FIPI

The Journal of Federation of Indian Petroleum Industry

Voice of Indian Oil & Gas Industry

October-December 2019 | Vol.18 Issue 4

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IN THIS ISSUE

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From the Desk of the

Director General

Greetings from the Federation of Indian Petroleum Industry (FIPI)!

Dear Members,

A very happy new year to you all.

The significance of this new dawn cannot be over-emphasized, as we are not only entering a new year but are also welcoming a new decade. This new-year presents us with the opportunity to take stock of the year gone by and enrich ourselves to ensure prosperity for all in the new decade.

As we stand at this crucial juncture in history, the world is faced with an era of global turbulence depicted by trade disputes among countries, ever-changing geo-political equations and an impending threat of a global recession. In 2019, the global economic performance was marred by the ongoing tariff war between the US and China. The impact of the trade war has now spilled over and is hurting other countries as well. The uncertainties over Brexit further exacerbated in the past year as the deadline has been further extended to 2020. In light of the subdued economic activities during the year, the International Monetary Fund (IMF) has revised its global GDP growth forecast to 3 per cent, the slowest pace in a decade.

The tremors of the ongoing turbulent global economic climate were also felt in India during the year and several sectors did not perform as was expected. The Reserve Bank of India's (RBI's) Monetary Policy Committee (MPC)revised its GDP growth outlook for 2019-20 downwards to 5 per cent in December, from 6.1 per cent. Taking account of the situation, the Government of India has already introduced a flurry of policy interventions to incentivize economic activity. The Indian economy, riding on its strong fundamentals and rejuvenated by the recent cut in corporate tax rates, is entering the new decade with zeal and enthusiasm.

The year 2019 exposed the global insecurities over vulnerability of energy supplies. As the US withdrew from the Iran Nuclear Deal, the country was placed under sanctions, effective from November, 2018. However, waivers were granted to eight nations, including India, for a period of six months. As on May 2019, when the waivers expired, Iran contributed 5 per cent of the global crude oil production and was the sixth largest exporter. Since May 2019, these countries were forced to look out for other suppliers for their crude oil requirements. The concerns over supply security only further heightened when the Saudi Arabian oil processing facilities were attacked in September using armed drones. The resulting apprehensions over security of supply have forced major importing countries to re-consider their sourcing strategies.

Over the last few years, the policy interventions and initiatives introduced by the Government will certainly help the Indian oil and gas sector to grow at an exponential pace. In the upstream side of the industry, Government policies such as Hydrocarbon Exploration and Licensing Policy (HELP), Open Acreage Licensing Policy (OALP), Discovered Small Fields (DSF) and National Data Repository (NDR)

have not just attracted wide attention from the global oil and gas industry but have also placed India as a preferred investment destination. In 2018, realizing the need for increasing the production from the aging fields in the country, the Government launched the EOR/IOR policy that is expected to provide the much needed fillip to the domestic oil and gas production. The long list of policy initiative only further substantiate the Government's commitment to increase the domestic production. We at FIPI, on behalf of the entire industry,are thankful to the Government for the progressive policy reforms and for being receptive towards industry suggestions for effective on ground implementation.

In the upstream side of the industry, the introduction of the new Open Acreage Licensing Policy (OALP) regime has not just attracted wide attention from the global oil and gas industry but has also received an overwhelming response over its four rounds of bidding.

In the midstream sector, the Government has further been working relentlessly to develope pan-India natural gas grid to realize the Prime Minister's vision of making cleaner fuel available to all at affordable prices. In this direction, after the conclusion of the ninth and the tenth round of CGD bidding, 70 per cent of the country's population and 53 per cent of its geographical area will now have access to CGD network. Mr Dharmendra Pradhan, Minister, Petroleum and Natural Gas and Steel has envisaged for an investment of over USD 100 billion for development of oil and gas infrastructure in the country in the next few years.

Taking account of the degrading air quality across major cities in the country, the Government of India has decided to leap frog to the BS VI fuel standards from April, 2020. The implementation of these progressive emission standards will align the Indian motor vehicle regulations with those of the most advanced countries in the world. Faced with such stringent specifications, Indian refineries have displayed great character by not just implementing the necessary up-gradations but also by implementation of the projects well before the scheduled timelines.

The Pradhan Mantri Ujjwala Yojana (PMUY) scheme was launched in 2016 with the objective of safeguarding the health of women and children and laying the basis for a fundamental material transformation at the bottom of the pyramid. The scheme has touched the lives of over 80 million under-privileged households in the country by providing them with free cooking gas connections.

With an objective toreduce the oil import bills and enhancing energy security, the National Biofuels Policy was introduced in April, 2018. The policy is providing an unprecedented push to the alternative fuels through forward looking initiatives such as Viability Gap Funding (VGF) and incentives for 2G ethanol production. The effectiveness of the new policy is evident from the fact that today ethanol blending has increased to over 6 per cent from 1 per cent in 2015. With such fast paced growth for ethanol blending, we are certain that country will surpass 10 per cent blending within next few years.

Over the last few years of its existence, FIPI has cemented its position as an able partner in the growth of Indian oil and gas industry. In 2019, FIPI was at the fore front advocating key policy issues such as inclusion of the sector under GST, marketing and pricing freedom for natural gas, fuel retailing policy amongst others. To further its advocacy efforts, FIPI also organised numerous events, conferences and workshops/training sessions. In February 2019, we co-organised Petrotech 2019, the flagship biennial conference and exhibition Indian oil and gas industry, under the aegis of Ministry of Petroleum and Natural Gas (MoPNG). FIPI joined hands with the World Petroleum Council (WPC) to organise the 2nd WPC Leadership Conference in Mumbai.

At FIPI, we firmly believe that any policy decision must be based on well informed and rigorously established objective evidence. FIPI commissioned various studies and produced research reports to substantiate its stand on various policy issues. During the past one year, FIPI commissioned five such studies including Climate Change Risks and Preparedness for Oil and Gas Sector; Impact of Oil and Gas sector on Indian Economy; Viability Assessment of LNG as a fuel for long distance transportation in India; Roadmap for Natural Gas Industry in India and Impact of Electric Mobility on India's oil & gas sector.

FIPI has been voicing the industry's concerns over non-inclusion of the five key petroleum products under GST at various levels in the Central/state Governments and the GST Council. As a result of FIPI's continued efforts, some of our recommendations have already been accepted by the GST Council. Below is a list of FIPI recommendations already

accepted by the GST council:

- GST rate on transportation of natural gas (without credit) reduced from 18% to 5%
- GST rate on transportation of natural gas (with credit) reduced from 18% to 12%
- GST rate on bunker fuel reduced from 18% to 5%
- GST rate on oil & gas offshore work contracts dropped from 18% to 12%
- GST rate on Transportation of petroleum crude and petroleum products reduced from 18% to 12%
- E-way bill on transports implemented on April 1, 2018
- No IGST on the import of ancillary and rigs under lease
- No GST on advance payment received for a supply
- For public transport buses running on biofuels rate reduced from 18% to 12% with ITC Credit
- Rate reduced on biodiesel from an erstwhile 18% to 12%
- GST rate on LPG supplied to household domestic consumers reduced from 18% to 5%
- GST rate on Mining or exploration services of petroleum crude and natural gas and for drilling services reduced from 18% to 12%

To further support its advocacy efforts, FIPI has commissioned a detailed report on the impact of non-inclusion of petroleum products under GST. The findings of the report will also recommend the Revenue Neutral Rate (RNR) for each product and how each state and centre would be impacted if these were to be brought under GST at these rates. In the coming year, FIPI intends to advocate the findings of the report with all relevant stakeholders for the earliest inclusion of the sector under GST.

During the third quarter of the committee year 2019, FIPI organised a day-long conference on Digital Transformation in Oil and Gas Sector'. An exhibition of the latest cutting edge digital technologies for the oil and gas sector was also organised alongside the conference. The conference witnessed targeted discussions on the various facets of digital technologies that are revolutionizing the modern day business.

In November 2019, FIPI organised the India pavilion at Abu Dhabi International Petroleum Exhibition and Conference (ADIPEC) at Abu Dhabi. ADIPEC is one of the largest exhibition and conference of the global oil and gas industry. The India pavilion was inaugurated by Mr Dharmendra Pradhan, Minister, Petroleum and Natural Gas and Steel. The India pavilion set up by FIPI adjudged as the best pavilion at the event.

FIPI organised the 'Annual Summit and Awards 2019' on 2 December. The day also marked FIPI's third foundation anniversary. For the first time, alongside the awards, FIPI organised a day-long conference with focussed discussions on key issues faced by the industry during the year. The FIPI Oil and Gas Awards recognised the exceptional performance by companies / individuals for contribution made by them towards the growth of Indian oil and gas industry. During the awards ceremony, Mr Dharmendra Pradhan, Minister, Petroleum and Natural Gas and Steel underlined that owing to the India's huge demand for energy and aspiration for better standards of living, the country is set to emerge as the epicentre for growth of global energy demand. He reminded the audience that energy sector has the potential to improve the lives of people in the country and it is the responsibility of the oil and gas companies to realize the Hon'ble Prime Minister's vision of making clean fuel available to all at affordable prices.

As the country enters a new decade, the oil and gas sector in the country will be faced with additional challenges arising from new IMO 2020 standards for marine fuels and implementation of BS VI standard fuels among other technical and commercial issues. However, we believe that inclusion of key petroleum products under GST; complete marketing and pricing freedom for natural gas; further liberalization of fuel retailing policy; and market creation for natural gas will continue to require our advocacy efforts.

At the cusp of this new decade, I assure you that FIPI will be at the forefront advocating for the industry issues and scripting the growth story of Indian oil and gas industry.

Dr. R. K. Malhotra

SPECIAL FEATURE

IJER editorial: The future of the internal combustion engine

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Executive summary

Internal combustion (IC) engines operating on fossil fuel oil provide about 25% of the world's power (about 3000 out of 13,000 million tons oil equivalent per year—see Figure 1), and in doing so, they produce about 10% of the world's greenhouse gas (GHG) emissions (Figure 2). Reducing fuel consumption and emissions has been the goal of engine researchers and manufacturers for years, as can be seen in the two decades of ground-breaking peer-reviewed articles published in this International Journal of Engine Research (IJER). Indeed, major advances have been made, making today's IC engine a technological marvel. However, recently, the reputation of IC engines has been dealt a severe blow by emission scandals that threaten the ability of this technology to make significant and further contributions to the reduction of transportation sector emissions. In response, there have been proposals to replace vehicle IC engines with electric-drives with the intended goals of further reducing fuel consumption and emissions, and to decrease vehicle GHG emissions.

Indeed, some potential students and researchers are being dissuaded from seeking careers in IC engine research due to disparaging statements made in the popular press and elsewhere that disproportionately blame IC engines for increasing atmospheric GHGs. Without a continuous influx of enthusiastic, well trained engineers into the profession, the potential further benefits that improved IC engines can still provide will not be realized. As responsible automotive engineers and as stewards of the environment for future generations, it is up to our community to make an honest assessment of the progress made in the development of IC engines over the past century, with their almost universal adoption to meet the world's mobility and power generation needs. Considering that the maturity of IC engine technology is something that many other technologies/possibilities do not have, we also need to assess the potential for future progress, as well as to assess the benefits offered by competitor technologies, in order to make responsible recommendations for future directions.

Factors impacting that future are discussed in this editorial and include the following:

- The fact that affordable energy has been instrumental in raising the standard of living in the world dramatically, particularly in poor countries, and the fact that so far in the history of humanity, the burning of fossil or bio-derived fuels has been the only reliable source of energy;
- The fact that the entire planet is linked by a massive transportation infrastructure that is largely based on the IC engine and that would require decades and tremendous expense to replace;
- The dramatic advancements in IC engine technology that have brought pollutant levels down a 1000-fold in past decades, and which now make particulate emissions from tire and brake wear a larger problem than engine emissions (in both IC engine powered and electric vehicles);
- The obstacles still faced by proposed alternatives, such as electric vehicles powered by batteries, which have tremendous cost, weight and other limitations, and which are hoped to be fuelled by renewables, such as wind and solar that currently represent only a miniscule fraction of the world's energy supply;
- And the fact that concerns about the impact of IC engines on climate change have become politically charged, even as they need to be assessed impartially. There is need for informed, data and sciencedriven government policies that promote a managed, realistic transition to sustainable future energy systems.

The vast majority of automotive engineers, including IJER editorial board members, are optimistic about the continuing importance of the IC engine to meet

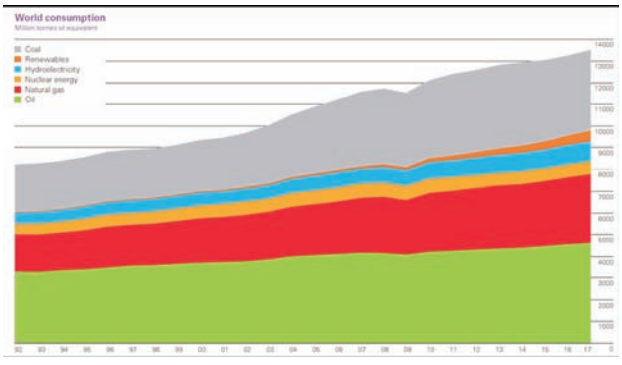

Figure 1. World energy consumption by source (millions of petroleum equivalent) in the last 25 years. 1 About 70% of fossil oil (i.e. about 3000 Mtoe) is consumed in IC engines.

the world's mobility and power generation needs. Certainly, exploring new and competing engine technologies, as well as new fuels, is important for a sustainable future for our planet. The inescapable conclusion reached in this editorial is that, for the foreseeable future, road and off-road transport will be characterized by a mix of solutions involving internal combustion engines (ICEs), battery and hybrid powertrains, as well as conventional vehicles powered by IC engines. Thus, there is a pressing need for recruiting the brightest young minds to engage in this effort.

Why the IC engine?

The transport of goods and people is essential to modern society, and currently transport is almost entirely powered by ICEs using liquid fuels due to their plentiful supply, convenience and affordability. In addition, stationary combustion engines (e.g. generators, not those for transport or off-road applications) are ubiquitous in our industries and in power generation facilities, which also promote the world's standard of living. Indeed, the demand for available and affordable energy is increasing with the increase in global population and prosperity, particularly in developing countries.

It is important to note that there are still no real alternatives that can compete with the IC engine over the entire range of applications that they cover and that, even today, IC engines are undergoing continuous further improvement.[3,4] These developments make it even more challenging for competing technologies to gain advantage over the IC engine. Focusing on transport, the demand for energy is very large. There are around 1.2 billion light-duty vehicles (LDVs) and around 380 million heavy-duty vehicles in the world, and these numbers are growing. The daily demand for liquid fuels exceeds 11 billion liters (23000 million tons oil equivalent per year, see Figure 1). All alternatives, whether they are alternatives to IC engines or alternatives to petroleum-based liquid fuels, face very significant barriers to fast adoption. But, ill-informed mischaracterizations of combustion have led to a belief in many quarters that the death of the ICE is both desirable and imminent. For example, many people believe that most of the world's GHG emissions come from cars and trucks, a misconception that is grossly incorrect, as discussed later. It is, therefore, not surprising that some young people are dissuaded from, or feel guilty for undertaking ICE research, the primary interest of this journal.

