Ice Tray: 180M50



Rudyard Kipling
captured them
for his novel.
We are capturing them again,
for a noble cause.



"ONGC Eastern Swamp Deer Conservation Project"

a CSR Initiative by ONGC to protect this rare species from the verge of extinction.

Eastern Swamp Deer or Barasingha (Rucervus duvaucelii ranjitsinhi), currently found in Assam is on the verge of being wiped away. This is truly sad for a wonder that once magnificently captured renowned author Rudyard Kipling's imagination in his novel "The Second Jungle Book".

ONGC stepped in to turn the tables on its possible extinction, and just at the right time.

The first phase involved carrying out baseline population estimates, study of habitat, veterinary intervention, genetic study and awareness campaign. Manas National Park was identified as the new site for its translocation - a separate viable location essential for conservation.

The translocation of 19 Swamp Deer from Kaziranga National Park to Manas was a big task. Its herculean nature drove the second phase as wildlife experts from South Africa, executed the process. By artificially creating their natural habitat inside Conical Booms, 19 Swamp Deer were then translocated. Soon the addition of 6 new fawns in the herd was a reason for celebrations.

The third phase is underway to translocate another 20 Swamp Deer to ensure the sustainability of the project.

For ONGC, it is the beginning of good things to come. Driven to preserve and save the endangered species from extinction, the entity is committed towards the true beauty of nature.

ओएनजीसी
ONGC

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Tel: 011-26752021, 26122148, Fax: 011-26129091. www.ongcindia.com /ONGC Limited @ONGC_

Workshop on 'Clean Fuels for Cooking & Transport: Social, Environment & Health Benefits'

Federation of Indian Petroleum Industry (FIPI) in association with the World Petroleum Council organised a workshop on "Clean Fuels for Cooking & Transport: Social, Environment & Health Benefits" in New Delhi on 27-28 April, 2017.Senior dignitaries from the Oil & Gas sector and several eminent personalities including Dr. Pierce Riemer, Director General, World Petroleum Council, Mr. Christ of van Agt, Senior Energy Analyst, International Energy Forum, Dr. Ajay Mathur, Director General, The Energy and Resource Institute (TERI), Mr. A.P. Sawhney, Additional Secretary, MoP&NG, Mr. Ashutosh Jindal, Joint Secretary (Mktg.), MoP&NG, Prof. Kirk R. Smith, Professor of Global Environmental Health, Director of the Global Health and Environment Programme, University of California, Berkeley, Mr. Sanjiv Singh, Director (Refineries), IOCL amongst other distinguished participants attended the workshop.

The workshop covered topics on cooking fuels including penetration of PNG in India along with improving the efficiency of supply chain in LPG distribution specifically in remote / rural regions. The impact on health, specially on rural women due to switchover to clean cooking fuels was a topic which was deliberated in detail during the workshop.

Apart from clean cooking fuels there was also a focus on clean and sustainable transport which needs to be developed in India. During the workshop the areas of discussion include use of LNG as a transport fuel and India leapfrogging from BS IV to BS VI type engines and its potential impact. During the workshop there was representation from auto manufacturers to deliberate on EV's, hybrid and hydrogen fuel cell vehicles which are considered as a future of mobility.


Workshop on
Clean Fuels for Cooking & Transport:
Social, Environment & Health Benefits
Federation of Indian Petroleum Industry (FIPI)
World Petroleum Council (WPC)


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Clean Fuels for Cooking & Transport:
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Organised by
Federation of Indian Petroleum Industry (FIPI)
in association with
World Petroleum Council (WPC)


FIPI

FIPI EVENTS

Workshop on 'Comparative Regulatory Frameworks to Increase Utilization of Natural Gas in India'

A workshop on the "Comparative Regulatory Frameworks to Increase Utilization of Natural Gas in India" was organized by Federation of Indian Petroleum Industry (FIPI) on 09th May, 2017 at New Delhi. The purpose of the workshop was to understand the experience of natural gas infrastructure development in Spain and Latin America. The workshop was also analysed in detail the barrier restricting higher use of natural gas in India.

The speakers from Gas Natural Fenosa (GNF) AneAriño Ochoa (Director Business Development), José MaríaSáez (Director of International Regulatory Affairs), Carlos Miravent Pi (Director International Business Development) and Mario García Gómez (Head of India Office) presented their experience in Latin America and Spain. Also their view on way forward for increasing use of gas in energy basket was shared.

During the session the specific models of evolution of gas regulation was discussed, wherein it has moved from local distribution to vertical integration and finally leading to a competitive market scenario. They also discussed how freedom ofentry and investment and the right to use infrastructure has helped in building a better transmission and distribution network. As per views of GNF, India needs to create a level playing field with LPG as consumer's decision on using a particular fuelshould not depend upon the amount of subsidy it is receiving. Also although auction continues, the tariffs to be implemented should be fixed by regulator based on market demand and competition with other fuels and focus should be more onproviding more connections to the customers in initial period of operation.

Shri A.P. Sawhney, Additional Secretary – MoP&NG addressed the workshop. He highlighted that with the number of new LNG terminals coming in, it will help in bringing more competition and the session has helped in bring new ideas which can be implemented in India. Dr. B. Mohanty from PNGRB gave concluding remarks of the session. He also shared that PNGRB is actively working on the issues to overcome bottlenecks raised during the session.

Mr. S. Rath, Director (E&P), FIPI welcoming the participants

Ane Ariño Ochoa Director (Business development Asia & North Africa), Gas Natural Fenosa

Shri A P Sawhney Additional Secretary, MoP&NG sharing his thoughts

A section of the participants

Seminar on "Gas based Economy & LNG"

A seminar on "Gas based Economy & LNG" was organized by Federation of Indian Petroleum Industry (FIPI) and "Energy Think Tank" on 19th May, 2017.

The seminar was focused to deliberate on the roadmap which India can follow in for next 10 years for growth of Natural Gas share in primary energy basket of India.

The eminent speakers of the session were both from industry and consulting background i.e. Mr. Prabhat Singh, (Managing Director & CEO, Petronet LNG Limited), Mr. Rajeev Khanna (Senior Advisor, Ernst and Young) and Mr. Rajeev Mathur (Managing Director, Mahanagar Gas Limited).

The session started with a welcome address by Dr. R. K. Malhotra, Director General, FIPI. Dr. C R Prasad, Convener, ETT gave his opening remarks and introduced speaker to the audience.

Mr. Prabhat Singh in his address, shared his view on global LNG market; how LNG market has changed its course froma closed club of major players to introduction of new small players. He mentioned that with the exploration of shale gas, the potential reserves are available for next 240 years. Hementioned that with new small players coming in the market there is a disruption towards conventional way of doing business. He shared the idea of saving average costs of transportation to the tune of USD 0.43 / MMBTU by mappingall sources / markets and if optimized. The idea of mapping LNG business with technology integration was his idea tobring in disruption in the conventional way of doing business so as to bring greater flexibility in global LNG market.