There is still great scope for even further improvements in engines with advances in combustion technologies, especially when combined with electrification. This has been recognized by the major original equipment manufacturers (OEMs), and Brown5 describes Toyota's release of its patents aimed at making hybrid technologies accessible to more manufacturers, which they believe will encourage production of electrified vehicles, including IC engine hybrids, plug-in hybrids, fuel cell and even fully electric vehicles. Indeed, it would be short-sighted if research and development on advanced power plant concepts slows, or is discontinued.

Engine emissions and the environment

Throughout the history of the IC engine—and decades before climate-change concerns became prominent— researchers have striven to improve its fuel efficiency, to reduce pollutant emissions and operating costs and to ensure the optimal use of finite fuel resources for current and future generations. Over the last four decades, in response to air-quality concerns, research on engine combustion, exhaust after-treatment and controls has led to a demonstrably cleaner environment thanks to a 1000-fold reduction in hazardous exhaust emissions (particulates, NOx, CO and unburned hydrocarbons (uHCs)). Many advances in these areas have been documented by technical articles in this journal.[6] Recently, however, major increases in concern about both air quality and the impact of GHG emissions on global warming have begun to drive local, national and international policy. Several initiatives are calling for drastic changes, and vehicle electrification is being heavily promoted. For example, the C40 Cities Climate Leadership Group, a group of 90 of the world's cities, which represents more than 650 million people and one quarter of the global economy, is focused on driving urban action to reduce GHG emissions

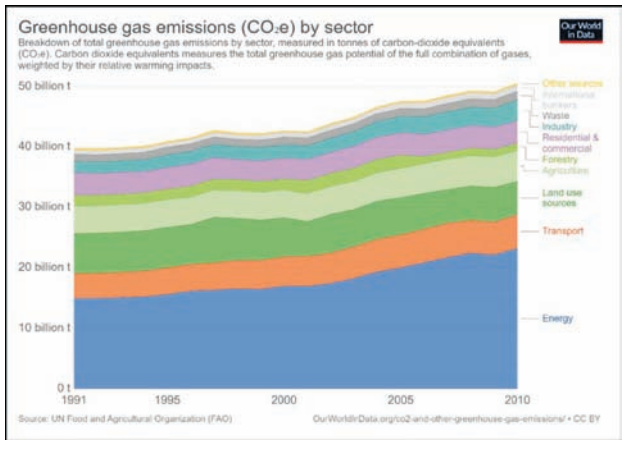

Figure 2. Global warming potential (GWP) in CO2 equivalent tons by sector.2 Transportation contributes about 10%.

and climate risks. Demands include eliminating combustion engines from inner city transport and the use of wind and solar as primary energy sources. However, as shown in Figure 1, wind and solar supply only a very small fraction of current energy needs. Despite technical advances and cost reductions for wind and solar power, it appears very unlikely that most fossil-fuel energy sources will be replaced by alternative carbon-neutral sources over the next two or three decades.[1]

Energy independence and energy security also play an important role in determining policy in many countries. Climate concerns must also be balanced by the observation that, by all objective/empirical measures of human development (e.g. absolute poverty levels, life expectancy, share of the world's population that is undernourished, education ...), the world has been improving consistently, particularly in poorer countries, over the past decades due to the availability of affordable energy, and due to the combustion of fossil fuels in particular. The developing world will continue to focus on growth and on moving their populations out of poverty, and this simply cannot be achieved through wind and solar alone—most of the world's electricity will still come from the combustion of coal or natural gas for decades. Climate justice must demand that the world's poor (not just the elite in Western countries) have a right to a better life. This requires the availability of affordable energy, including from fossil fuels, until such time that proposed alternatives, such as wind and solar, and possibly as-yet-undiscovered technologies, become practical and affordable. But, for this to happen, significant obstacles will need to be overcome, including developing the means to store energy for use when there is no sun shining or wind blowing. The development of batteries capable of storing enough energy to meet needs is still a bottleneck, and was, in fact, even bemoaned by Thomas Edison to Henry Ford in their competition for control of transport engines over a 100 years ago!

IC engine and electrification

It is likely that future mobility will be characterized by a mix of solutions, involving battery electric and hybrid electric vehicles (BEV and HEV), fuel cell electric vehicles (FCEVs) and conventional vehicles, depending on consumer acceptance (e.g. cost), the country considered and the specific application (city, country, personal, freight, etc.). Thus, the combustion engine will still play a central role, whether used for power generation or for powering the vehicle itself, even in strongly electrified powertrain configurations. Because of this, there is great interest in improving the thermal efficiency of IC engines without significant increases in purchase and operating costs in the short-to-medium term. These goals can be achieved through improvements in combustion, after-treatment and control systems, and by partial electrification in the form of hybridization, together with vehicle weight reduction and more efficient ancillary systems.

Although there is great current interest in the electrification of transport, only BEVs eliminate the need for an IC engine. However, life-cycle analyses7 of the GHG impact of BEVs that consider the energy used in electricity generation and battery manufacture show that their true benefit is significantly less than is apparent at first sight. Many analyses ignore the upstream CO_2 in fuel extraction, refining and transportation, as well as in the production and distribution of electricity. Large amounts of energy are required to extract the critical raw materials needed for batteries and electric motors (cobalt, lithium, rare earths, etc.), together with huge amounts of water. End-of-life disposal—oxicity in particular—also needs to be factored into life-cycle analyses. (Many of these considerations also apply to equipment for wind and solar photovoltaic power generation.) Moreover, the construction of a new electricity infrastructure, capable of recharging millions of BEV's, will require further raw materials and energy consumption (with consequent CO_2 emission), and may be limited by the availability of critical materials.

The high cost of BEV's, as compared to IC-enginepowered vehicles (conventional or hybrid), is also driving the development of effective, but previously deemed uneconomical, methods to increase the IC engine's efficiency with advanced

combustion modes, and to further reduce pollutant emissions. In this sense, the competition between electric motors and IC engines is stimulating beneficial evolution of the thermal engine itself.

"Zero emissions"

It has been estimated that the fuel consumption in spark-ignition (SI) vehicles could be reduced by as much as 50% in the United States compared to the current average,[4] and tailpipe CO_2 emitted will be reduced correspondingly. With existing catalysts and control systems—and these continue to be improved—particulates, NOx, uHCs and CO could also be reduced to negligible levels from both SI and diesel engines.

Frequently, pollutant emissions and CO_2 emissions from combustion are presented as being entirely equivalent, so that even engines with exceedingly low criteria pollutant emissions (NOx, CO, uHCs, and particulates) are also regarded as polluting. Technically and practically, there is an important distinction. CO_2 emissions necessarily accompany any hydrocarbon combustion or chemical oxidation process, including human and animal life. The CO_2 emitted from an engine is directly proportional to the hydrocarbon fuel consumed, which is continually being reduced by technological improvements.

In terms of the criteria pollutants, the goal to achieve "zero impact emission vehicles" is very close, thanks to advanced combustion modes and innovative after-treatment systems, including extensive use of catalysts and high-filtration-efficiency diesel and gasoline particulate filters (D/GPF) in the after-treatment system, while the use of urea injections and selective catalytic reduction (SCR) is leading to extremely low NOx emissions (e.g. 0.02 g/bhp-h or 15–20 mg/km). Indeed, there are even examples of vehicles having tailpipe unburned HC emissions below those in the ambient air at the engine's intake, so-called negative emission vehicles! Indeed, the pollutant emissions discharged at the tailpipe outlet will be so low as to be hardly measurable, and their practical impact on air quality will be negligible.

In terms of particulate matter emission, the impact of tire and brake wearing is already much higher than that due to the IC engine (tire wear produces around 50 mg/km of particulates), reaching values around 10 times the emission from the engine (5 mg/km). 8 This implies that today's conventional IC engine-poweredcar is equivalent to fully electric and hybrid cars with regard to particulate emissions, when tire and brake and other contributions (e.g. road dust) are accounted for.

There are routes to short-term CO_2 reduction that are viable more quickly. First, a switch from gasoline to diesel ICE reduces CO_2 emissions by an estimated 11% at the tailpipe, and a diesel mild hybrid delivers a further 6% reduction. The final swap to full hybrid delivers another 16%. Note, however, that there is a public misconception, based on obsolete technologies and the recent emission scandals, that the diesel engine is a high-pollution engine. As discussed above, this ignores the major advances that have been made in the last several decades in diesel engines and exhaust emission after-treatment.

Significant improvements to gasoline engines are also available with vehicle electrification. A direct switch from gasoline to gasoline-mild-hybrid can deliver 11%, and a further 23% in moving to full hybrid.[4] As these numbers demonstrate, there are immediate-term options for significant fuel efficiency improvement and, hence, CO_2 reduction of the order of 30% or more, for both gasoline and diesel.

It is also clear that "zero emissions" BEVs will not replace IC engines in commercial transport to any significant degree because of the weight, size and cost of the batteries required.[7] Short of a major breakthrough in battery technologies, for the foreseeable future combustion engines, running on petroleum-based liquid fuels, will largely continue to power transport of the world's goods and services. A transition from the gasoline or diesel ICE to a full gasoline/diesel hybrid can significantly reduce emissions.[4] But, due to the long turnover and replacement time of vehicles, it will take a long time (decades) for full hybrids-even if they become common-place and affordable options-to become a major fraction of the world's vehicle population. The sustainability of transport in terms of GHG and other environmental impacts, affordability and energy security can certainly be ensured by improving combustion engines, and this requires renewed emphasis on engine research and development.

Fuels

In the medium-to-long term, there is even greater scope for improving engines by co-designing fuel/engine systems for optimal performance.[9] Single- and dual-fuel technologies, such as homogeneous charge compression ignition (HCCI), premixed controlled compression ignition (PCCI), and reactivity controlled compression ignition (RCCI)[10,11] offer

significant promise for improving efficiency and reducing unwanted exhaust emissions.

These advanced combustion modes can also benefit from available fuels or fuels whose composition is optimized for each application. To also reduce dependence on fossil fuels and for a decarbonization transition, progress is being made in the introduction of CO_2-neutral biofuels and synthetic fuels. Often, criticism of the ICE is not about the engine, but about the source of the fuel, and the use of bio or synthetic fuels can mitigate total carbon emissions. Indeed, some marketed biodiesels are more than 70% net-carbon neutral today. Some countries and states have even implemented a lowcarbon fuel standard (LCFS) and provide monetary incentives to encourage the biofuel market.

Hydro-treated vegetable oil (HVO) is a promising renewable drop-in fuel for diesel engines with very low CO_2 impact. Another emerging technology produces liquid transportation fuels from solid ligno-cellulosic, non-food biomass via fast pyrolysis, which is a thermal decomposition process that breaks down materials by heat in the absence of oxygen, producing syngas, biooil and biochar. Bio-oil can be upgraded catalytically to liquid fuels. As a result, fast pyrolysis of waste biomass can produce biofuels and could enable a reduced carbon economy.

The use of alternative, synthetic fuels derived from waste biomass and renewable electric energy has also been proposed to produce an electrofuel (e-fuel) with net zero CO_2 emission (i.e. carbon neutral). This approach is currently being investigated as a smart way to store renewable electric energy when a production peak occurs, thanks to a chemical process to generate hydrocarbons from H_2 (produced by electrolysis of water) and CO_2 captured directly from the atmosphere or from other industrial-or bio-sources. Longer term, carbon capture technologies have been demonstrated to be able to collect and then dispose of or sequester CO_2 from vehicle tailpipes, and are projected to be cost effective.[12]

Energy sources and the future

For electrification, electricity has to be produced, either by the IC engine (in the case of a hybrid vehicle), or from a power generating station and the grid. For the latter, it is currently mainly produced from non-renewable energy sources (with about ;40%–50% losses, although these can be substantially higher for older coal-fired power plants which are still prominent in much of the world). In addition, the transport of electricity to the end user, together with corresponding charging/discharging losses at the battery, and the role of low or high operating temperatures in reducing battery performance accounts for another ;5%–20% loss, resulting in an overall efficiency that is actually comparable to that of hybrid vehicles powered with IC engines and fossil fuels. Perhaps there is a political advantage to drawing power from the grid in that unwanted emissions are "not in my back yard." The problem is flushed away to less visible areas, but with substantially less—and sometimes no—reduction in global carbon footprint. Indeed, a BEV charged from coal-fired electricity can easily have a larger carbon footprint than a comparably sized non-hybrid ICengine-powered vehicle.

Renewable sources (including hydroelectricity) currently constitute about 10% of the global energy mix. The BP review of World Energy[1] forecasts that the fraction of total energy production from renewables will only reach about 14% by 2040, and in many regions, fossil fuels, including coal, will remain the greatest source of energy. It is, therefore, clear that in the medium term, the alternative of BEV transportation may modestly reduce, but will by no means eliminate, global CO_2 emissions. Of course, with a reduction of coal-fired electricity and transition CO_2-neutral technologies, this situation could change.

Furthermore, much faster charging will be needed for broad market acceptance of plug-in and BEVs—note that essentially all scenarios currently involve substantial taxpayer or consumer subsidies for such chargers. In addition, mass electrification will require dramatic alterations to the entire electrical distribution system, from the power plant to the charging point. Given these issues, even the more aggressive mainstream market forecasts show IC engines still being in most cars in 2040,[13] and representing an even higher portion of the truck market.

Replacement of IC engines in heavy-duty transportation faces even greater difficulties in these respects. For example, a heavy-duty Class 8 truck in the United States with a 500-mile range, operating as an electric truck requires a battery with energy of; 1000kWh. Assuming a battery-to-motor efficiency of 95%, the appropriate battery weighs at least 5.5 metric tons (compared to about 1.3 metric tons for its diesel engine), and it consumes a significant part of the allowable payload. With the 120kW Tesla

Supercharger the battery takes around 12 h to charge.[7] In addition, there is little discussion on replacing train and ship engines, a testimony to the extreme power requirements and unacceptably long battery charging times needed for these applications.[7]

A sustainable mobility future will require a diverse portfolio to ensure the right technologies for the right applications, and it will span IC engines, fuel cells, pure EVs and hybrid-driven propulsion systems. Like-forlike ("apples-to-apples") comparisons are critical for accurate technology assessments of social, economic and environmental impacts. More specifically, successful technologies must be market competitive in cost, user requirements, lifecycle emissions and lifecycle efficiency; must ensure domestic energy security; and must consider societal impacts related to manufacturing and the acquisition and recycling of critical materials. To this end, the ICE and supporting infrastructure are well established, and innovations associated with technology developments continue to improve the overall efficiency and emissions signature of combustion-based technologies.