Mr. Rajeev Khanna in his presentation highlighted the industrial corridors which are under development which will be the potential regions for Natural Gas consumption. Hehighlighted the need of a comprehensive Gas Road Map witha proper plan on flow of capital required for infrastructure development and detailed national level project planning.

Mr. Rajeev Mathur in his presentation spoke about the potential scale of developing city gas distribution. He mentioned the extent of penetration PNG can have in smartcities which require planning at the City Master Plan stage. He also mentioned about development of green highway sand collaboration between automotive sector and gas industry to make such plans economically viable.

The session was followed by Q&A / Open House. Vote of thanks for the session was given by Mr. S Rath, Director (E&P), FIPI.

Dr. R. K. Malhotra Director General, FIPI welcoming the participants

Mr. Prabhat Singh Managing Director & CEO, Petronet LNG Limited giving his address on Global LNG Market

Seminar on Gas based economy & LNG

Participants in the seminar

Interactive Session with Mr. Bob Dudley, Group Chief Executive, BP p.l.c

Federation of Indian Petroleum Industry (FIPI) organized an interactive session with Mr. Bob Dudley, Group Chief Executive, BP p.l.c on June 15, 2017.

Several eminent personalities including Shri Dharmendra Pradhan, Hon'ble Minister for Petroleum & Natural Gas, Shri Piyush Goyal, Hon'ble Minister for Power, Coal, New & Renewable Energy & Mines; Shri Rajiv Pratap Rudy, Hon'ble Minister for Skill Development & Entrepreneurship; H.E. Sir Dominic Asquith, High Commissioner of the United Kingdom; Shri K. D. Tripathi, Secretary, MoP&NG; Shri Mukesh Ambani, CMD, Reliance Industries; senior officials from the Government of India, CEOs, CMDs, Managing Directors of various Oil & Gas companies in India, amongst other distinguished participants attended the session.

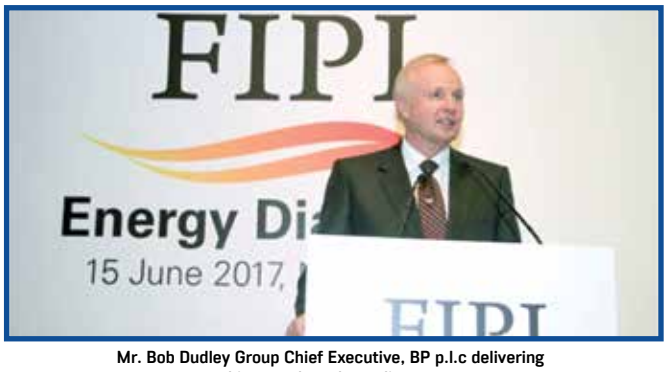
Dr. R. K. Malhotra, Director General, FIPI in his welcome address mentioned that a lot of debate has been going on about the future energy scenario due to disruptive technological development and emergence of alternatives particularly electric vehicle, batteries, hybrids & fuel cells, etc. He further stated that as per IEA & BP energy outlook, both Oil & Gas will continue to play a dominant role even by 2040 and petroleum fuels will continue to fuel the transport sector".

Shri D. K. Sarraf, Chairman FIPI & CMD ONGC in his opening remarks said, "We are happy to have amidst us Mr. Bob Dudley to share his wide experience and wisdom on the global energy landscape and the future of Oil & Gas business. I am sure with this session with Mr. Bob, we would get a platform where we will exchange ideas and benefit immensely in terms of our understanding of the energy transition".

Mr. Bob Dudley, Group Chief Executive, BP p.l.c, in his speech said, "We need to adapt digital technologies & make things simpler & standardised to grow. India is going to need all forms of energy. If you are large energy consumer, then low prices are good news. People of many parts of India are able to switch from firewood, kerosene to Natural Gas for cooking. Energy is the most important catalyst for achieving the sustained growth".

This was followed by a highly engaging and inspiring session, focusing on high level deliberations concurrent with the domain of energy.

Dr. R. K. Malhotra Director General, FIPI welcoming the guests and introducing the session.



Mr. Bob Dudley Group Chief Executive, BP p.l.c delivering his speech to the audience.

Shri Piyush Goyal, Hon'ble Minister for Power, Coal, New & Renewable Energy & Mines also attended the session.

Shri D. K. Sarraf Chairman, FIPI and CMD, ONGC addressing the guests

Several eminent personalities including Shri Dharmendra Pradhan, Hon'ble Minister for Petroleum & Natural Gas, Shri Rajiv Pratap Rudy, Hon'ble Minister for Skill Development & Entrepreneurship, H.E. Sir Dominic Asquith, High Commissioner of the UK, Shri K. D. Tripathi, Secretary, MoP&NG, Shri Mukesh Ambani, CMD Reliance Industries Limited, senior officials from the Govt. of India, CEOs, CMDs, Managing Directors of various Oil & Gas companies in India, amongst other distinguished participants attended the session.

Workshop on 'Cyber Attacks and Its Threats'

FIPI organized a half-day workshop on "Cyber Attacks and Its Threats" in association with Data Security Council of India (DSCI), A NASSCOM® Initiative on June 15, 2017 at New Delhi.

CEO of DSCI Ms. Rama Vedashree delivered her Introductory Address during the Inaugural Session at the workshop. She mentioned that due to increase in cyber-attacks, management should now consider security investments as a part of regular risk management and take all action to secure systems.

Mr. Abhimanyu Ghosh, Officer on Special Duty, Govt. of India, National Security Council Secretariat delivered his special address. He appreciated the efforts of FIPI and DSCI in generating awareness on the critical issues of cyber threats and providing a platform for exchange of experience and knowledge. He mentioned that Government is willing to look into any suggestion from industry in this respect.

The workshop witnessed enthusiastic participation from over 60 delegates with sessions encompassing Imperatives of Critical Infrastructure for National Cyber Security Preparedness; Effective defense-in-depth strategies for SCADA/ICS systems; Mitigating cyber-security risks in SCADA/ICS environment. The discussions centered on increasing risks associated with the cyber world and concluded upon the pressing need of finding a solution to cyber threats, besides suggesting various tools for the same.

The session was followed by Q&A. Vote of thanks for the session was given by Mr. N.K. Bansal, Director (Oil Refining & Marketing), FIPI.

Mr. N.K. Bansal Director (Oil Refining & Marketing), FIPI delivering the welcome address and opening remarks.

Ms. Rama Vedashree CEO, DSCI delivering the Introductory Address

Mr. Abhimanyu Ghosh Officer on Special Duty, Govt. of India, National Security Council Secretariat delivering special address.

Panel discussion on 'Mitigating overall cyber-security risks' moderated by Mr. Vinayak Godse, Senior Director, DSCI


A section of participants

India-UK Energy for growth partnership Business RoundTable on Oil & Gas

The Federation of Indian Petroleum Industry (FIPI) and Confederation of Indian Industry (CII) in partnership with the Ministry of Petroleum & Natural Gas, Government of India, and the Department for International Trade (DIT), British High Commission, New Delhi organised a Business RoundTable on Oil & Gas on 7 April 2017 at Hotel Taj Mahal, Mansingh Road, Delhi. This Round table was a part of the INDIA–UK Energy for Growth Partnership, being held from April 06-07, 2017 as part of the 'GREAT for Collaboration' programme of the Government of India and the Government of United Kingdom. The round table was attended by a Ministerial and Industry Delegation from UK led by the Rt Hon'ble Greg Clark, Secretary of State for Business, Energy and Industrial Strategy, Government of UK, and senior Indian Government and Industry members.

Dr. R. K. Malhotra, Director General, FIPI delivering the welcome address


Mr S. Rath, Director (E&P), FIPI making comments on Deepwater Drilling

Global Natural Resources Conclave

FIPI associated as Industry Partners for first 'Global Natural Resources Conclave' organised by Network18 & CII on the 5th & 6th of April, 2017 at Taj Palace, New Delhi. The aim was to create awareness and to spell out the ground realities, in terms of issues and opportunities and drawing the natural resources dividend. The Conclave attracted global participation and witnessed proactive collaboration from industry leaders in the natural resources space spanning all sub-sectors, i.e. Oil & Natural Gas, Mining & Minerals, Power, Metals - Aluminium, Copper and Zinc, etc.

Shri Dharmendra Pradhan, Minister of Petroleum & Natural Gas addressing the Global Natural Resources Conclave

Col. Rajyavardhan Singh Rathore, Minister of State for Information and Broadcasting addressing the Global Natural Resources Conclave

A section of participants on Global Natural Resources Conclave

Five days training programme on 'Business Analytics' with Great Lakes Institute of Management, Gurgaon

A five days training programme on Business Analytics especially to Oil & Gas industry was organized on April 10-14, 2017 with the assistance from Great Lakes Institute Management, Gurgaon. The programme received an over whelming response. 35 officers from Oil & Gas industry participated in the programme.

The objective of the programme was to familiarize the participants about the significance and use of Business Analytics in the management and decision making. The practicing executives of Oil & Gas industry were exposed to applications of tools along with case studies from the industry.

Industry Academia Interface on 'A-Z of Oil'

Federation of Indian Petroleum Industry organized Industry-Academia Interface Programme on 'A-Z of Crude Oil' in association with IndianOil Institute of Petroleum Management (IIPM), from May 1 – 2, 2017 at Gurgaon.
The objective of organizing this Industry – Academia Workshop is to have a two-way interaction between practicing managers and the learned faculty of academic institutions on Oil & Gas Industry to enrich knowledge on both the sides.

The programme was conducted by experts from the industry and designed for the teaching faculty of Engineering Colleges, Universities and Industry members. Participants from various educational Institutes, attended the programme. Presentations were made by the faculty drawn from Oil & Gas sector on all the aspects of crude oil including exploration and production, logistics, refining, etc. For the first time, a slot was kept for participants to present their work in their respective institute. Dr. Sunil Kumar from IIP, Dehradun presented his work on Energy Optimization in Crude Distillation Unit.

Group photograph

Gas Roadmap Workshop

FIPI with support of industry members and in association with KPMG is carrying out a study on "Gas Roadmap of India – 2030". In this regard first workshop on Developing Natural Gas Vision – 2030 was organized on 22 June, 2017. The workshop was attended by around 32 members from 20 different organizations.

It is a known fact that no vision can be drafted without the inputs from the key stakeholders who represent a cross section of an industry. Realizing the importance of the viewpoint of the stakeholders, the session was conducted through an interactive group discussion. The methodology that was adopted for the session include formation of groups under different categories, develop a vision in consultation with the group members and lastly key 'Asks' to achieve the defined vision.

From the exercise the top issues will emerge, which will form the basis of the further study towards developing a comprehensive natural gas Roadmap for India.

News From Members

Honeywell expands production of natural gas solutions at Russian Plant

Honeywell Process Solutions (HPS) announced that it will expand the manufacture of Oil & Natural Gas solutions for the Russian sector at its Arzamas plant. This will include gas measurement equipment and gas regulators for medium and high-pressure applications.

The expansion will include new production lines, equipment and training at the company's existing plant in the Nizhny Novgorod region of Russia. The plant is part of Honeywell's Elster® Gazelektronika business. "These Oil & Gas solutions are very important to the growing sector in Russia," said Alexei Zenkevich, HPS business leader for Russia, Belarus and Armenia. "This is the right time to expand our range of solutions to better serve local customers with high-quality products tailored to their requirements. This also aligns to the current priority of the Russian government creating opportunities for industrial growth."

21st Refinery Technology Meet at Vaisakhapatnam Inaugurated by Hon'ble Minister of State – (I/C), P&NG

Refinery Technology Meet (RTM), one of the most prominent technical conferences pertaining to refining sector in the country, is being periodically organized by Centre for High Technology (CHT) under the aegis of MOP&NG and attended by luminaries from Oil industry. The first RTM was held 30 years ago and so far 20 RTMs have been organized in association with Indian Oil Companies on various themes, relevant to Oil Industry.

CHT organised 21st RTM in association with HPCL at Visakhapatnam during 20-22 April, 2017. The theme of the Meet was 'Refining to Petrochemicals – The Way Ahead'

The meet spans over three days engaging key stakeholders from downstream petroleum sector for deliberation of latest trends in refining technologies across the Globe.

21st RTM of this year dealt with various aspects of Global Energy scenario, Refining and Petrochemicals integration, Process optimization & Upgradation, Value Added Products, Innovative solutions to create and add value from the existing assets, improve process and energy efficiency, Yield

Optimization, Process integration and intensification, Loss Control, Reliability Management, minimizing Environmental impact etc. Eminent speakers & experts in their respective fields delivered lectures and made technical presentations during the RTM.

Speaking on the occasion, Hon'ble Minister emphasized the need for innovation in the Refining sector, greater emphasis on Research & Development, increased need for Environment Protection and Reduction in emissions. He specifically mentioned that the state of art HP Green R&D Centre at Bengaluru which he had inaugurated last year, is truly a world class R&D Centre.

He gave away Prizes in various categories in Refinery and R&D field. He lauded the efforts of CHT, HPCL and all other Oil Companies for successfully organizing the 21st RTM.

Mega Driver Training Workshop

A mega driving training workshop was conducted by the PCRA and oil PSUs, under the aegis of the Ministry of Petroleum & Natural Gas, to sensitise the masses about the importance and advantages of fuel conservation and its effective utilization.

HPCL organised the event in Visakhapatnam on behalf of the industry. Hon'ble Minister of State (I./C) for Petroleum & Natural Gas inaugurated the event on April 20, 2017.

The workshop covered topics on petroleum conservation, safety and cashless transactions. A health camp was also conducted for the drivers in association with Care Hospital. A one-time educational grant of Rs. 5,000 each was given to children of drivers, who passed Class 10 and best drivers were given gift cards of Rs. 5,000 each.