The climate alarm

Popular and governmental response to predicted effects of anthropogenic global warming ranges from skepticism to alarm, with alarm dominating recent public perception, media content and announced national and regional policies. The necessity for, and/or the role of engine combustion research and development in the race toward a CO_2-emission-free world is under debate, but we as the engine combustion research community, believe that the IC engine will continue to play an important role, if only for the reason that such an energy transition would undoubtedly take significant time. However, there is still controversy about the precise role of anthropogenic GHGs and CO_2, as well as the major GHG, water, on global climate change.[14] An overlooked fact is that, with hydrocarbon fuels, each molecule of CO_2 leaving the vehicle's tailpipe is accompanied by at least one molecule of H_2O. The actual balance between water vapor (as a GHG), and the clouds in the atmosphere, which reflect solar rays back into space and, thus, cause cooling, is still an active area of climate research.[15]

Often, in the popular press, the debate is between those who quote unproven climate models that predict disastrous effects on our climate, and those who appreciate the catastrophic consequences, particularly on the poorest among us, in abandoning fossil-carbondriven sources of energy (as well as the IC engine) that have driven the development of civilization so far. In any event, it should be clear that the practical consequences of societal action inspired by climate concerns could dramatically affect not only the long-term future of IC engines, but would also impact all aspects of energy and power use, as well as the standard of living on our planet. Major improvements of the combustion engine will be necessary to achieve dramatic reductions of GHG emissions in the coming decades.

With regard to GHG emissions, the contribution of transport to Global Warming Potential emissions has historically remained at 10%, as seen in Figure 2.2 Thus, a worldwide massive shift to electric vehicles could only result in a global (potential) reduction of about 10% of the equivalent tons of CO_2. (This also assumes that all electric vehicles would charge their batteries from energy sources without CO_2 emissions (i.e. renewable/nuclear).) Even for LDVs, as outlined in this editorial, an all-electric future will not arrive easily, quickly or cheaply, and IC-engine-driven transportation still has a major role to play for at least the next three decades.[7] It would be tragic if industry and governments were to abandon the very real near- to medium-term reductions in CO_2 and criteria emissions that are achievable with IC-engine-based propulsion because of over-optimism about the rate at which renewable or decarbonized sources can replace fossilfuel energy for transportation. (On the other hand, the rapidly expanding universe of consumer electronics is poised to outpace transportation as a source of global energy consumption. In 2015, Internet-connected devices, high-resolution video streaming, e-mails, surveillance cameras and smart TVs consumed 3%–5% of the world's electricity. The growth of the Internet of Things, driverless cars, robots and artificial intelligence (AI) is adding significantly to this demand for power. It has been estimated that computers and communications could use as much as 20% of the world's electricity by 2025.) We believe that public advocacy and educational programs, both in schools and in families, should focus not on instilling fear of global warming and climate change, but on how humanity can arrive at a hopeful future through increased efficiency of IC engines and other energy-consuming systems, development of renewable power sources, rational policy-making based on full-life-cycle analysis of alternatives and systematic

mitigation of the potential effects of global warming, as well as voluntary self-moderation of our consumer instincts.

Future research directions

Since its inception almost 20 years ago, this journal has chronicled advances in research in engines.6 The journal's goal continues to be to provide a stimulating forum to encourage progress in IC engine R&D. In this spirit, the final section of this editorial provides a (possibly incomplete) list of potentially fruitful research topics that would be helpful to the field of engines. Advances in these areas would certainly benefit from worldwide collaborations between researchers in industries, government laboratories and academia.

Engine efficiency

Combustion system. The development of novel combustion systems, including use of ultra-high fuel injection pressures, and new mechanical layouts, possibly beyond the slider crank, should be encouraged. This could be paired with combustion technologies with highly diluted combustion (stoichiometric with exhaust gas recirculation (EGR) as well as lean burn with excess-air ratios above 2). For this combustion improvement, mixture formation and charge motion, and ignition technologies including installation of pre-chambers need to be investigated.

Gas exchange. Improvements in engine breathing are of interest, potentially via exhaust gas turbochargers to realize fast response and low temperature combustion with ultra-high-pressure supercharging, large quantities of EGR, and further improvements in the Miller cycle with variable valve systems, while maintaining the required oxygen levels. Further development of exhaust gas energy recovery systems with turbo-compounding and possibly chemical reforming should be encouraged.

Electrification. Electrification offers significant improvements in system efficiencies, as well as GHG control, possibly leading to thermal efficiencies beyond 50%. The development of more efficient engines specifically for hybrid and range-extender systems (which enable the engine to run over a limited speed-load range) would also be helpful.

Engine lubrication. Reduction in mechanical loss should be achieved by improving lubrication systems with less oil consumption, especially for new engines with restricted operational areas in loads or speeds.

Engine thermal and energy management. Engine thermal and energy management is needed to comply with real driving emissions (RDEs) and to improve fuel economy. Not only reducing IC engine heat losses, but also improved thermal systems that include exhaust heat recovery systems, after-treatment systems, and their optimal control will be key technologies for the future.

Engine after-treatment

Emission-reduction technologies leading toward near zero emissions are required also by regulations. The establishment of improved and low-cost after-treatment systems to remove uHC, particulate matter and NOx emissions under low temperature and excess oxygen exhaust gas conditions without sacrificing thermal efficiency is needed. Methods to reduce RDEs from gasoline engine vehicles at full load in enriched combustion or cold starting (which generate much particulate matter) with less expensive after-treatment devices should be explored.

Fuels

The efficient utilization of dual-fuel combustion, and combustion of diesel/natural gas should be researched.

In addition to ultra-dilute burn and development of direct gaseous fuel injection systems, research is needed to reduce methane slip and to improve thermal efficiency and exhaust gas emissions on natural gas engines, especially for large ships and co-generation. Analysis of global fuel usage suggests that the use of surplus low octane number fuels will become an important topic in the near future.16 Also, intensified research on bio- and e-fuels for GHG mitigation would be helpful. "Designer" fuels offer the potential for efficiency improvements and near-zero pollutant emission.[17]

These could include admixtures of variable H_2-quantities to hydrocarbons, oxygenated components and even quite new chemical components (e.g. NH3). Research tools needed for engine development include the following:

Engine simulations

Supported by detailed experiments, there have been great advances in computational fluid dynamics (CFD) modeling of combustion processes. Simulation tools are now heavily used by most engine OEMs to help design and optimize engines, benefiting from the vast computational power available to both industry and academia (e.g. Hasse18). Thanks to the rapid development of AI, various automatic

predictions and optimizations are also being put into practical use. However, the optimization of engine combustion relies on accurate submodels, many of which need further development to increase their predictive capability, as well as to reduce the need for empirical calibration. This is an active area of research utilizing Direct Numerical Simulations with an imminent introduction of machine learning and data science technologies. In addition, engine combustion includes transient phenomena such as cycle-to-cycle variations that are not well understood or analyzed.

Development of vehicle simulation models that include the power source together with its system components, transmission, peripheral devices, battery, motor, inverter and driving drag is needed.

Engine and vehicle control

Real-time combustion control to reduce control margins and cycle-to-cycle variations requires calibration and control software innovation, possibly with onboard physical / statistical model-based control using AI. On-board optimization of multi-input/multi-output systems with model predictive control is needed. Control of efficient fuel injection systems to optimize mixture formation spatially and temporally in the combustion chamber, and methods to ensure stable ignition in very lean or dilute mixtures in SI engines, possibly using pre-chambers, and low-temperature plasmas would be of interest. Also, the use V_2X to reduce fuel consumption of vehicles in real driving conditions needs to be analyzed.

Closure

In summary, the ICE, and IC engine research have a bright future, in contrast with some widely distributed media reports (e.g. The Economist19). The power generation and the vehicle and fuel industries are huge, representing trillions of dollars (US) per year in turnover, with a massive infrastructure. We are certainly in revolutionary times, but it is clear that power generation sources will not become fully renewable and transport will not become fully electric for several decades, if ever. However, research to improve efficiency and methods to reduce dependence on fossil fuels are exciting directions for future IC engine research. It is very likely that highly efficient "fully flexible" engines with hybridized solutions will be a big part of sought-after efficiency improvements, as well as emission/GHG reductions.[20]

Finally, it must be acknowledged that, in practice, people select their choice of powertrain based on numerous factors, including cost. Consumer preference is not decided by politicians, nor by car-makers, nor academia. Policy unilaterally favoring one technology solution may be deeply inefficient and perhaps even the wrong eventual solution. A better approach is to use real-world data to allow competing technologies to flourish; if they evidence efficiency improvements and emission reductions, and they then need to be delivered as soon as possible. Continued progress requires that we recruit the brightest young minds to engage in this effort to deliver a vibrant and sustainable future for the ICE.

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International J of Engine Research
1–8
IMechE 2019
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CLEAN FUELS

Hydrogen-The Time Has Come

Adopted from the speech by Dr. R. K. Malhotra, President Hydrogen Association of India and Director General FIPI in the 8th International Hydrogen and Fuel Cell Conference (IHFC-2019) held from 8th - 9th December 2019 at Mumbai

According to the International Energy Agency (IEA), the time is right to tap into hydrogen's potential to play a key role in clean, secure and affordable energy future. According to the report now is the time to scale up technologies and bring down costs to allow hydrogen to become widely used.

Since we met last year in this conference on Hydrogen and Fuel Cells 2018, organized by Hydrogen Association of India, lot has happened which make me believe that for Hydrogen-The Time has Come.

The issue of global warming due to energy related CO_2 emissions is now recognized not only as an issue but as Climate Emergency. Hydrogen the carbon free fuel is now being seen as an enabler for extensive de-carbonizing several sectors of industry and transport.

We today in various forums are discussing about energy transition more often than earlier. However, I believe the world has always been in transition though the rate of transition has been different as we moved from wood to coal and from coal to oil and from oil to Natural Gas. In this process we have been reducing carbon to hydrogen ratio in the fuel. Now the time has come for hydrogen the ultimate carbon free fuel which can be produced from variety of sources and processes.

The transition to a de-carbonizing energy system to address the issue of global warming will require radical transformation on how we will generate, distribute, store and consume energy. We will have to focus on energy efficiency in all spheres of activities to reduce CO_2 emissions. As the use of fossil fuels is likely to continue in foreseeable future, we will have to fix carbon while producing oil & gas or even coal and ensure that how CO_2 could be captured during the combustion of the fossil fuels or converted into useful chemicals. I hope you all agree that we will now need carbon free fuel for use in power generation, industrial use and transportation and hydrogen seems our best bet for the survival of the planet.

The question often raised is where the hydrogen will come from and at what cost? How we can store and transport hydrogen? The question we need to also ask is Can we Reduce Carbon Emissions while producing Hydrogen? Currently, hydrogen is mainly used by refineries which are the largest producers and consumers of hydrogen besides in the ammonia and methanol production. Most of the hydrogen is currently produced from fossil fuels and in the production processes the carbon di-oxide is emitted. In the near term may be till 2030 the cost advantage of producing hydrogen fromfossil fuels is likely to continue. We, therefore, will need to address issue of carbon emissions while producing hydrogen.

Electrolysis though the oldest method of producing hydrogen from water using electricity, is not a dominant process as of today. However with reduced cost of renewable electricity (from wind and solar pv) this may regain its dominance in the time to come. Further developments of electrolysis process will help improve efficiencies and also help further reduce the cost of hydrogen production through this route. Difficulty in electrolysis is that the membrane that divides the electrolysis cell limits the pressure in the electrolysis cell to 10-30 atmosphere,

while in most applications pressure of hundreds of atmospheres is required.In addition, the presence of the membrane complicates the process, and it also requires expensive periodic maintenance.

A new technology developed by Israel researchers, published in the journal Nature Energy, dramatically improves hydrogen production efficiency to 98.7 per cent and significantly reduces CO_2 emissions.

This process-called E-TAC (electrochemical-thermally-activated chemical) water splitting – is based on cyclic operation.In the first stage, the cathode produces hydrogen by reducing water molecules while the anode changes its chemical composition without producing oxygen.Then, the cathode is passive while the anode produces oxygen by oxidizing water molecules. Next, the anode returns to its original state and the cycle begins again.The absence of the membrance simplifies the whole process, reduces costs and even at a cost of billions of dollars.

Several such other electrolysis technologies are also being developed the above was only an example.

In the near term, the production of hydrogen from natural gas reforming however is likely to be the most cost-effective route for producing hydrogen with least CO_2 emissions without deploying Carbon Capture Use and storage (CCUS). As the fuel cost is the biggest single component for hydrogen production, the cost of natural gas will have direct co-relation with the cost of hydrogen. Natural gas accounts for nearly 75% of hydrogen production globally about 70 million tones of hydrogen using around 205 billion cubic meter (BCM) of natural gas which is around 6% of the total natural gas used world over. Steam Methane Reforming (SMR) is the most widely used technology, though Auto Thermal Reforming (ATR) is also being used. CCUS can be applied in both the SMR and ATR with potential of reducing carbon emissions of upto 90%. The technologies of CCUS are available and can be deployed but only adds to the cost of hydrogen production. Methane splitting offers a potential method to produce hydrogen and some of the researchers have shown possibilities of producing carbon fibre and carbon nano tubes along with hydrogen to make the process cost effective.

Hydrogen from coal using gasification, is a well established technology used for several decades. An estimated 23% of global dedicated hydrogen production using about 107 MMT of coal is used which is 2% of the global coal use. However the CO_2 emissions in hydrogen production from coal amounts to 19 tonnes of CO_2 per ton of hydrogen produced which is twice as much as for the hydrogen produced from natural gas. This means that carbon capture, utilization and storage (CCUS) technologies will need to be used if hydrogen from coal is to have a place in the era of energy transition while taking care of the climate change emergency. The syn gas produced through the coal gasification can be used in a combined cycle power plant. An additional water gas shift unit could be added to produce more hydrogen allowing the coal gasification plant to shift between the production of electricity and hydrogen as per needs. If CCUS could be added during hydrogen production, even the electricity produced would qualify as green electricity.

Countries like India and China with abundance of coal, producing hydrogen from coal even with CCUS may be a cost effective method of producing hydrogen. The current CCUS technologies may enable reduction of CO_2 emissions to as low as 2 kg of carbon di-oxide per kg of hydrogen produced while advanced technologies when developed and deployed may emit only 0.4 kg of CO_2 per kg of hydrogen produced.

Hydrogen can be produced from Bio-mass through different routes, Bio-mass gasification can be similar to coal gasification and in fact, it is possible to have co-gasification of coal and bio-mass and even petcoke. During my days at IOCL R&D we had patented a process for such co-gasification which can be deployed for producing hydrogen. Anaerobic digestion can produce bio-gas from sewage sludge, agro waste, household waste etc. and bio-gas can be further processed and purified to produce hydrogen.

Hydrogen can also be produced using nuclear energy or waste heat. ONGC Energy Centre in collaboration with few research institutes have been working on copper-chloride and sulphur-Iodine technologies but scaling up of the same is a challenge at present.

We can produce and use hydrogen today and I am optimistic that we will be able to produce carbon free hydrogen from variety of sources in near future. I read a paper recently which states that the scientist have found a novel way to extract hydrogen from

oil without releasing carbon dioxide and methane which are left in the ground. The CEO of Proton technologies which is commercialising the extraction method told that this is the silver bullet for clean energy and clean climate.

As a researcher, I believe that while we know how to produce hydrogen and fix carbon issue, we shall soon be also able toidentify cost effective routes.One of the latest reports from Bloomberg stated that the cost of producing hydrogen gas from renewables i.e. wind & solar pv is expected to be falling upto 80% by 2030. The report states that renewable hydrogen costs may fall to as low as $1.40 a kilogram by 2030 from the current range of $2.50 to $6.80 per kg of hydrogen with prices falling further in time to come

So we have several routes and can produce hydrogen today to move forward on hydrogen economy.