SCOPE Meritorious Award

HPCL has been conferred with two prestigious "SCOPE Meritorious Award 2014-15" for Best Women Empowerment Company and Environmental Excellence & Sustainable Development. Hon'ble President of India, Shri Pranab Mukherjee presented the Awards to C&MD - HPCL, Shri M. K. Surana on the occasion of 8th Public Sector Day Celebrations jointly organized by Standing Conference of Public Enterprises (SCOPE) and Department of Public Enterprises (DPE) at Vigyan Bhawan, New Delhi.

OIL made two Hydrocarbon Discoveries

Oil India Limited (OIL), through its exploratory efforts has made 2(two) Hydrocarbon Discoveries in the Moran Petroleum Mining Lease (PML) in the Upper Assam Basin in the month of April 2017 in the wells Borbhuibil-1and Lakwagaon-1. The well Borbhuibil-1 encountered multiple sands in Barail and Lakadong+Therria formations. On testing, a 15m Barail sand at a depth of 3322m produced oil at the rate of 28 m^3/d. A 10m Lakadong+Therria sand at a depth of 4300m produced oil at the rate of 100 m3/d. The feasibility of bringing the discovery on production at the earliest is under study.

In the well Lakwagaon-1, discovery of a gross column of 30m oil sand in Barail formation has been made which produced 42 m^3/d of oil on initial testing. The well is currently on production. The discoveries have opened up avenue for further exploration of already identified leads / prospects in the area.

OIL Bags Golden Peacock National Training Award & Golden Globe Tigers Award 2017

Oil India Limited (OIL) has recently bagged the Golden Peacock National Training Award 2017 and Golden Globe Tigers Award 2017 for industry excellence in Training. While the Golden Globe Tigers Award was conferred to OIL for Learning & Development (L&D) Department's initiative under "Best Development Programme in Public Sector for Workers" (Excellence in Training and Development), the Golden Peacock National Training Award 2017 was given for OIL's efforts in the field of innovative Leaning & Development

The Golden Peacock National Training Award 2017 was given away during India's Dubai Global Convention 2017 in Dubai by His Highness Sheikh Nahyan bin Mubarak Al Nahyan, Cabinet Member and Minister of Culture and Knowledge Development, Govt. of UAE, among others dignitaries, to Shri B P Sarma, RCE, OIL and Shri R K Talukdar, GM (L&D), OIL and Lt. Gen. J. S. Ahluwalia, PVSM (Retd.), President, Institute of Directors, India.

The Golden Globe Tigers Award was given to OIL at Golden Globe Tigers Awards Night 2017 organised at Pullman City Centre Hotel and Residences, Kuala Lumpur, Malaysia. OIL won from among 214 applicants, including SMEs, public, private, government enterprises and NGOs for the year 2017.

OIL India International Pte. Ltd. Completes US$ 500 million bond issuance

Oil India International Pte. Ltd., a Singapore based wholly owned subsidiary of Oil India Limited (OIL), has successfully completed US$ 500 million Reg S bond offering on 11 April 2017. The US$ 500 million Reg S Senior unsecured 10-year notes are guaranteed by Oil India Limited which is one of the leading Indian Oil & Gas 'Navratna' CPSE engaged in the exploration, development, production and transportation of crude oil and natural gas. OIL is the second largest public sector exploration and production company with government of India being the majority shareholder with current shareholding of 66.60%.

The bonds are rated 'BAA2' by Moody's and 'BBB-'by Fitch. The US$ 500 million bond issue marks second successful foray of Oil India Group in USD Reg S markets and represents the lowest spread achieved by any Indian issuer for a 10 year USD transaction in last decade. The US$ denominated 10-year bonds were priced at a spread of 172.5 bps over the 10-year US treasury and will bear fixed interest coupon of 4% per annum. The bonds will mature on 21 April 2027. The credit spread of current issuance is 100 BPS tighter than OIL'S maiden US$ 500 million 10 year bonds issued in 2014.

IndianOil Refineries create new performance benchmarks during 2016-17"

IndianOil refineries recorded an all time high performance on all critical parameters for the fiscal year 2016-17. The nine refineries of IndianOil have also successfully fulfilled the commitment of rolling-out BS-IV grade auto fuels across the country on April 1, 2017. This has reaffirmed the confidence of the industry and the stakeholders in the capabilities of We have now set sights on accomplishing the vital, though challenging, goal of supplying BS-VI quality auto fuels across the country, by April 1, 2020. Achieving such a quantum jump across two fuel quality grades, in a short span of three years has never been attempted worldwide. I am confident that IOCians will rise to the challenge and accomplish all the targets to ensure IndianOil's leadership position". Mr. Sanjiv Singh, Director (Refineries) shared this while addressing IOCians to mark the beginning of the new fiscal year.

Another landmark achievement in Refining Technology by IndianOil R&D in the 'Year of Innovation & Technology'

In the quest to bring technological innovation to enhance the profitability, the Refining Technology discipline of IndianOil R&D has achieved another landmark by demonstrating the performance guarantee parameters for an indigenous technology implemented for the first time.

Following commissioning of the revamped Coker-A unit at Barauni Refinery in January 2017, Performance Guarantee Test Run (PGTR) was successfully completed in March 2017 meeting all the minimum as well as performance guarantee parameters. Significant benefits like reduction in coke yield by about 4 wt% and corresponding increase in distillate yield were obtained without compromising the quality of Anode grade coke. Apart from yield benefits, savings in energy by about 35% was also realized primarily due to reduction in recycle and single furnace operation.

Team R&D had carried out extensive pilot scale studies to provide an innovative solution for improving the performance of Coker-A unit at Barauni Refinery by way of reducing the coke yield while ensuring the production of Anode grade coke. This paved the way to implementation of IndianOil-EIL Delayed Coker technology in the revamp of 600 TMTPA capacity Coker-A unit, making it first of its kinds in India.

MoU Signed with Petrobangla for Cooperation in the area of R-LNG

Driving impetus to the relationship between India and Bangladesh, MOUs were signed in the field of Power, Oil & Gas, IT, Security, Defence, Mass Media etc during the recent visit of H.E. Sheikh Hasina Hon'ble Prime Minister of Bangladesh.

An MoU was also signed between Indian Oil Corporation Limited and Bangladesh Oil, Gas & Mineral Corporation (Petrobangla), Bangladesh for mutual cooperation in the area of supply of Re-gasified Liquefied Natural Gas (R-LNG) and Development of Pipeline Infrastructure.

The MoU was exchanged by Mr. B. Ashok, Chairman IndianOil with Mr. Abul Mansur Md. Faizullah, Chairman, Petrobangla in the ceremony organised at Hotel Taj Palace, New Delhi on 10 April 2017. The MOU was exchanged in the presence of H.E. Sheikh Hasina, Hon'ble Prime Minister of Bangladesh and Mr. Dharmendra Pradhan, Hon'ble Minister of State - Independent Charge, Ministry of Petroleum & Natural Gas.

The objective of MoU is to formalize a non-binding framework of co-operation to facilitate activities that can contribute to mutual benefits of IndianOil and Petrobangla in the field of R-LNG

Sri Lanka Oil Sector Delegation Visits PRPC

With a view to strengthen strategically important ties between India and Sri Lanka in Hydrocarbon sector, a delegation comprising of 30 members from Sri Lanka Oil Sector visited Panipat Refinery & Petrochemical Complex (PRPC) on 20th April, 2017. A warm welcome was accorded to the delegation headed by Mr. Ariyawansa Hewage Sarath Wijesinghe, Additional Secretary, Ministry of Petroleum, Government of Sri Lanka by Shawl and Flowers' bouquet by Mr. V.K. Raizada, Executive Director (T).

While addressing the delegates, Mr. V.K. Raizada touched upon the rich historical culture of both the countries. He emphasised on working to further enhance and strengthen the cultural and commercial ties between both the countries as India and Sri Lanka are member nations of several regional and multilateral organisations such as SAARC. He also shared the robust physical and financial performance of PRPC complex to the delegation.

Delegates of International Refining and Petrochemical Conference (IRPC)-2017 Visits PRPC

In order to acknowledge and strengthen the capabilities on the emerging opportunities and challenges in downstream industry world over, Gulf Publishing Company and Hydrocarbon Processing has organized International Refinery & Petrochemical Conference -2017. This conference was supported by Indian Oil and Federation of Indian Petroleum Industry (FIPI) and was held on 18 -19 April, 2017 at the Taj Palace Hotel in New Delhi, India.

To give further impetus on learning best practices and the latest advancements in the hydrocarbon sector, the delegates from various countries like USA, UK, Germany, Italy, Netherlands and Iran headed by Ms. Melissa Smith, Event Director, Gulf Publishing Company (GPC) visited Panipat Refinery & Petrochemical Complex (PRPC) on 20th April, 2017 at the Community Centre of PRPC Township. They were warmly greeted by Mr. V.K. Raizada,

Union Minister and MoS for Heavy Industries and Public Enterprises of India inaugurates IndianOil stall at CSR Fair at New Delhi

Hon'ble Union Minister and MoS for Heavy Industries and Public Enterprises of India, Mr. Anant Geete and Mr. Babul Supriyo inaugurated the IndianOil stall at the ongoing CSR Fair at New Delhi, today in the presence of Mr. A. K. Sharma, Director (Finance), IndianOil, Mr. Verghese Cherian, Director (HR), IndianOil, Mr. S. Mukherjee, ED (I/c) HR & CSR, CO, Mr. Subimal Mondal, ED (HR& CSR), CO, Mr. Harsh Sachdev, ED (RS), NRO, Mr. Mr. Kalikrishna M, GM (CC), CO and other officials from IndianOil. The Fair is being organised by PHD Chambers under the aegis of Department of Public Enterprises from 4-6 May, 2017 at Pragati Maidan, New Delhi.

Going around the IndianOil stall, Mr. Geete and Mr. Supriyo appreciated the visually appealing panels communicating various CSR initiatives undertaken by IndianOil across the nation. IndianOil stall has actual beneficiaries of IndianOil CSR projects as the Corporation's brand ambassadors. Mr. Geete was impressed by the specially abled bag maker from Guwahati, trained under IndianOil CSR, who is showcasing handmade bags and mats made out of Water Hyacinth. The Hon'ble Union Minister had a word of praise for the IndianOil team and stall as he wrote "Excellent!", in the visitors' book. He also appreciated the presence of nurses from Assam Oil School of Nursing and Assam Oil College of Nursing who are conducting BP and Hemoglobin tests of the visitors at the stall.

IOC, BPC and HPC sign joint venture agreement for West Coast Refinery Project

India's emergence as a global refining hub received a big boost with the three downstream PSU oil majors, Indian Oil Corporation, Bharat Petroleum Corporation and Hindustan Petroleum Corporation, joining hands to build one of the world's largest integrated Refinery-cum-Petrochemicals complexes in Ratnagiri district of Maharashtra. The joint venture agreement for the West Coast Refinery Project was signed by Mr. Sanjiv Singh, Chairman, IndianOil; Mr. D Rajkumar, CMD, Bharat Petroleum; and Mr. MK Surana, Chairman, Hindustan Petroleum in the presence of Mr. Dharmendra Pradhan, Minister of State (Independent Charge), Petroleum & Natural Gas; and Mr. K.D. Tripathi, Secretary, Petroleum.

The 60 million metric tonnes per annum (MMTPA) west coast refinery-cum-petrochemicals complex will be a state-of-the-art unit built at an estimated cost of US$ 40 Billion, and is expected to be commissioned by the year 2022.

It will be a green refinery comprising 50 units designed to operate at the highest level of efficiency, and will be self-sufficient in power and utilities requirements, besides creating a benchmark in environment management.

HURL website launched

Hindustan Urvarak & Rasayan Ltd. (HURL) has been incorporated as a joint venture company of three Maharatna companies, namely IndianOil, Coal India Ltd. and NTPC, together with FCIL & HFCL, for revival of the fertiliser plants located at Gorakhpur (Uttar Pradesh), Sindri (Jharkhand) & Barauni (Bihar). Mr. Sanjiv Singh, Chairman, IndianOil, and Chairman, HURL,launching the website of HURL at IndianOil's Corporate Office at New Delhi in the presence of Mr. Arun Gupta, MD, HURL, and other HURL directors, namely, Mr. AN Jha, Mr. KP Gupta and others. All the three projects are being implemented on a fast-track mode and are scheduled to commence commercial production of urea by the end of 2020. The URL of the website is http://www.hurl.net.in/

Oil & Gas in Media

Minister of Petroleum & Natural Gas, Shri Dharmendra Pradhan co-chairs India OPEC Institutional Dialogue at Vienna

The Minister of State (I/C) for Petroleum and Natural Gas, Shri Dharmendra Pradhan visited Vienna, Austria to co-chair the 2nd India-OPEC Institutional Dialogue at the OPEC headquarters. The meeting took place two days prior to the OPEC Ministerial meeting that is scheduled from 25th May.

Shri Pradhan held a one-to-one meeting with the Secretary General of OPEC Mr. Mohammad Sanusi Barkindo. Later he discussed bilateral issues of interest at a delegation level dialogue. Shri Pradhan highlighted the importance of India – OPEC engagement and discussed on the effects of the production cut of 1.8 mbpd by OPEC and non-OPEC countries on the global oil market volatility. The Minister said that India had been and continued to be a reliable customer of OPEC countries, the only big economy where the demand for crude oil continues to rise each year. About 86% if India's import of crude oil, 70% of natural gas, 95% of LPG are from OPEC countries. Shri Pradhan also informed about the increasing refining capacity of India and future expansion plans. He also briefed OPEC about the expanding petrochemical sector in India.