The next challenge after production is the storage, transport and delivery of hydrogen and creating infrastructure for this purpose. We in the energy industry, oil & gas have experience of handling hydrogen in refineries, besides the transportation, supply and distribution of natural gas. The oil & gas industry can therefore have smooth transition to produce and distribute hydrogen for various applications. Though the challenges are slightly different e.g. embrittlementof steel with hydrogen and high pressures required for storage etc. they are not insurmountable and can be easily addressed by our industry. In India we are building up a large gas grid for supply of natural gas which will cover almost 70% of India's population. We can always have decentralized hydrogen reformers close to the natural gas pipeline and supply hydrogen in near by areas. It would also be much easier to add CCUS units with such reformers rather than controlling carbon emissions while using natural gas in industry or transport.

Further on regulatory front, the safety regulations as are prevalent in countries which are moving forward on hydrogen much faster can be adopted till such time the Indian regulators and the industry can develop its own regulations.

Though hydrogen can be used for variety of applications in the industry, I would like to now talk about its application in transport sector where, there is spur of activity around electric vehicles. The major issue of concern in time to come with battery vehicles would be the dependence on lithium and cobalt and the issues around its pricing and availability besides environmental and human rights during mining. The shift to battery electric vehicles will also require charging infrastructure to be developed. The battery electric vehicles will have limitation of range and also will require much longer time for charging of batteries while the hydrogen can be re-fuelled much faster in 2-3 minutes like natural gas at the dispensing stations and the vehicles can also have longer range.

With today's technology if you produce hydrogen by electrolysis then you would lose 30% of the energy but when electricity is made from coal or natural gas, 60-70 per cent of the energy is lost in production and distribution. When we produce hydrogen from natural gas or even coal, we will not lose that 60 or 70 per cent of the energy. I earlier spoke about the range and it is the real problem with battery trucks, e.g. a 40 tons battery electric truck with 500 km range need 8 tons of battery. Do we want to carry the cargo in a truck or batteries? The fuel cell stack and hydrogen tank in the truck will be much lighter. We also need to compare the overall carbon emissions, and it is estimated that as long as we continue to produce electricity from coal and use it in electric vehicles, the carbon emissions issue would be even more serious as compared to use of petrol and diesel.

Hydrogen being the carbon free fuel will not emit any harmful gases like electric vehicles, though the oxides of nitrogen to some extent will be an issue, if hydrogen is used in internal combustion engine. In case of fuel cells, the exhaust is only water vapour. While I was at IOCL R&D, we had started using mixtures of hydrogen in CNG and did lot of work even on partial reforming of natural gas which made the HCNG technology cost effective. I am glad that my successor Dr Ramakumar is taking it forward to commercialize the technology. Even the Supreme Court of India taking notice of the development, has mandated large demonstration project at one of the bus depots in New Delhi. Of Course this is only an interim route for moving towards hydrogen economy. The next obvious stage which is now set is to move to hydrogen fuel cells which can replace internal combustion engines. The much higher efficiency of fuel cells as compared to internal combustion

engines will reduce the overall consumption of energy so crucial for a country like India which has large dependence on energy imports.

Lot of research work has been done globally to developed advanced fuel cell technology with reduced costs and high durability . The use of noble metal like platinum today in fuel cells is far lower than in the initial stages of its development. According to Toyota, it plans to bring the price of fuel cell cars to the level of hybrid cars by 2025. Toyota's optimism on fuel cell costs is quietly shared in the industry as the production of fuel cells scale up their costs will drastically come down. Researcher from the University of Waterloo in Canada have developed a new fuel cell that lasts atleast ten times longer than the current technology. This would make the fuel cells economically practical if mass produced to power vehicles. The waterloo experts feel that their design approach would make the cost comparable or even cheaper than gasoline engines. We have been having hybrid vehicle technology which have gasoline engines as well as smaller batteries. The fuel cells can replace such gasoline engines in hybrid vehicles and our oil and gas companies can switch over to supply of hydrogen in place of gasoline for such vehicles. The fuel cell vehicle in which we use compressed hydrogen to generate electric power through a highly efficient fuel cell which produce only water and heat as a by-product and if we can produce hydrogen in a sustainable manner either from renewables or even fossil fuels with CCUS technology, we would be able to move towards the decarbonizing the transport energy system while having zero emissions.

So Ladies and gentlemen, I am happy that we created a forum i.e. Hydrogen Association of India which has been working as a catalyst to promote hydrogen and fuel cell research activities and out annual conference is an appropriate forum to deliberate on issues of concern to the stakeholders so that the same could be taken up with appropriate agencies. I am thankful to all of you those who have been supporting us in our endeavour and it is our collective wisdom which will certainly help in ushering the hydrogen economy in India.

When we started the hydrogen activities at IndiaOil's R&D centre more than a decade ago, many said that the hydrogen economy is far away and I mentioned that it is the responsibility of we researchers to plan for future. I am glad that today lot many people are talking about hydrogen and even Supreme Court of India not only mandated the use of HCNG but have also advised the policy makers to look at the way Japan is developing the hydrogen economy to tackle the issues related to environmental pollution.I am happy to see much larger gathering in our 8th edition of Hydrogen and Fuel Cell Conference this year which is also an indicator of growing interest in hydrogen. After this conference we will come out with a status paper and would like to define action plans which are required for further promotion of hydrogen.

DIGITALISATION

Breakdowns Prediction of Data Center Servers through Data Analytics using R

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1. Background

Today when the world is moving at a fast pace towards digitization, Data analytics is becoming a competitive edge for organizations. Data Analytics is the application of Data, Technology, Statistical tools and mathematical models to help business gain an improved insight, foresight and help make better fact based decisions.One of the important data analytics techniques, Predictive Data Analytics, Once being anoptional is now becoming critical.

Even though today there is an emphasis on understanding and applying predictive modeling techniques, may be over the next few years the application of these powerful techniques will become standard for the organizations/businesses. Then, there might not be so different from applying data analytics and computers for businesses that want to thrive and survive in a highly competitive and regulated marketplace.

Hence, understanding, applying and interpreting data analytics (predictive data analytics) is a challenge to every oneof us now.

2. Problem Statement

Any organization requires a pool of servers loaded with customized applications to cater the needs of the people connected internally & externally to the corporation. Most of these servers are mission critical which means breakdown of these machines is just not acceptable and failure of these impact the business continuity ultimately ends in loss to the company. Hence, it is the job of the Server/ System Administrator to ensure these mission critical servers and related devices healthy on daily basis. To achieve this goal, server administrator uses set of tools to monitor various features of the servers which contributes to the failure/breakdown and regulates the same on a daily basis. Even though, it is a good practice to monitor and take preventive actions on daily basis, our goal of keeping machines 100% up and running 24x7 is not getting fulfilled as we depend only on the previous and current data.

Hence, the problem now is "How to predict/forecast the server health or breakdown conditions?" over a period of time so that advance actions can be taken without waiting for the actual situation to happen.

3. Proposed Solution

Now it's the role of data analytics, to be more specific "Predictive Data Analytics" in forecasting the server health based on trend of the previously collected data. Let's look at some basic concepts of data analytics techniques and related tools used for this purpose.

Data Analytics is the application of Data, Technology, Statistical tools and mathematical models to help business gain an improved insight, foresight and help make better fact based decisions.

Following are the stages in data analytics

1. Data Source Identification
2. Data Cleaning
3. Data Analysis
4. Selection of Data Model
5. Prediction / Forecasting
6. Inference / Interpretation of Results
7. Keep improving your data model for accurate prediction (repeat 4 to 6)

Data Correlation is a way to understand the relationship between variables in a dataset. Correlation is used as a basic quantity for many modelling techniques. Correlation b/w two variables is measured in terms of correlation coefficient which varies from -1 to +1

There are three types of correlations.

Positive Correlation: It means that if feature X increases then feature Yalso increases or if feature X decreases then feature Y also decreases. Both features move in tandem and they have a linear relationship. Correlation coefficient for this type of correlation varies from 0 to+1 and generally if this value is between 0.7 and 1.0, then the two variables are said to be strongly positively correlated with each other. Correlation coefficientis+1 indicates a perfect positive linear relationship.

Negative Correlation: It means that if feature X increases then feature Ydecreases and vice versa. Correlation coefficient for this type of correlation varies from-1 to 0 and generally if this value is between-0.7 and -1.0, then the two variables are said to be strongly negatively correlated with each other. Correlation coefficientis 11 indicates a perfect negative linear relationship

No Correlation: No relationship between two attributes. Correlation coefficient for this type of correlation is Zero.

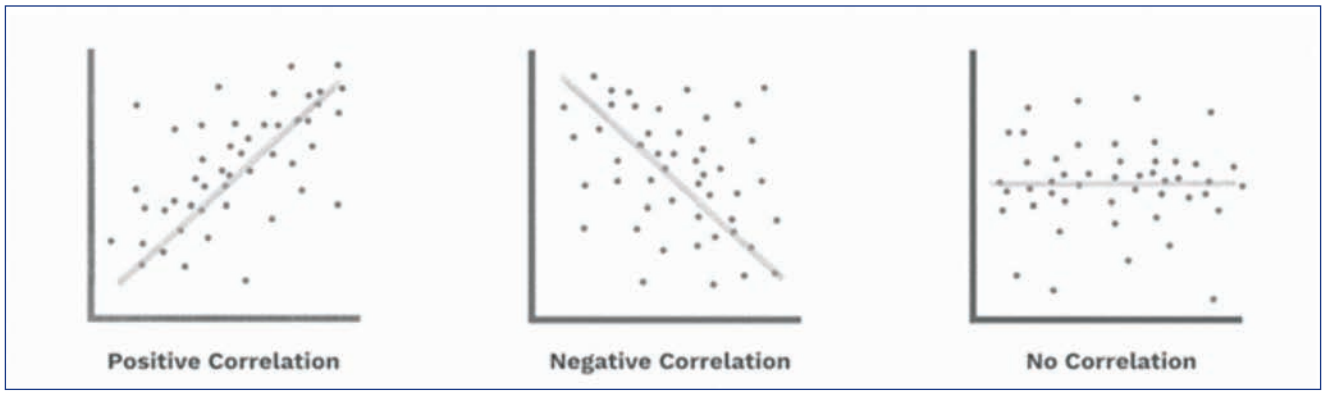

Figure 1.0: Types of Correlations based on correlation co-efficient

Linear Regression Modelling: Linear regression is a linear approach of modeling the relationship between a dependent variable and one or more independent variables. If it is of one variable is called simple linear regression and for more than one independent variables, is called multiple linear regression.

Simple linear regression: it is a very straightforward approach for predicting a quantitative response Y on the basis of a single predictor variable X. It assumes that there is approximately a linearrelationship between X and Y. Mathematically, we can write this linear relationship as $Y \approx c + m*X$

In the above equation: c, m are constants that represent the intercept, slope in the linear model. Once, these constants are known, then it is quite simple to predict values of Y for the values of X.

R Programming: R is a programming language and free software environment for statistical computing and graphics supported by the R Foundation for Statistical Computing. The R language is widely used among statisticians and data miners for developing statistical software and data analysis.

R Studio: RStudio is an integrated development environment (IDE) for R, a programming language

for statistical computing and graphics.The RStudio IDE provides a mechanism for executing R functions interactively from within the IDE.

4. Challenges encountered

Even though it looks simple to predict the server health / break downs, following are the challenges faced during implementation of the model:

1. How and what data needs to be collected on continuous basis?
2. How to Process this data from several devices and transform into a single source for feeding into the model?
3. Will data collection impacts the device performance?
4. How to define threshold values / breakdown values?
5. What if the data gets changes during prediction? Any control to be maintained to track the change in data?
6. How to interpret the results after prediction and making them meaningful?
7. How to share the information / knowledge derived from the model to the management?

During the implementation, all the above challenges are solved and finally able to predict the device health over a period of time.

5. Implementation of the solution

In this case study, prediction is done for the servers running Windows Operating System and to predict the breakdown of the device, the characteristic property of Local Storage of the hardware is considered. As already described earlier, various stages of data analytics addressing our problem are as below:

1. **Data Source Identification:** As mentioned above, device health is derived based on the storage capacity i.e. % free storage as on date. Hence, it is clear that data source should contain the date wise storage details like total storage, used & free storage and these details are to be collected for each partition present in the hardware. These details can be collected using Performance Management (perfmon.exe) utility built in windows operating system(may be different in other operating systems).

Steps to follow for collecting data using perfmon.exe:

- Open perfmon.exe utility and define a new data collector set.
- Select the Local storage property for this user defined new data collector.
- Define the sample interval and file with format to store the data.
- Schedule the above task on daily basis to collect the data on continuous basis.

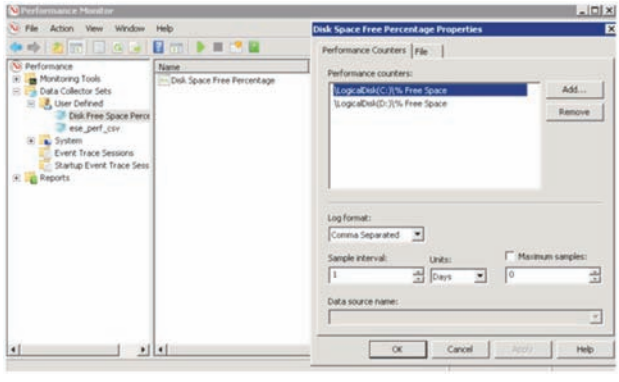

Figure 2.0: Data Collection using Performance Management utility

2. **Data Cleaning:** This step basically intended to keep the data in a structured and certain standard format so that analysis of the data will be error free. Here data is being collected in comma separated format (.csv) and as we get the data from the automated utility, data is assumed as structured and minor changes can be done programmatically.
3. **Data Analysis:** After collecting the data, a basic data analysis is done using Data Analysis utility. The results of analysis are as follows:

Figure 3.0: Data Analysis on the collected data

4. **Selection of Data Model:** After the analysis, it is found that two variables i.e. date and % free space are correlated (positive correlation) and hence, simple linear regression model can be used for predicting the % free space over a period.
5. **Prediction / Forecasting:** As the model we have chosen is simple linear regression model, two constants i.e. slope and intercepts are required for predicting the % free space variable. To find

out these two constants and forecast the values, R script is programmed using R Studio and details of the script are as follows:

- Find out basic information like # of drives, total & free storage using wmic command for each of the server.
- Now loop through all the source data files and create one master file with scaled data parameter (starting date is referred as 1)
- A control file needs to be created programmatically which contains the date from which data needs to be taken for prediction.
- The Control file can be prepared by looping through all the values in the master file and finding the date at which major deviation occurred b/w two values.
- Apply linear regression which is inbuilt in R studio (lm(y~x)) on the master data and predict the dates at which 85%, 90% and 95% of the storage will be full.

6. **Inference / Interpretation of Results:** Post prediction, there are three dates for each of the equipment forecasted by the model in R Studio.

   Date85: Date at which storage will be 85% full

   Date90: Date at which storage will be 90% full

   Date95: Date at which storage will be 95% full.