In this context, Shri Pradhan underlined the importance of market and reiterated the need to intensify bilateral dialogue to change the nature of engagement from a buyer-seller relationship to an Energy Partnership. He added that in today's oversupplied market, it was important for producers to understand the perspective of consumers and the demand centers and the changes that have taken place in these demand centres. He stressed on the fact that while the security of supplies was important for consuming countries, the security of demand was equally important for producers. In this context, he emphasised the importance of a purposeful and improved dialogue among producer and consumer countries, particularly benefitting India as a fast growing market.

Shri Dharmendra Pradhan, Minister of Petroleum & Natural Gas launches BS-IV grade fuels nationwide

Minister of State (I/C) for Petroleum and Natural Gas, Shri Dharmendra Pradhan formally launched BS-IV grade transportation fuels across the country from Bhubaneswar. The event coincided with Utkal Divas (formation day of the State) being celebrated in Odisha.

To mark the historic occasion of the launch of BS-IV fuels across the country, the Hon'ble Minister symbolically commenced sale of the eco-friendly and low-emission fuels from 12 different locations across the country through live video links - Varanasi, Vijayawada, Durgapur, Gorakhpur, Imphal, Bhopal, Ranchi, Madurai, Nagpur, Patna, Guwahati and Shillong.

At the event, the Petroleum Minister also handed over a deposit-free domestic LPG connection under the Pradhan Mantri Ujjwala Yojana (PMUY) scheme to Swalia Bibi of Shikharchan Basti in Bhubaneswar to mark the completion of release of 2 crore LPG connections to women beneficiaries from below poverty line (BPL) households across the country under the Pradhan Mantri Ujjwala Yojana (PMUY).

The Minister reiterated the Ministry's commitment to holistic vision of Hon'ble Prime Minister, Shri Narendra Modi. He said that with the launch of the BS IV Fuel, a new era of clean transportation fuels has begun. This era will benefit all citizens of our country by substantially reducing pollution levels everywhere.

Shri Pradhan said that from today India will have "Only BS-IV" fuels. He complimented the OMCs for working in unison to set up refining infrastructure and logistics in record time for the launch of BS-IV grade fuels across the country as per schedule. The OMCs are incurring an expenditure of Rs. 90,000 crore on phase-wise upgradation of fuel quality in the country.

Minister of Petroleum & Natural Gas, Shri Dharmendra Pradhan addressed the media on the Pradhan Mantri Ujjwala Yojana (PMUY)

Minister of State (I/C) for Petroleum and Natural Gas, Shri Dharmendra Pradhan addressed the media on the Pradhan Mantri Ujjwala Yojana (PMUY), a flagship scheme of the Ministry of Petroleum and Natural Gas.

Shri Pradhan said that the PMUY has surpassed the targets for the financial year 2016-17 in terms of installing new connections. Over 2.20 Crore connections have been given in the first year of its launch scheme to BPL families as per the SECC 2011 data. This has surpassed the target of 1.5 Crore connections for the financial year. PMUY was launched on 1st May, 2016 at Ballia, Uttar Pradesh by Hon'ble Prime Minister, Shri Narendra Modi.

In the financial year 2016-17, Oil Marketing Companies have given 3.25 Crore new connections across the country. This is the highest ever LPG connections released in any given year. Today the total number of active LPG consumer has crossed 20 Crore. This has been a quantum jump from 14 Crore in the year 2014 he said.

Shri Pradhan said that the LPG demand in the country has registered a growth rate of more than 10%. More than 4,600 new distributors have been added in the last 3 years which have come up primarily in rural areas.

Speaking on the key features of implementation of PMUY, Shri Pradhan said that 85% of the new consumers have come back for a refill. About 38% of the beneficiaries in PMUY are from SC/ST category. He added that PMUY has been implemented in a participatory mode involving beneficiaries, elected representatives, distinguished personalities, local administration etc. A differential communication strategy to popularize the scheme as well as educating beneficiaries on safety norms through regional languages was carried out. There is a 360-degree engagement and also monitoring of the implementation of the scheme. Shri Pradhan said PMUY has become a social movement with the beneficiaries coming forward in large number to apply and get the cylinders installed.

Workshop on impact of GST on the Oil & Gas Sector

Minister of State (I/C) for Petroleum and Natural Gas, Shri Dharmendra Pradhan reviewed the impact of GST on the Oil & Gas Sector. A workshop was organized by the Ministry after various public and private sector stakeholders from upstream, downstream and midstream segment raised several concerns on the likely impact of GST on the Oil & Gas Industry. Secretary for Petroleum and Natural Gas, Shri K. D. Tripathi was also present during the review.

While welcoming GST as a progressive form of taxation, the Industry representatives referred to several provisions in the GST which could have adverse impact on upstream, midstream and downstream sectors. Several petroleum products namely Crude Oil, Petrol, Diesel, ATF and Natural Gas have been kept out of the GST. It was brought to the notice of the Ministry by the Industry representatives during the workshop, that, this exclusion will result in huge stranded taxes in the hands of oil industry due to non-availability of Input Tax Credit towards non-GST products.

The Industry representatives highlighted that GST in its present form needs few amendments and clarifications as it may have negative impact on the Domestic Oil & Gas production, manufacturing, capital investment, pipeline expansion plans etc. It was also brought to the notice of the Ministry that exclusion of pipeline network from the definition of Plant & Machinery may adversely affect long term capital investment in the pipeline infrastructure projects. A suggestion was made that Green fuels like Natural Gas, CNG, Bio-Diesel and Ethanol Blended Petrol should be zero rated to promote environment friendly fuels.

The Petroleum Minister, Shri Dharmendra Pradhan noted the concerns raised by the Industry and assured them to convey this to Hon'ble Finance Minister for agreeable resolution of the issues involved. Minister also asked the representatives of the industry to raise their concerns with respective state governments particularly oil and gas producing states to agree to make changes in those provisions pertaining to Oil & Gas Sector which may affect the new investments and employment generation.

Cabinet approves signing of Framework of Understanding between India and Bangladesh on Cooperation in the Hydrocarbon Sector

The Union Cabinet chaired by the Prime Minister Shri Narendra Modi has approved signing of Framework of Understanding (FoU) on Cooperation in the Hydrocarbon Sector with Bangladesh. The objective of the proposed FoU is to establish a cooperative institutional framework mechanism to facilitate and enhance India-Bangladesh bilateral cooperation in the hydrocarbon sector on the basis of equality and mutual benefit.

The FoU promotes bilateral cooperation at the sub-regional and regional levels. It will provide impetus to development and enable the two countries to realize their developmental aspirations, shared destiny and common vision of a peaceful and prosperous South Asia.

The proposed FoU is non-binding in nature and will be valid for five years.