Server Administrator Dashboard

#	IPAddress	Drive	Total	Used	UsedPer	Free	FreePer	Risk	Date85	Date90	Date95
1	-	C:	279 GB	145 GB	52 %	134 GB	48 %	Low	2022-02-15	2022-06-20	2022-10-23
2		D:	558 GB	412 GB	74 %	146 GB	26 %	Low	2019-11-13	2019-11-14	2019-11-16

Note : This is an auto generated email through RStudio

Figure 4.0: Predictive model forecasting the breakdown dates

Based on the above dates, one can easily plan necessary preventive actions and ensures the servers up and running 24x7.Also, a utility is developed in R studio which mails the whole data to the server administrators as shown above.

The beauty of this script is that, it works dynamically i.e. after breakdown dates are predicted and server administrator has taken the action, the change in data is sensed by the script and it predictsthe set of new dates. It means that the script predicts the break downs based on the latest data which ensures the accuracy of the model.

6. Conclusion

In this case study, we have shown our practical implementation of the predictive model on server breakdowns. However, the same approach can be adopted to any of the equipment to know when the machine/device might get failed. Is it not interesting to know when the device fails and take necessary maintenance and increase life the equipment? Hence, Data Analytics is powerful technique to predict the helps in taking fact based decisions and R is a powerful tool to implement data analytics and is open source & free to use.

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RELIABILITY

Pipeline Integrity Matters

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Pipelines are the energy veins of the world. Much of the world runs on pipelines. From the time we get up in the morning until we go to bed at night, it's difficult to find a moment when we haven't used energy transported by a pipeline. Crossing the landscape largely buried, pipelines traverse quiet wilderness and bustling communities, providing the safest and most efficient method of hydrocarbon transportation in the world today .Out of sight does not mean out of mind. Integrity of pipeline is now a major focus which may be attributed to a couple of factors, which include new legislation, technical advancements, strict penalties for accidental leakages, environmental concerns , ageing of pipelines and also considering the impact of pipeline related incidents have proven to be fatal. All elements of integrity are important since we know that the weakest part determines the strength of the entire system.

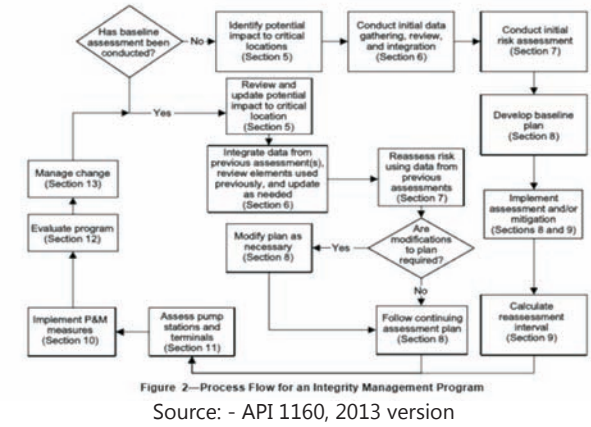


Figure 2—Process Flow for an Integrity Management Program

Source: - API 1160, 2013 version

A pipeline integrity management program should:

Identify threats to pipeline integrity, potential consequences to the public and the environment in the event of a release, Rank segments of the pipeline system according to the risk each poses, Provide for assessment of the integrity of each segment in a timely manner based on identified threats and the risk to minimize the possibility of a release, Specify repairs or mitigative actions to carry out in a timely manner to prevent releases, Establish reassessment frequencies, Define preventive and mitigative measures to address relevant threats including those not covered by integrity assessments, Use the findings of integrity assessments to update and improve the integrity management process.

Pipeline Integrity threats are mainly categorized

1) Time Dependent

2) Stable

3) Time Independent

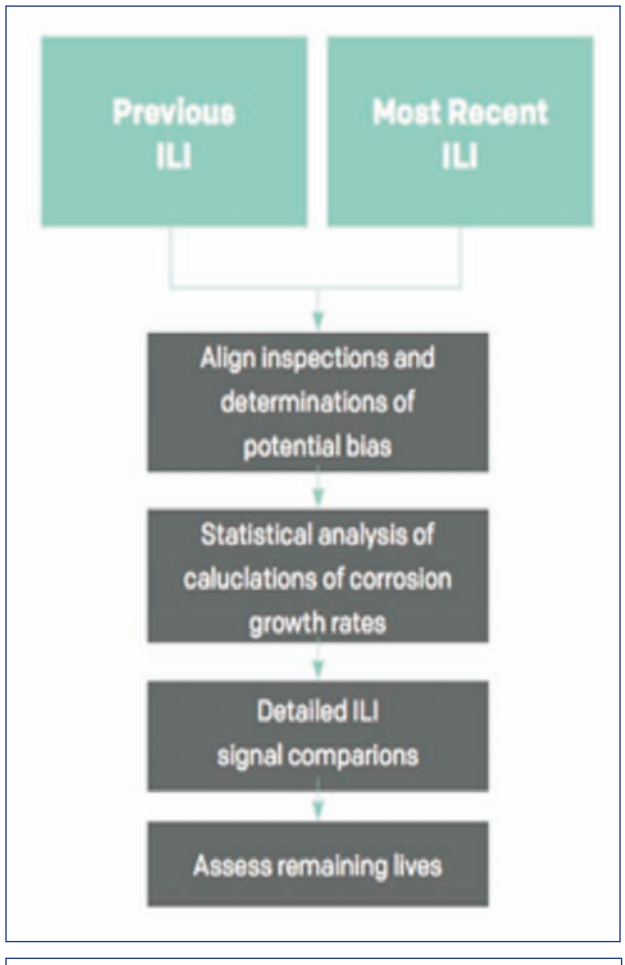
Reassessment of the integrity a pipeline segment subject to a time-dependent anomaly growth mechanism should be carried out at appropriate intervals to minimize the risk of a pipeline failure

caused by an anomaly that was too small or was under the reporting size criteria detected in the last assessment growing to a size that would fail at maximum calculated surge pressure or 1.1 times MOP.

Accurate corrosion growth rates are needed to predict pipeline availability as a function of time, to identify the need for and timing of field investigations or repairs and to determine optimum re-inspection intervals. The consequences associated with using wrong corrosion growth rates range from the inefficient use of resources (time, people and money) on unnecessary repair/inspections to unexpected pipeline failures. The identification of where corrosion is active on a pipeline and how fast it is growing is a complex process which is understood in the general sense but is highly variable

There are various approaches that can be used to define corrosion growth rates for use in pipeline integrity assessments. The major advantage of using repeat ILI data to derive corrosion rates over other methods is that the ILI can provide growth rate information on the whole detectable corrosion distribution density giving visibility of what is happening along the entire pipeline. Further XYZ mapping plots the infrastructure and population density for risk assessment. Fingerprint ILI is warranted for the above to establish the initial pipeline health assessment post commissioning. In specifying a 'fingerprint' inspection the pipeline operator should consider why the inspection being is done, as this will affect the probability of detection (POD),probability of Identification (POI) , defect reporting levels, assessment method and acceptance criteria that should be used.

The application of fixed rates can be very conservative and will lead in many cases to unnecessary repairs or if the rates are too low to an unsafe assessment of the future integrity of a pipeline. Using location specific (variable) growth rates (both scenarios of applying the maximum rate per pipe joint and defect specific rates) has been found to provide more realistic and targeted predictions of repair needs. The location specific growth rates give accurate predictions of the corrosion severity over time. With the benefit of this hindsight, the predictive analytics employed for evaluating and applying ILI based corrosion rates can be further improved and refined to give more accurate predictions of the future pipeline condition, the response schedule and optimized timing of re-inspections.



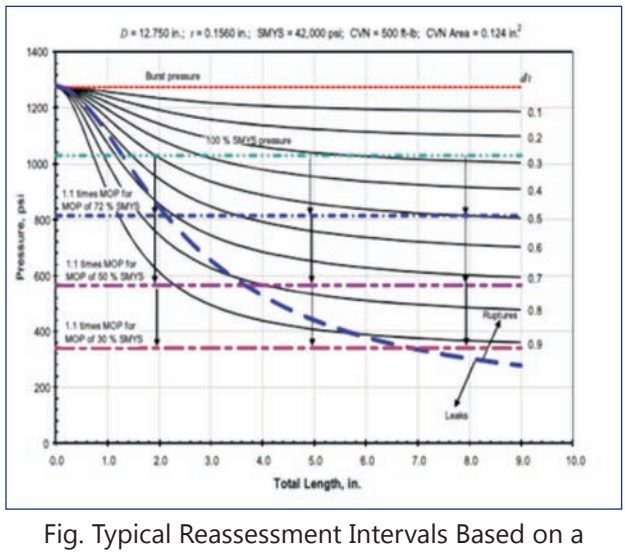


Fig. Typical Reassessment Intervals Based on a Specific Failure-pressure-vs-anomaly-size Mode

Source: - API 1160, 2013 version

Time is now to review of multiple-data-set ILI results from several pipe joints with simulated defect locations from ILI surveys .The same has been implemented on BPCL pipelines as for ageing pipelines corrosion growth rates have been derived and very useful in aligning the reassessment intervals. Further the Fingerprint inspections have been implemented on our new pipelines creating a baseline data for the future advanced inspections. BPCL has established stringent inspection criteria at 0.95POD and 0.90POI to establish quality data for analysis.The ILI runs and subsequent signature analysis and data treatment have been very useful in uprating of pipelines and remaining life estimation.

Time is now to convert data to information to add value to the initiatives being taken and the amount being invested towards data gathering. The information gathered over time has to be translated into effective corrosion mitigation/control programs. Reviewing from a deeper understanding of information from corrosion monitoring and other sources is required. For effective corrosion control it is important to understand "where, when and why" pipeline damage takes place – the proactive and investigative approach as discussed shall be of great use and the inputs derived shall have a positive impact on the pipeline integrity matters.

ENERGY SECURITY

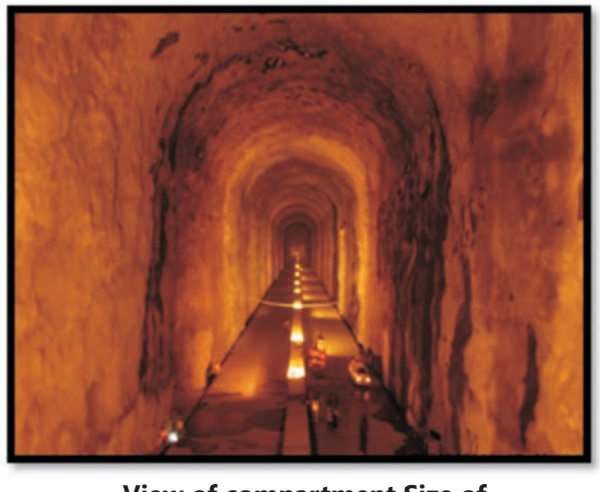
Indian Strategic Petroleum Reserves Limited (ISPRL)

H.P.S. Ahuja
CEO & MD, ISPRL

INDIA is home to 17% of the world population, but contain less than 1% of the known oil and gas reserves. It imports about 70% of its oil and gas requirement and this dependence may increase to 90% by 2020 as indicated by the trend in energy usage. Oil and gas are supplied to a great extent by the Organization of the Petroleum Exporting countries (OPEC) and the supply from these countries is expected to increase, especially from Saudi Arabia and Iraq, which shall be able to increase production from their new fuel reserves by 2035.

Storage of crude oil and other petroleum products in unlined caverns is a well-proven technique, with successful implementation in many parts of the world. The Government of India started the construction of underground crude oil caverns in 2008 to store 5.33 million metric tonnes (MMT) of imported crude oil in three crude reserves, based on a 15-day crude oil requirement in all the Indian refineries. Underground storage of hydrocarbons is not only more secure, safe and economical than above-ground storage, but also has several environmental and operational advantages.

Govt. of India through ISPRL brought the idea of creating underground caverns for crude oil as crude oil could be procured in large quantities and brought in VLCC's at lower freight and stored in these large capacity caverns. Transferring crude oil to inland refineries through a pipeline was easier and cost effective compared to transporting products to the consumption points.



View of compartment Size of underground Cavern

Strategic storage will also help in price stabilization as Crude oil can be strategic stocked during low demand and used during high demand. Storage of fuels only in underground unlined rock caverns is currently being implemented in India and locations with the most flexible means of oil and gas transport network have been selected. Storage of fuels in

unlined rock caverns is a mature and well-proven technique that was originally developed in Sweden in order to achieve an advanced protection level against various geo political situations leading to supply disruptions. The storage principle of underground rock caverns has been successfully implemented in several countries including Sweden, Finland, Norway, Japan Singapore and South Korea.

Night View of ISPRL Vishakhapatnam facility

The hydrogeological containment principle ensures that there is no leakage or contamination of underground water bodies. The construction cost of underground rock cavern storage is cheaper than that of surface tanks. As the size of the caverns increases, the cost of the cavern decreases, i.e. the cost decreases with storage volume. The most significant savings in operating

(i) reduced land rent/cost,

(ii) reduced amortization of construction costs,

(iii) considerable savings in insurance costs (reduction of 60–70% when compared to above-ground facilities),

(iv) reduced maintenance cost and

(v) reduced safety requirement and cost. The huge rock mass that is excavated can be used as building material and aggregate for concrete reclamation work.

International Energy Agency (IEA) norms require that each member country should hold oil stocks equivalent to 90 days of net imports. USA, Japan and Korea which are member countries of the IEA have created Strategic Reserves in different types of storages both underground and aboveground. Even though, India is not a member of the IEA but is mainly dependent on imported crude oil for its domestic needs of which large portion of come from the Middle East. It was felt that India had adequate refining capacity and a product inventories could be maintained by the Refineries for meeting the contingencies arising out of supply disruptions.

ISPRL created history by successfully created underground marvels in the country at Visakhapatnam (1.33 MMT), Mangalore (1.5 MMT) and Padur (2.5 MMT). The underground storage caverns created by ISPRL are one of biggest underground activity ever undertaken in the country. The total tunneling carried out by ISPRL is over 30 kilometers with a total excavation of nearly 220 lakh tons of hard rock. The rock debris generated by ISPRL could fill one square kilometer of land to a height over 100 meters. The cross sections of the crude oil caverns crated are as tall as a ten storey building (100 ft). More than 3,75,000 cubic meters of concrete and shotcrete was used which was more than the concrete used in Burj Khalifa, the world's tallest building. The steel used in ISPRL is 40 % more than the steel used for construction of the Iconic Howrah bridge of Kolkata.

Advantages of Underground storage of hydrocarbons

1) technologically proven, more secure, safe and economical, generates less evaporation losses and more environment friendly than above-ground storage.

2) Unlined rock caverns require very low maintenance and safety is in-built as product storage occurs at a depth, which is fully isolated.

3) Hazards on account of sabotage by terrorist activity, war, bombing (nuclear bombs), storms, earthquakes, floods, typhoons, tsunamis, external fires, etc. are minimized.

4) The Surface land requirement is also very low compared to conventional above ground storage. The land requirement for underground cavern technology would be about one sixth of the land required for above ground storage.

5) The life of the underground storage is much longer than above-ground storage.

6) Capacity created is always available for storage as there is not downtime due to maintenance & inspection as required for above ground storage tanks.

7) The facility is usually created beneath barren and non-agricultural land as it requires continuous strata of rock mass thereby saving the precious

agricultural lands.

8) Underground storage facility is created at an almost 50% cost of the above ground facility.

9) Capacity enhancements in underground caverns are achieved at a marginal increase in cost. For an example, if we wish to double the capacity from 0.4 MMT to 0.8MMT, then it could be achieved by an increase in the project cost of only 15-20% however the same is not true in case of above ground storage tanks.

10) ISPRL is aiming to provide storage solutions at most cost-effective rates to all the future refinery projects and its initiatives in unlined storage and would save land requirements for Refinery projects and create storage space at most cost-effective prices.

11) There is a high degree of protection against bombs and sabotage, unlike aboveground storages. Land cost especially near port locations, can be a major component of the project cost for storages

Locations

Vishakhapatnam facility of ISPRL caters to the needs of HPCL Vishakhapatnam refinery, which is connected through a Pipeline and crude can also be transported through Vessels to Paradip Refinery, Haldia, IOC Guwahati refinery, Numaligarh refinery.

Mangalore Facility caters to the needs of MRPL which is connected through a Pipeline and can also be transported to BPCL Kochi, HPCL Mumbai, BPCL Mumbai

Padur facility is designed to take care of IOC Baroda Refinery, and Panipat refinery, HMEL, Reliance, Nayara in Jamnagar, through Oil tankers and can also supply to MRPL through a 36 Kms 42" diameter pipeline.

The Vishakhapatnam facility has two compartments, Cavern A of 1.03 MMT and cavern B of 0.3 MMT . The smaller compartment of 0.3 MMT has been taken by HPCL on proportionate cost sharing basis and the refinery is using it regularly as an alternate storage to refinery.

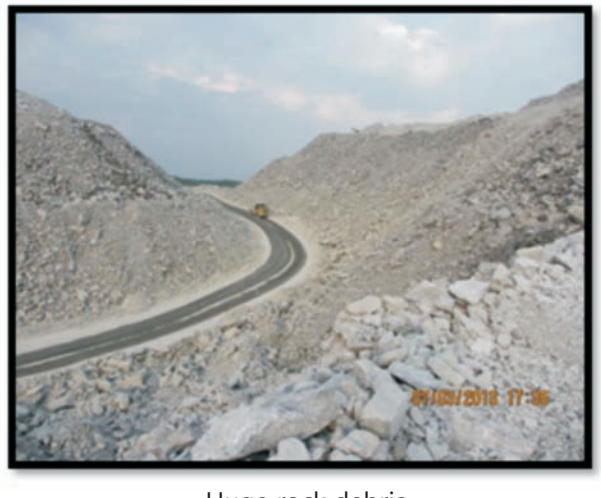
Challenges

There are numerous challenges in creating and operation of the large caverns. The large compartments in caverns can save costs and are excellent for strategic reserves, but can be a problem if commercial use of the caverns is thought of. In a single large compartment only one grade of crude oil can be stored. This restricts the option of use to one particular crude grade to the refinery.

Disposal of rock debris and muck generated during creation of caverns is a major issue which needs to be resolved during project execution stage.

Geology of underground works can change drastically even in geologically stable areas. Geological risk is a major challenge in underground rock caverns.

Water ingress is a concern which needs to be addressed as and when heavy seepage is observed. Rock fall incidents can set back the project timelines drastically.



Huge rock debris

Agreements with Overseas National Oil Companies

The Mangalore facility has two compartments of 0.75 MMT each and one of the compartments has been given to Abu Dhabi National Oil Company (ADNOC). An agreement was signed between ADNOC and ISPRL on 10th Feb'2018 , permitting ADNOC to use one compartment at Mangalore. ADNOC stored approx. 5.8 Million Barrels of crude at ISPRL's Mangalore cavern. It will use part of this oil as commercial to supply its customers in India, while the rest will remain as strategic storage to be released to meet emergencies such as supply disruptions due to natural disaster or geopolitical factors.

For ADNOC, storing oil in India will allow the company to competitively meet market demand in India and across the fast developing south East Asian economies. This is the latest among several investment proposals India is working on to turn its west Asian oil suppliers into strategic investors in the country's oil economy.

MoU Signing with ADNOC for Padur

In addition, ISPRL signed a MoU with Saudi ARAMCO on 28th of October 2019 on the sidelines of the visit of Hon'ble Prime Minister to Riyadh, for sharing one compartment at Padur. Further discussions are underway to convert this MoU to a definitive agreement. Incidentally, Padur facility has four compartments of 0.625 MMT each.

Phase II

The Phase I of storages now provide 9.5 days of cover and OMC's have a total stock of nearly 64 days. So effectively, total days cover available in the country is about 74 days. In addition, the Union cabinet in June 2018, had approved creation of additional 6.45 MMT of crude oil reserves at two locations, Chandikhol in Odisha (4 MMT) and Padur in Karnataka (2.5 MMT) along with dedicated SPM's under Phase 2 of the Storage Program. The Phase 2 is to be done on a Public Private Partnership (PPP) mode. Implementation of Phase 2, will add another 12 days of cover making it a total of 86 days.

FINANCE

Direct Tax Reforms

CA Neetu Vinayek

CA Hiten Sutar

CA Bhagyashree Jain

On 20 September 2019, the Government of India ('GOI') amended the Income tax Act, 1961 ('the Act') vide the Taxation Laws (Amendment) Ordinance, 2019 ('the Ordinance').The amended version of the Ordinance, in the form of the Taxation Laws (Amendment) Bill, 2019, was later approved by the Parliament and received presidential asset on 11 December 2019. The primary purpose of the Ordinance was to bring India's corporate tax rate at par with key competing economies like China (25 percent), Japan (23.2 percent), United States of America (21 percent), Vietnam (20 percent), etc. The tax reforms introduced through the Ordinance shall give boost to various sectors like automobiles, shipping, exports, housing and infrastructure etc. The move is seen as a push towards the government's 'Make in India' initiative and making India a US $5 trillion economy by 2024-2025. The GOI has estimated the revenue impact of new tax rates and other measures under the Ordinance at Rs.1.45 lakh crore. This could increase the fiscal deficit for the year 2019-20 from 3.3 percent of Gross Domestic Product ('GDP') to 4 percent of GDP.

The changes suggested vide the Taxation Laws (Amendment) Bill, 2019 are discussed hereunder:

i) Concessional tax rates

The Bill proposes to provide option of lower rate of taxation to domestic companies to promote growth and investment and attract fresh investments in India. Through the amendments, two new taxation regimes were introduced by the GOI for the domestic companies i.e. Section 115BAA and Section 115BAB, which are discussed hereunder:

Domestic Companies

Currently, a domestic company is chargeable to tax at the rate of 25 percent (plus applicable surcharge and cess) if its turnover or gross receipt does not exceed Rs. 400 crore during the financial year 2017-18 or if a domestic manufacturing company opts for taxability under section 115BA, on satisfaction of certain conditions. In all other cases, a domestic company is chargeable to tax at the rate of 30 percent (plus applicable surcharge and cess).

As per newly introduced Section 115BAA, domestic companies will have an option to pay tax at reduced rate of 22 percent (25.17 percent including surcharge and cess) subject

[1]Surcharge at 7 percent in case income does not exceeds INR 10million otherwise 12 percent
[2]With effect from 1 April 2019 i.e. AY 2020-21
[3]Surcharge of 10 percent in case income exceeds INR 10million

to the condition that the total income of the company is computed without claiming specified deductions, tax holidays, additional depreciation, incentives, exemptions and additional depreciation available under the Act. In case of amalgamation, the amalgamated company, which has opted for new regime, shall not be allowed to set off loss or depreciation, if the same is attributable to prohibited deduction or allowance. Further, the Company would not be subject to minimum alternative tax ('MAT') on book profits.

If the prohibited allowance or deduction is claimed, then the benefit of this new regime will not be available.

With the reduction in the corporate income tax rate, the post-tax returns of the domestic companies would strengthen the financial position and profitability of the Indian companies. Lower tax rates will make India a more competitive arena for future investment. With more funds available with the corporate sector, it is expected that this would allow flexibility to Companies to make capital investments and thereby create employment opportunities in India.

Manufacturing Companies

Section 115BAB provides for reduced corporate tax rate of 15 per cent (17.16 per cent including surcharge and cess) for company's setup and registered on or after 1 October 2019, which commences manufacturing on or before 31 March 2023. Important aspect that should be considered here is that the taxpayer should not be engaged in any other business activity other than manufacture and production of article or thing and research in relation to or distribution of such article or thing manufactured or produced by it.

Similar, to the new tax regime applicable to other domestic companies, the new manufacturing companies would also not be eligible to claim certain tax exemptions/ deductions. Further these companies are required to fulfill following conditions:

i. the business of the new company shall not formed by splitting up, or the reconstruction, of a business already in existence;

ii. the new company does not use old used machinery, which exceed 20% of the value of the total plant and machinery; and

iii. the new company does not use any building previously used as a hotel or a convention centre, as the case may be, in respect of which deduction under section 80-ID has been claimed and allowed.

Non-fulfillment of aforesaid conditions will make the company ineligible for reduced rate of taxation. However, in such a situation, the domestic company can opt to be taxed at 22 percent (plus applicable surcharge and cess), provided the deduction based conditions are not violated. Further, the Company would not be subject to MAT on book profits.

Exercise of option under section 115BAA/ 115BAB

The option to avail the benefit of section 115BAA/ 115BAB must be exercised on or before the due date specified under Section 139(1) for furnishing of first return of income in the prescribed manner. This option once exercised cannot be withdrawn subsequently.

The above amendments would also have implications on the corporate profitability of the companies operating in oil and gas sector. We discuss hereunder certain relevant considerations of the Bill vis-à-vis the impact on oil and gas sector.

i) Whether or not an activity constitutes 'manufacture' or 'production' has always been a matter of judicial interpretations. In order to remove ambiguities, the term 'manufacture' was defined under the Act to mean transformation or bringing in to existence a new and distinct object or article or thing. The term 'production' is not defined under the Act. Hon'ble Apex Court's landmark judgement held that the term 'produce' has wider connation than the word 'manufacture'. Any activity which makes a product marketable and usable to the customer would amount to production.

Gauhauti Tribunal while deciding whether taxpayer's activity relating to exploration of crude oil falls within the definition of mineral oil and whether the same amounts to manufacture

[3]With effect from 1 April 2019 i.e. AY 2020-21
[4]ITO v Arihant Tiles and Marbles P Ltd (320 ITR 79) (Apex Court)

or production activity held that drilling operations for the purpose of production of petroleum would amount to mining activity or mining operation and taxpayer would be treated as engaged in mineral based industry. The Tribunal further held that exploring crude oil for the purpose of refining the same to various by-products would amount to production.

Recently, Apex Court held that bottling of Liquified Petroleum Gas ('LPG') into cylinder amounts to production. The Court held that any activity which brings a commercially new product into existence distinct from original component constitute production. The Court observed that the process of bottling of LPG renders it capable of being marked as a domestic kitchen fuel. This process makes it a viable commercial product only after undergoing highly technical and complex processes as the LPG produced in refinery cannot be directly supplied to the consumer for domestic use.

For availing reducing rate of 15 percent, the GOI has excluded certain activities from the ambit of manufacture or production of article or thing like development of computer software in any form or in any media, mining, bottling of LPG, etc. Since, mining and bottling of LPG is excluded from the list of permissible manufacturing or production activity, the new companies engaged in exploration and production activity or bottling of LPG shall no longer be able to claim the benefit of reduced rate.

Considering, exploration and production is highly risk prone, capital intensive and subject to global competition with high volatility of prices, concessional tax rate would have been a welcome step to boost the oil and gas sector. The sector would hope that in order to boost oil and gas production, the GOI should by way of notification bring the aforesaid activities (mining and bottling of LPG) within the scope of section 115BAB.

ii) India is the second largest refiner in Asia and has been an interesting investment destination for the global Oil companies. It needs to be analysed whether new companies engaged in refining are eligible to take the benefit of concessional tax rate since, products by refineries are not usable without undergoing process to remove impurities and thereby making it a reusable product.

iii) The new companies engaged in manufacture of lubricants, petrochemical business, oilfield equipments and other products can opt for the lower rate of taxation of 15%. Reduced taxation would make these companies competitive vis-à-vis the companies from outside India.

iv) It should be noted that if a company is engaged in any non-manufacturing business, it cannot opt for concessional tax regime. Accordingly, if a new company is engaged in petrochemical activity in first year and in subsequent years undertakes exploration activity, the company will become ineligible to continue to pay tax at concessional rate since mining activity is impermissible activity as per section 115BAB. Thus, to enjoy the lower tax rate of 15 percent, it is essential for a company to carry out permitted manufacturing company. Having diversified business activities (which are not prescribed business activities) may pose the risk of not being eligible for a lower rate of tax under section 115BAB.

v) The new manufacturing companies who does not fulfill the conditions as mentioned above loose the benefit of reduced rate of claim of 15%. Thus these conditions needs to be monitored on yearly basis to avoid any adverse tax impact. For e.g. An oilfield equipment manufacturing company may have old assets valuing 10% of the total value of the plant and machinery in first year of opting the new regime. However, if in the subsequent year the value of old plant and machinery increases to 25% of total value of plant and machinery, the new manufacturing company would loose the benefit of new regime in the year of violation of condition and in all subsequent years.

vi) Provisions of section 115JB i.e. MAT provisions itself shall not be applicable to the domestic company which exercises the option to be governed by new regime. However, the

[6]Assistant Commissioner of Income tax v Oil India Ltd (179 ITD 455) (Gauhati Tribunal)
[7]CIT v Hindustan Petroleum Corpn Ltd (396 ITR 696) (Apex court)

amendment does not provide for abatement or surrender of MAT credit but only restricts companies opting for reduced tax rate from claiming MAT credit. In case a company violates the conditions prescribed for availing the reduced rate, the company would be taxed under the old regime. In that scenario, MAT credit can be availed.

Here it is worthwhile to annalyse as to whether the companies can write-off MAT credits and claim the write-off as a tax admissible deduction.

vii) Expansion of refineries, gas treatment installations, chemical plants, distribution networks and other infrastructure require heavy investment in assets like plant and machinery/ ships. It is important to analyse the beneficial provisions relating to additional depreciation and investment allowance embedded in the current tax regime before opting for beneficial sections providing reduced rate of taxation. Companies should undertake a cost benefit analysis to understand what is more beneficial in terms of tax outflow over a period before forgoing the deductions/ exemptions provided under the provisions of the Act.

i) Rate of MAT for all other companies (including domestic companies continuing to avail tax incentives) is reduced to 15 percent (excluding surcharge and cess)

Conclusion

Reduction in corporate tax rates for domestic companies is a bold and radical measures implemented by the GOI to tackle slowdown in the economy. This kind of impact will have an enduring positive effect on the stock markets, investments and the economy in general. The reduced tax rates should provide major impetus to the manufacturing sector in India. Slashing down the overall corporate tax rates by almost 10% across the board and other favourable factor pave the way for cementing India's status as favourable manufacturing destination against the backdrop of existing global trade dynamics.