Shri Dharmendra Pradhan, Minister of Petroleum & Natural Gas meets visiting PM of Mauritius Mr. Pravind Kumar Jugnauth

The Minister of State (I/C) for Petroleum and Natural Gas, Shri Dharmendra Pradhan met H.E. Prime Minister Mr. Pravind Kumar Jugnauth of Mauritius who was on a two day visit to India for bilateral meeting. It was the first overseas visit of Prime Minister Jagnauth to India following his taking over the office as PM of Mauritius in January 2017. During his meeting, Shri Pradhan discussed the strong and ongoing engagement with Mauritius in the Hydrocarbon sector. Since 2006, Mangalore Refineries and Petrochemicals Ltd. (MRPL), India's PSU refinery, has been supplying petroleum products to Mauritius. Both countries are presently working towards further deepening the engagement in the Oil & Gas sector. Both also discussed on the bunkering and oil jetty projects that are being jointly taken up by MRPL, Indian Oil Corporation along with State Trading Corporation of Mauritius (STCM). Both discussed on cooperation in the Natural Gas sector in Mauritius. In this regard, they decided that a delegation from Petronet LNG Ltd (PLL) will visit Mauritius at the earliest to have detailed discussion with authorities and stake holders in Mauritius.

New Appointments

Shri Sanjiv Singh takes over as Chairman of IndianOil

Shri Sanjiv Singh has taken over as Chairman of Indian Oil Corporation (IndianOil) with effect from 1st June, 2017. Prior to his elevation, he was Director (Refineries) on the IndianOil Board since July 2014. Concurrently, he will also be Chairman of Chennai Petroleum Corporation Ltd. (CPCL) and Hindustan Urvarak and Rasayan Ltd. (HURL), a joint venture company set up to revive the fertiliser plants at Gorakhpur, Sindri and Barauni. A chemical engineer from IIT-Roorkee with a Diploma in Management, Mr. Sanjiv Singh joined IndianOil in 1981. He has served IndianOil for over 35 years, spearheading refinery operations as well as mega greenfield and brownfield projects in refining and petrochemicals.

Dr. P. Chandrasekaran, takes over as Director (Exploration and Development), OIL

Dr. P.Chandrasekaran has taken over as Director (Exploration and Development) of Oil India Limited (OIL), India's second largest National Exploration & Production Company, on 1st April 2017.A post-graduate in Geology from Madras Presidency College, he is also accredited with a Ph.D from the premier institute IIT Roorkeeon the subject "Petroleum Prospect and Risk Evaluation". Dr. Chandrasekaran started his career with ONGC at Mumbai as an Operations Geologist in 1984. In his rich and illustrious career spanning over three decades DrChandrasekaranwas closely associated with discoveries like Pasarlapudi, Mandapeta, Lingala, and Ravva. Also, at Assam & Assam Arakan Basin, he was involved in managing all NELP Blocks of the Basin.

Shri Gajendra Singh, Director (Marketing), GAIL (India) Ltd.

Shri Gajendra Singh, Director (Marketing) is M.Sc. (Electronics). He started his career in processing and interpreting of seismic data in upstream Industry, and possesses 32 years of illustrious career in hydrocarbon sector. Shri Singh has been involved in the execution of several prestigious projects of GAIL starting from the HVJ and has held various leadership and strategic positions. Some of these key roles where he has served as the Head of Department include General Manager (Gas Sourcing and Gas Marketing), Executive Director (Operations & Maintenance).Prior to his appointment as Director (Marketing), Shri Gajendra Singh served as Executive Director (Marketing), he has been responsible to fulfil GAIL's vision to source and market natural gas from international and domestic sources; to facilitate capacity utilization of pipeline infrastructure, investment in new pipelines etc. He has been managing company`s top line and bottom line through various Zonal offices located across India. He joined GAIL in Year 1986, having worked in ONGC in 1985.

Shri JC Nakra has assumed charge as Director (Projects) of Engineers India Ltd. (EIL)

In a career spanning about 36 years,Nakra has worked in a wide array of domains including Projects, Construction & Marketing. He joined EIL in 1983 as a Mechanical Engineer (Construction) in the Ocean Engineering Division. Subsequently, he served in various capacities in Marketing and Project Divisions. Nakra has steered the marketing initiatives of EIL for business development in India and abroad and has also led project management teams for implementation of major projects. Prior to joining EIL, he worked as a mechanical engineer in Jagat Jit Cotton Textile Mills (JCT), Fibre Division, Hoshiarpur from 1981 to 1983. Nakra is a Mechanical Engineering Graduate from Punjab Engineering College, Chandigarh (1981 Batch) and also possesses a Post-Graduate Diploma in Management Studies from Jamnalal Bajaj Institute of Management Studies, Mumbai. Prior to this, he was holding the position of Executive Director - In-charge (Projects) in EIL.

Shri K.Sivakumar appointed as Director (Finance), Bharat Petroleum Corporation Ltd.

Shri K. Sivakumar is a qualified Chartered Accountant, Cost Accountant & Company Secretary. He joined Bharat Petroleum in 1987 and has worked in various facets of Finance, Internal Audit, ERP etc. He was part of the organization restructuring effort - CUSECS and was a key member in formulation of IT strategy and also has played a pivotal role in SAP implementation. He has contributed significantly in the Governance, Risk and Control aspects of various processes across the Corporation.

Statistics

India: Oil & Gas

Domestic Oil Production (Million MT)

		2013-14	2014-15	2015-16	April 2016 - March 2017	
					Qty.	% of Total
On Shore	ONGC	6.71	6.07	5.82	5.93	33.71
	OIL	3.47	3.41	3.23	3.26	18.53
	Pvt./ JV (PSC)	9.41	9.06	8.81	8.40	47.75
	Sub Total	**19.59**	**18.54**	**17.86**	**17.59**	**100**
Off Shore	ONGC	15.54	16.19	16.54	16.28	88.38
	OIL	0	0	0	0	0.00
	Pvt./ JV (PSC)	2.66	2.73	2.55	2.14	11.62
	Sub Total	**18.2**	**18.92**	**19.09**	**18.42**	**100.00**
Total Domestic Production		37.79	37.46	36.95	36.01	100
	ONGC	22.25	22.26	22.36	22.21	61.68
	OIL	3.47	3.41	3.23	3.26	9.05
	Pvt./ JV (PSC)	12.07	11.79	11.36	10.54	29.27
Total Domestic Production		**37.79**	**37.46**	**36.95**	**36.01**	**100**

Source : PIB/PPAC

Oil Import - Volume and Value

	2013-14	2014-15	2015-16	April 2016- March 2017
Quantity, Million Mt	189.2	189.4	202.1	181.15
Value, INR '000 cr.	864.88	687.42	415.36	431.62
Value, USD Billion	143	112.7	64.4	66.70
Average conversion Rate, INR per USD	60.48	61.00	64.50	64.71