Additionally, as most of the companies are already paying tax at the rate of 25 percent, it may not be easy for them to forego all deductions, incentives and accelerated depreciation and switch to new tax regime. Companies, before taking decisions to switch their taxability to new regime, should carry out cost benefit analysis by comparing the possible revenue loss due to relinquishment of deductions and benefits with the possible gains due to reduction in tax rate.

GOI may consider granting additional benefits / deductions to entities operating in oil and gas sector which will propel development of oil and gas sector. To ensure increase in growth and opportunity in the oil and gas sector, fiscal impetus should be provided to the sector.

The information contained herein is of a general nature and is not intended to address the specific circumstances of any particular individual or entity. The views and opinions expressed herein are those of the author.

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[8]With effect from 1 April 2020 i.e AY 2021-22

UPSTREAM

Matured Oil & Gas Field Management – Strategy for Better Volume Realisation

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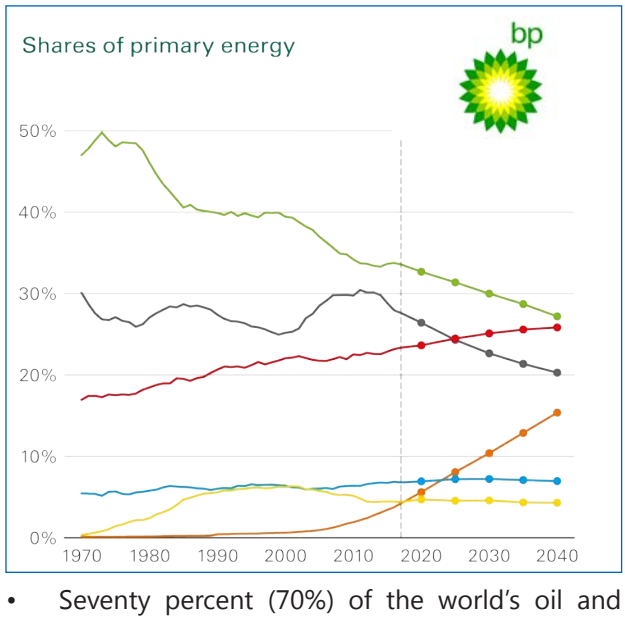
Mature fields account for more than 70% of the world's oil and gas production. Their recovery potential is enormous with 80% of estimated reserves found in the Middle East and North Africa regions, 43% in the Asia Pacific region, and 24% in Latin America. Increasing recovery from mature fields involves extending the life of the well or field beyond the decline curve through secondary, improved and enhanced recovery (EOR) methods. A 1% increase in production could add 2 extra years to the global hydrocarbon supply and help meet future energy demands.

- Most of the recent forecast predicts that the fossil fuel will continue to dominate the primary energy basket till next 40-50 years.Out of that, Oil and Gas will continue to have a share of around 28% each in primary energy basket of the world. Oil % will drop from current 35% or so to 28% whereas gas % will rise from 22% at present to 28% by 2040. Coal will also have a share of 20% by 2040 albeit decline from the current level of 36-38%. Renewable share by that time will reach to 15% or so from the current level of 6-7%. (BP energy outlook 2019). When we look at primary energy demand fuel-wise, Mckinsey Energy Insights 2019 predicts that even by 2050, oil will occupy 29% share, gas 22% share, and coal 14% share with renewable & other fuel type having 34% share. So, Oil and Gas will continue to be on the "majority" or say on driving seat on world energy space for significantly longer period of time. This fact necessitates the next set of "how, why, where" to move forward so as to keep meeting the projected oil & gas demands.



- Seventy percent (70%) of the world's oil and natural gas production is coming from matured fields (IHS CERA). Over the years, world has not been able to add more prolific fields. New fields added over last two decades or so are small and marginal in nature which declines faster and

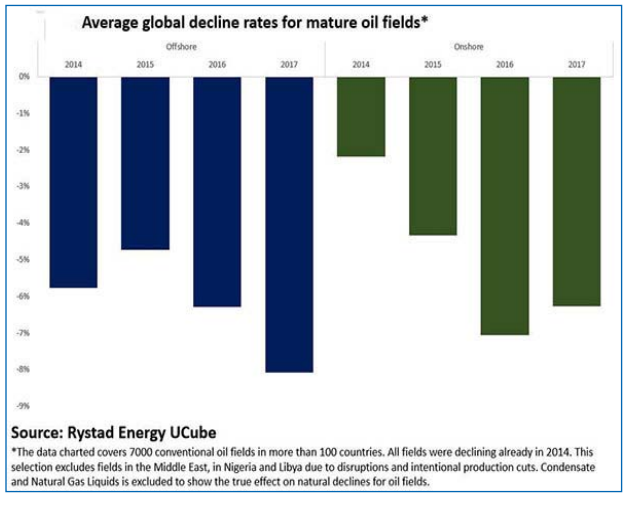
the life-cycle of which does not support further investments. One study reveals the fact that 90% of the fields that are producing oil (around 40,000 fields), is small & marginal field holding just 3% of world oil reserve. 94% of the world's discovered oil reserve is lying in 1500 major fields. And the top 100 oil fields out of this 1500, account for 50% of current production and 65% of reserves. So prolific major fields hold the key for significant contribution to world's oil and gas production.

- Mature fields are still left with huge potential. Majority of matured fields have recovery currently in the range of 20-30%. With current set of technologies & wisdom, we are considering the average recovery factor of matured fields being 70% for gas and 35% for oil. But with new set of tools, technologies, techniques and paradigms, we can work on those matured fields to raise its ultimate recovery factor by another 20% or more. i.e we can go up to recovery factor 90% for gas fields and 55% or so for oil fields based on the reservoir complexity. We have seen this to happen. Strajford field in Norway has seen recovery factor around 70%. Prudhoe Bay in Alaska is seeing recovery around 50%. So a huge potential is still left to be exploited.

EXPECTED OIL RECOVERY EFFICIENCIES

	Original oil in place, %
Primary methods	
Liquid and rock expansion	Up to 5
Solution gas drive	20
Gas cap expansion	30
Gravity drainage	40
Water influx	60
Secondary methods	Up to 70
Gas reinjection	
Waterflooding	
Tertiary methods	Up to 80
Thermal (steam, combustion, hot water)	
Miscible (CO_2, HC gases, N_2, flue gas)	
Chemical (polymers, surfactants)	

- Matured fields are declining faster. One study by Rystad Energy Ucube reveals that fields have declined at much faster rates in 2017 as compared to 2014. Offshore fields have decline of - 8% in 2017 as compared to – 5 % or so in 2014. Onshore fields also have decline of - 7% in 2017 as compared to around -2% decline in 2014. This has primarily because of lower level of activities (like drop in drilling activities) in already-declining field. This faster decline in matured fields is an area of concern: from technological perspective in terms of how to contain it and also from the perspective of world oil market dynamics where projections & planning have been done considering certain percentage of field decline.



- With consumptions outpacing production in a big way, we have left with no choice but to indulge and recommit ourselves to the mature fields. Increasing recovery from mature fields involves extending the life of the well or field beyond the decline curve through secondary, improved and enhanced recovery (EOR) methods. Simply boosting the recovery factor of the world's existing oil fields by 1% would provide for two to three years of worldwide consumption. The share of oil & gas in world's primary energy basket will have substantial bearing on the way we ensure additional percentile recovery from the matured fields. So we have to keep raising our bar over recovery factor realisation by keep applying ourselves periodically & continuously: technically, scientifically and with right kind of management wisdom & interventions at right time.

Handling matured field in the declining phase is a different art and science and a different game altogether.

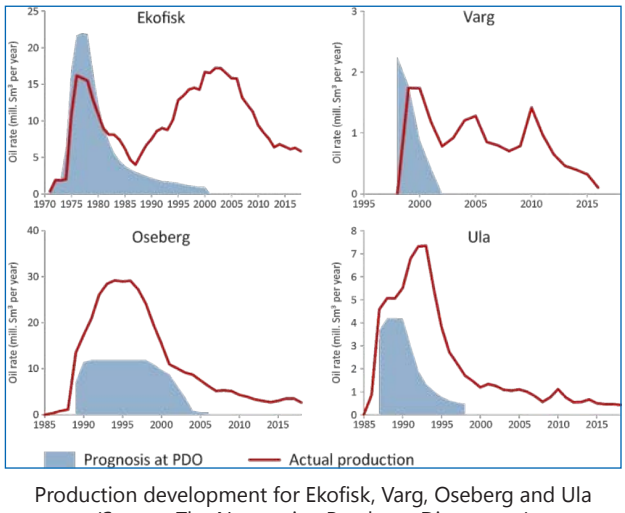
Each matured field is different. Each field has its own reservoir and sub-surface characteristics and requires different set of thoughts, actions, strategies, stipulation and dispensations to bring to the surface whatever can be brought (recovered) economically, safely and viably.

Each company is struggling containing the decline that is happening much faster now. Yet they are busy in devising the doable propositions in the backdrop of present set of technologies, wisdoms and dispensations. With the kind of understanding, knowledge and expertise which world has acquired by now and the learning made over these years in the matured field, I am sure each one is busy charting their next course of action. For each them matured field is the bread & butter and on one would leave any stone unturned to see that they survive and flourish for significantly longer time in future.

With over 40 years of working with this industry, I have jotted down few submission for the larger fraternity to kick-start the momentum.

Changing perception is the very first step. Start treating matured field as Potentially Young; not old enough

Why we call field matured when a significant and huge potential is still left out to be exploited and when still there exists possibilities of adding new reserve resources in that field (reserve augmentation). Whether a field is matured or not depends on several factors like type, size & complexity of the reservoirs, exploitation strategy, recovery percentage, technology adopted and yet to recover hydrocarbon reserves etc. So, we should start treating the matured fields as potentially young fields to leverage the huge potential still left out there and to keep producing for significantly longer time through various measures of technology & innovation. Let me explain:



Production development for Ekofisk, Varg, Oseberg and Ula
(Source: The Norwegian Petoleum Directorate)

The field-life cycle was offshoot of the then peak oil theory. What were propounded in late 70s and early 80s is definitely not valid today. Declining production and end of field-life after certain years were the things that have been conceived and calculated a long back when technologically "much" were not known about this industry, particular the sub-surface issues. With every passing day, a lot of new learning were made about a particular field and/or about a particular reservoir. And based on the new insights and new inputs, field life went on prolonging. With passing time, we kept on adding new reserves, new layers, and new sub-layers within the same reservoir block thereby kept extending the "1P", "2P" & "3P"reserve numbers. Economic limits of the field also witnessed good extensions and with evolving & commensurate technologies, the viability of producing from the field kept on getting "favourable".

See the graph. How with time and with more understanding of field behaviour improves the production –life-cycle.

Majority of 30-40 years vintage fields are still having recovery factor in the range of 20-30% or so. With new technologies and new paradigms, many a fields having similar reservoir characteristics & vintage has achieved recovery up to 60% or so (Norway North Sea fields, ONGC fields Ankleshwar&Gandhar at Gujrat). With new set of tools, technologies, techniques and paradigms, we can work on those matured fields to raise its ultimate recovery which can go up to 90% for gas fields and 55% or so for oil fields.

We have seen this to happen. Fortis field is still producing. Fortis field that started production in 1975, got sold to Apache by BP in 2003 when its production went down to around 35000 bopd from the plateau production of over 500,000 bopd (1978). Apache Corporation initiated an intensive re-evaluation of the field and added further 800 MMbo in its reserves. By undertaking various efficiency measures and installing new equipment, it has brought new life to the field which is now producing 70,000 bopd and is expected to be still pumping oil

for the next twenty years. Prudhoe Bay in Alaska is seeing recovery around 50%. Stratjford Field which is heading towards the recovery of over 70% is an example of how new techniques, technologies, applications and integrated approach can extend the field life and recovery from the field. Back home in India, the way we have extended the field life and recovery factor of Mumbai High field, the giant Bassein sour gas field, the Raava field, and the Ankleshwar & Gandhar fieldsand with the huge potential still left in those fields, speaks volumes challenging the usual notion of fields being classified as matured. So we can raise our bar over recovery factor realisation by keep applying ourselves periodically & continuously: technically, scientifically and with right kind of management wisdom & interventions at right time.

Start thinking matured field as Potentially Young (instead of old) and then start re-writing the investments and deliverables.

So huge scope still exists in the prolific mature fields to maximise the recovery. What we are talking is Ultimate recovery. When we take Original Oil in Place (OOIP) in consideration, there exists another huge scope of converting the OOIP into Ultimate Recovery category. So matured fields still have a huge potential ready to be exploited by applying new set of intent, content and direction. One such thing to start is start thinking those matured field as YOUNG and then start re-writing the investments and deliverables.

Technology holds the key. Disruptive technology will bust many a myths of matured/brown field.

Small measures applied so far, technologically & otherwise, have fetched us only a marginally increased incremental volumes. The bigger volumes from the brown fields still left with huge potential requires much bigger 'Technological Interventions". We require technology and/or mind-set or the wisdom that has to be "Disruptive". Horizontal Drilling technique or segmented completion in multi-layered Mumbai High field in India were such disruptive technology we have embarked upon when we started our journey of redevelopment in early 2000s. Intelligent completions, synthetic based mud formulations, etc. were few other disruptive things that we applied during our redevelopment efforts and got good success. Exploiting Mangala heavy oil field in Rajasthan through polymer flooding from day one was another disruptive thinking.

Now what will be the next degree or scale of "disruptive technology" for particular field or reservoir, the experts, the institutes and all the stakeholders has to work upon intensely, cohesively and convincingly. And it will not come in a day or in a year either. We have to give sufficient handholding and good enough gestation period for the "Disruptive technology" to get conceived, to get evolved and most importantly to get applied successfully. With no new major fields coming in our fold either locally in India or globally across the world, the existing brownfields having huge potential left will continue to be saviour for oil & gas production numbers across the world for significantly longer time in future. Bringing in few "disruptive technologies" are the only option left to bring bigger volumes from the existing brownfields. The last Davos summit has seen talks by various industry leaders for the need of disruptive technologies in their respective areas. Our industry also needs that. And, introduction to "Disruptive Technology" is not fence sitting enjoying sport. All stakeholders have to participate on field to make it reach its winning conclusions.

Make technology accessible, customised and cost effective "picking-from-the-shelf phenomenon"

Technologies have given us many a breakthrough. It's the time for more innovation and more investment in R&D to bring out better solutions for complex field problems and to exploit more oil & gas. By doing this, we can do justice to the huge potentials available across the globe across the geographies.

And then we have to address this requirement of "customised" solutions. Every well or a group of wells are behaving differently from another set of wells within the same matured field. And for different matured field, you can imagine the scale of differential behaviour. Field-wise, layer-wise, sub-layer-wise, reservoir dynamics are changing and the change is definitely not the uniform for all matured fields. Obviously, any intervention in the field and the well has to be field and well specific. Rather, the time has come to move from the "field" concept to "well" concept and articulate all our technology interventions "well-specific". But then, it is easier to say than done. Task is quite huge. And the cost of such exercise is also very huge given the kind of R&D it will invite and kind of premium the "domain expert" will seek.

Massive drive towards Reservoir Pressure Maintenance Exercises

Water injection not only help reservoir pressure maintenance but also helps in bettering reservoir parameters like porosity, permeability & crude quality (avoiding asphalting), thereby improving fluid withdrawal per well. Lifting the more liquid should be the focus by augmenting & maintaining reservoir pressure and by regulating gas production.