Source : PIB/PPAC

Oil Import - Price USD / Barrel

	2013-14	2014-15	2015-16	April 2016- March 2017
Brent (Low Sulphur - LS- marker) (a)	107.5	85.43	47.46	48.65
Dubai (b)	104.58	83.77	45.63	46.98
Low sulphur-High sulphur differential (a-b)	2.92	1.66	1.83	1.67
Indian Crude Basket (ICB)	105.52	84.15	46.17	47.16
ICB High Sulphur share %	69.9	72.04	72.28	71.03
ICB Low Sulphur share %	30.1	27.96	27.72	28.97

Source : PPAC/OPEC

Refining

Refining Capacity (Million MT on 1st April 2017)

Indian Oil Corporation Ltd.	
Digboi	0.65
Guwahati	1.00
Koyali	13.70
Barauni	6.00
Haldia	7.50
Mathura	8.00
Panipat	15.00
Bongaigoan	2.35
Pradip	15.00
Total	**69.20**

Chennai Petroleum Corp. Ltd.	
Chennai	10.50
Narimanam	1.50
Total	**12.00**

JV Refineries	
DBPC, BORL-Bina	6.00
HMEL, GGSR	9.00
JV Total	**15.00**

Bharat Petroleum Corp. Ltd.	
Mumbai	12.00
Kochi	12.40
Total	**24.40**

Hindustan Petroleum Corp. Ltd.	
Mumbai	7.50
Visakhapattnam	8.30
Total	**15.80**
Other PSU Refineries	
NRL, Numaligarh	3.00
MRPL	15.00
ONGC, Tatipaka	0.10
Total PSU Refineries Capacity	**154.50**

Private Refineries	
RIL, Jamnagar	33.00
RIL , (SEZ), Jamnagar	27.00
Essar Oil Ltd. , Jamnagar	20.00
Pvt. Total	**80.00**

**Total Refining Capacity of India 234.5*
(4.7 million barrels per day)**

*** Not include capacity of 6000 TMT of Cuddalore refinery of Nagarjuna.**

Crude Processing (Million MT)

PSU Refineries	2013-14	2014-15	2015-16	April 2016-March 2017
IOCL	53.13	53.59	57.19	65.19
HPCL	15.51	16.18	17.23	17.85
BPCL	22.97	23.18	24.09	25.36
CPCL	10.63	10.78	9.63	10.25
MRPL	14.65	14.68	15.6	15.97
NRL	2.61	2.78	2.52	2.69
SUB TOTAL	**119.5**	**121.19**	**126.26**	**137.31**

JV Refineries	2013-14	2014-15	2015-16	April 2016-March 2017
HMEL	9.27	7.34	10.71	10.52
BORL	5.45	6.21	6.4	6.36
SUB TOTAL	**14.72**	**13.55**	**17.11**	**16.88**

Pvt. Refineries	2013-14	2014-15	2015-16	April 2016-March 2017
ESSAR	20.2	20.49	19.11	20.92
RIL	68.03	68.04	69.44	70.17
SUB TOTAL	**88.23**	**88.53**	**88.55**	**91.09**

	2013-14	2014-15	2015-16	April 2016-March 2017
All India Crude Processing	222.45	223.27	231.92	245.28

Crude Capacity vs. Processing - 2016-17 April 2016 - March 2017

	Capacity On 01/04/2016 Million MT	% Share	Crude Processing Million MT	% Share
PSU Ref	135.07	58.71	137.31	55.98
JV. Ref	15	6.52	16.88	6.88
Pvt. Ref	80	34.77	91.09	37.14
Total	**230.07**	**100**	**245.28**	**100**

POL PRODUCTION (Million MT)

	2013-14	2014-15	2015-16	April 2016-March 2017
From Refineries	216.44	217.08	227.9	238.96
From Fractionators	3.87	3.65	3.38	4.29
Total	**220.31**	**220.73**	**231.28**	**243.25**

DISTILLATE PRODUCTION (Million MT)

	2013-14	2014-15	2015-16	April 2016- March 2017
Light Distillates, MMT	58.81	59.54	63.60	67.53
Middle Distillates , MMT	112.85	113.41	118.31	122.54
Total Distillates, MMT	**171.66**	**172.95**	**181.91**	**190.07**
% Distillates Production on Crude Processing	**77.17**	**77.46**	**78.43**	**77.49**

INTERNATIONAL PRICE EX SINGAPORE, ($/bbl.)

	2013-14	2014-15	2015-16	April 2016- March 2017
Gasoline	114.31	95.45	61.72	58.11
Naphtha	100.22	82.22	48.54	47.22
Kero / Jet	**121.23**	**66.62**	**58.17**	**58.42**
Gas Oil (0.05% S)	**121.99**	**99.44**	**57.63**	**58.93**
Dubai crude	**104.58**	**83.77**	**45.63**	**46.98**
Indian crude basket	**105.52**	**84.16**	**46.17**	**47.16**

CRACKS SPREADS ($/ bbl.)

	2013-14	2014-15	2015-16	April 2016- March 2017
Gasoline crack				
Dubai crude based	9.73	11.68	16.09	11.13
Indian crude basket	8.79	11.29	15.55	10.95
Diesel crack				
Dubai crude based	17.41	15.67	12	11.95
Indian crude basket	16.47	15.28	11.46	11.77

Source : PIB/PPAC/OPEC

Gas

Gas Production/Comsumption/Import

	2013-14	2014-15	2015-16	April 2016- March 2017
Net Gas Production (MMSCM)	34574	32693	31138	30848
LNG Imports (MMSCM)	17728	18536	21309	24686
Import Dependency (%)	34	36	41	44
Total Gas Consumption (MMSCM)	52302	51229	52447	55534

Domestic Gas Price ($/mmbtu)

Period	Domestic Gas Price (GCV Basis)	Price Cap for Deepwater, High temp Hingh Pressure Areas
November 14 - March 15	5.05	-
April 15 - September 15	4.66	-
October 15 - March 16	3.82	-
April 16 - September 16	3.06	6.61
October 16 - March 17	2.50	5.30
April 17- September 17	2.48	5.56

Conquering Newer Horizons

With a legacy traversing three centuries from the successful commercial discovery of crude oil at Digboi in 1889 and Independent India's first oil field in Naharkatiya - all in the north eastern state of Assam - Oil India Limited was born on 18th February, 1959 to increase the pace of exploration in Northeast India.

Dogged determination of some of the finest oil & gas explorers and a committed workforce has enabled OIL to expand its pan India presence and spread its wings overseas with footprints in countries such as Libya, Gabon Nigeria, Sudan, Yemen, Venezuela, USA, Bangaldesh, Mozambique, Russia and Myanmar.

Today, as a Navratna PSU, Oil India Limited is fully committed to achieve the co-created vision of becoming "the fastest growing energy company with Global Presence" with special emphasis on carrying out its duties as a responsible corporate citizen.

Setting the right pace globally

ऑयल इंडिया लिमिटेड
(भारत सरकार का उद्यम)
Oil India Limited
(A Government of India Enterprise)

CIN : L11101AS1959GOI001148

GAIL (India) Limited

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- Switch to Natural Gas, a Greener Fuel
- Use Public Transport
- Ensure Pollution-Free Air

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