Water injection is important. For example, see how effectively it worked for the Ekofisk field. Field was originally produced by pressure depletion and had an expected recovery factor of 17 per cent. Since then, comprehensive water injection has contributed to a substantial increase in oil recovery. Large-scale water injection started in the field in 1987, and in subsequent years, the area for water injection has been extended in several phases. With this, the expected final recovery factor for Ekofisk is now estimated to be over 50 per cent. In addition to the water injection, compaction of the soft chalk provides extra force to drainage of the field. Field is betting big on water injection to improve its recovery further, by installation of the subsea injection template recently in 2019. Reservoir pressure maintenance through water injection and gas injections has played a very effective role in sustaining and maintaining the productions in Osberg, Troll, Strajford and many other such fields which are currently boasting of high recovery factor. In India also, all major fields are sustaining its production primarily on the back of massive reservoir pressure maintenance exercises that they have pursued over the years and still pursuing. Ravva field has gone for full scale water injection that has resulted in recovery of 60%. Panna field had not pursued water injection. This resulted in recovery only by 27% for the field. Team Panna relied more on their drilling efficiency.Geleki field is still having a very low recovery factor in absence of requisite water injection. Western Offshore fields of ONGC are also on water injection.

Efficient & Effective Water Injection continues to be the key for maximising recovery from mature fields.

Needed injectivity for the given well has to be ensured.

Else, the game is lost.

The paragraph above outlines how important reservoir pressure maintenance exercise is. So we must pursue it across the reservoir with objective of lifting more liquids, albeit carefully to avoid bad water breakthrough. Our mature fields are producing more water than oil and the phenomenon is similar worldwide across all mature fields Inefficient and ineffective water injections lead to increased water cut that in turn affects our lift operations and increasing our lifting cost.Improving the efficiency & efficacy of water injection programs in our field is still a challenge and requires a new paradigm, wisdom and technology to accelerate our efforts. Redistribution of injection water, profile modification, relocation of injectors, drilling of additional injectors, workover of injection wells are some of the area that requires focussed attention towards containing bad water breakthrough and for better liquid off-take from the well. Going for Life of Field Seismic (LoFS), as applied in Eckofisk field, will help in better water-flood monitoring and reservoir management. We also have to address the issue of justifying returns for the huge capex (and opex as well) that will be incurred towards water injection efficiency improvement pursuits. Our geo-scientist has to apply themselves with more insights into reservoirs to tell how much extra volume will get produced (after duly factoring-in the reservoir uncertainty & probability) once we harp upon planned water injection exercises. A tough task but it is a necessity and requirement now in the backdrop of squeezed funding and new oil-market-price dynamics.

Persisting with Redevelopment in short to medium terms(with EOR being long term proposition)

Redevelopment (and rolling redevelopment thereafter) of the existing field is still the most preferred low risk option worldwide to improve production number as reservoir and deliverables are pretty known. It helps in offsetting natural decline and then to get incremental oil volumes. If we do not pursue IOR /Redevelopment, natural decline itself will strip around 7-8% of our existing production volume on annual basis. So, redevelopment is the way through which world is engaged in offsetting this decline and sustaining the production and improving it further.

In North Sea (both UK side and Norway side), redevelopment efforts along with pressure maintenance through water injection and gas

injection & WAG, has helped sustaining their production numbers and improving the recovery. Ecofisk, for example, has maintained its production through continuous water injection and drilling of new production and injection wells. The Ecofisk Life of Field Seismic (LoFS), installed in 2010, helped in providing data for water-flood monitoring and reservoir management as well as observation of dynamic changes in overburden. On the back of all these has led to ecofisk' recovery factor over 50% or so. Though it is also a fact that over the years, Norway offshore has seen additions of many a small new fields year after year on regular basis that has helped them in sustaining and reviving the production. From 151 fields in 1975-2000 period, 102 more fields got added in between 2000-2009 and 68 more fields got added in between 2009-2018, making total 321 fields (oil, gas & condensate fields) producing at North Sea UK continental shelf. Similarly, around 23 small & medium sized fields were added in Norway North Sea since 2012, helping them reversing the decline from 2011 onwards that were set-in between 20001 and 2013. They are further working on 150 more projects to improve recovery from existing fields. Addition of the new fields provides the much needed cushion in sustaining the production while undertaking many a revamp, repair, refurbishment, and other field-development plans and field-integrity exercises (that warrants significant shutdown periods) that companies apply in matured fields in extending their field-life.

Our geo-scientists and reservoir-engineers has to apply themselves with more insights into reservoirs to tell how much extra volume will get produced (after duly factoring-in the reservoir uncertainty & probability) once we harp upon planned water injection exercises. A tough task but it is a necessity and requirement now in the backdrop of squeezed funding and new oil-market-price dynamics

All major players in India has followed the similar trajectories in sustaining their production after the peak happened to their fields: rolling redevelopment, reservoir modelling, locating by pass oil, infill drilling, adding new layers and sub-layers, producing from new zones (un-swept and bypass areas), massive reservoir pressure maintenance exercises and applying suitable EOR techniques and pursuing many a production optimisation activities like deeper gas lift injections etc. In ONGC, about 1/3rd of its total domestic production is coming from the 27 redevelopment projects that the company has been pursuing in phases since long. The redevelopment plans applied in Raava Field (PKGM1) and Cambay field (CB/OS-2) of Cairn India has helped company come of its declining production phase. Oil India has also made huge investments (around 4000 crore in last 5 years) into IOR & EOR schemes.

Experience, however, has shown that though redevelopment has helped, subsequent redevelopment has shown diminishing returns in terms of oil volume fetched per unit of investment made and in terms of withdrawal per well. This is a geo-scientific challenge and the Geoscientists & Sub surface engineers are working hard to reverse the phenomenon.

Pursuing well-by-well approach to improve well productivity

It is important to look how we can improve the well-productivity of the base wells in the scenarios in fields that have been subjected to a number of rolling redevelopment schemes. Every drop of liquid production changes the reservoir fluid and pressure distribution characteristics. Ensuring its current status or working in real-time is important. Reservoir needs to undergo frequent reservoir studies and that too for substantially for longer period. This will lead to immediate production loss due to well closures for such a huge studies/actions. This will further lead to enhancing logistics, particularly for offshore, to ensure timely and frequent visits

Mature fields, therefore, requires a well-by-well analysis to device suitable well intervention plans and techniques. This will necessitates coming together of a host of functionalities and domain together and arriving at a doable proposition in true multi-disciplinary environment: Well Re-Engineering + Reservoir Re-Engineering + Monitoring & Control Re-Engineering + Data Analytics Tools & Software + Technology so as to Maximise the recovery potential of each well and lowering the cost per BOE.

WELL RE-ENGINEERING

+

RESERVOIR RE-ENGINEERING

+

MONITORING & CONTROL RE-ENGINEERING

+

DATA ANALYTICS TOOLS & SOFTWARE

+

TECHNOLOGY

=

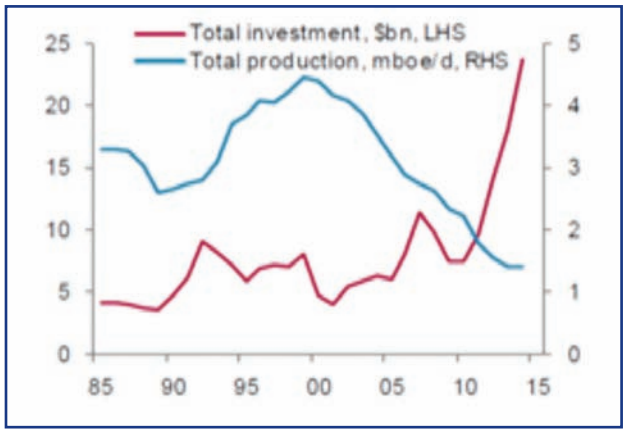
TO MAXIMISE THE RECOVERY POTENTIAL OF EACH WELL AND LOWERING THE COST PER BOE

Debottlenecking at Surface Facilities and improving efficiency of process and operations

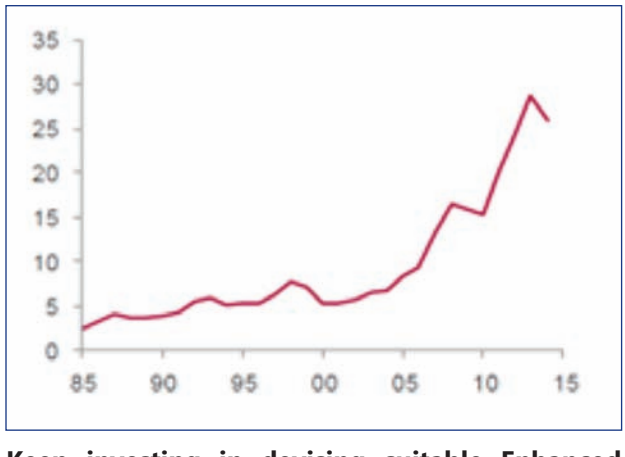
To produce the potentially young matured fields, the life of surface facilities need to be extended in such a way that the field can be produced safely for another 20-30 years. For this, we have to plan the endeavours to do debottlenecking at Surface Facilities and improving efficiency of process and operations. We can ensure this through Reconstruction & Revamping Projects, Rolling Pipeline Replacement Projects, Life Extension of Well Platform project and through many a projects directed towards improving the safety, integrity and longevity of process, operations and maintenance and other inter-& intra-field activities. This will necessitates repair, replacement, retrofit, up-gradation of many a facilities, system, sub-system, auxiliaries and ensuring a seamless-whole thereafter. Adequate provision of shutdown and loss of production days has to be kept in plans and formulation while calculating the expected yearly production numbers from the field.

Huge investments will be required; Plan it judiciously avoiding over-activities and by following the standardisation

Fact remains that remaining oil reserves are not an easy oil. Producing next volumes now requires huge investment. Huge Technology Infusion required to improve well productivity and reservoir pressure maintenance. Cost of operations are increasing every subsequent years in matured field, primarily owing to high water cut & high GOR of the field and also because of huge expenditure being incurred in improving the structural, operational and process integrity and safety of platforms, pipelines, wells and equipment and also on pursuing many a development and production optimisations exercises.



Look at the development spending at UKCS (upper graph) & NCS (lower graph) at North Sea. (Source: Oxford Institute of Energy Studies: Has the North Sea entered the late-life crisis; Dec2015). Maximising production from mature field is really a huge challenge knowing the fact that matured field requires much bigger investment. For justifying returns, industry has to take a call in ensuring many expenditure cuts that are unnecessary; particularly stop over-engineering (engineering and design template becoming known & so obvious over these years) and resorting to "fit-to-purpose" development plans. Following the "Standardisation" will help rationalise the expenditure.



Keep investing in devising suitable Enhanced Oil Recovery Techniques and towards its cost-effectiveness

Secondary recovery techniques through which the world is largely engaged in maximising production volumes from matured field can give us a recovery

only up to a limit. Beyond that next big incremental volume from mature fields will come only from EOR. After primary and secondary oil recovery, up to 75 per cent of oil may be left in the well. Next big incremental volume from mature fields will come only through EOR techniques. So while it is important that we keep upgrading our tools, techniques, thoughts on secondary recovery and improved oil recovery fronts, it has now become essential to keep engaged ourselves on making EOR techniques a reality in big way. Else we will be leaving the field for "abandonment" without bring to the surface additional 10 to 15% which EOR can bring from that field.

EOR processes are therefore key to boost oil production in mature fields. EOR techniques and formulations are field specific, layer specific, zone specific and requires huge R&D besides the huge investments. EOR is a long term Game but it has to be played sooner or later to exploit the full recoverable potential of the matured field. It is 10 years plus time-frame game from concept to implementation.

EOR is still not deployed predominantly in the world. Its application and success has mostly been in Sandstone Reservoir. Carbonate Reservoir yet to see wide deployment of EOR. Just to drive home a point, by 2010, of the 1500 EOR projects which world was engaged into, either thermal or chemical or gas injection (co_2) methods, 78% was there in sandstone reservoirs and only 18% is there in carbonate reservoirs (SPE paper 130113, April'10). And to my understanding, application % has not changed much thereafter.

EOR Techniques deployed so far is contributing only less than 5% of the total oil production of the world. USA is fetching maximum from EOR. In USA, 5% of its annual production is coming from EOR (Thermal & carbon dioxide). Cantrell field, USA is producing good with gas injection (continuous or WAG) N2 flooding. Midland Farm Field, Texas, USA, is also doing well with Polymer Flooding (Surfactant Polymer). High Pressure Air Injection (HPAI) method is seeing steady rise in use in USA light oil carbonate reservoir in Montana, North Dakota and South Dakota. Venezuela (Thermal & CO_2), Canada(Thermal & CO_2), Indonesia (Thermal), Libya (CO_2), China (Thermal, CO_2, Chemical/Polymer) are some other countries who are harping onto EOR bus to accelerate their field productions.

EOR still continues to be 10 year game from Concept-to-Rollout and Hugely Expensive.

Technology needs to Evolve Further.

For India, many EOR has been applied in its onshore and offshore fields. Polymer Flooding in Sanand Field, In-Situ Combustion (ISC) in Santhal, Balol&Lanwa Field, WAG in Gandhar field, etc has seen good success. Mangla field EOR (Polymer +Alkaline Surfactant Polymer) is a huge success. In Offshore field, which is primarily a carbonate reservoir, ONGC has tried SWAG and WAG techniques but it has not met the desired success. Currently, ONGC is working on Low Salinity water flooding (LSWF) which has recently emerged as a potential EOR technique for both sandstone and carbonate reservoirs. The enhancement in recovery factor and production depends on the characteristics of the reservoir. Geo-scientific study suggest additional 1 to 2 % recovery (of in-place volume) from this technique is feasible from this technique. Pilot Scheme has been finalised for Mumbai High Field which is expected to be in place by April 2021. The process will be extended to the whole field in future based on the pilot results. ONGC is also in process of putting many EOR schemes in its onshore fields like In-Situ Combustion at Santhal field, Alkaline Surfactant Polymer (ASP) Flooding in Viraj field, Polymer Flood Pilot in Bechraji field, Cyclic Steam Stimulation (CSS) Pilot Lanwa field, Miscible gas injection in Gandhar field (GS-12) and Immiscible WAG injection in GS-9 and GS-11 sands.

EOR is energy intensive and very expensive in terms of upfront investment costs. In particular, the much talked about CO_2 EOR projects which has been successfully used in 136 projects onshore in the USA, along with projects in Hungary, Croatia, Turkey, and offshore in Brazil. This CO_2 EOR requires huge investments and hence the huge incentives as economic modelling suggests. For example, developing each CO_2 EOR project in Central North Sea Fields require at least £1Billion in risked up-front investment costs. Oil Pricing and its sustainability is a big consideration to ensure project feasibility for any EOR project, in particular CO_2 EOR. Economic Modelling done for Central North Sea fields (by Professor Alex Kemp at Aberdeen University) suggests that incentives & free supply of CO_2 at site, along with an oil price of at least $90/bbl (alternative

studies suggest $70/bbl oil with low risk models) are required for CO_2 EOR for the period 2020-2030 and beyond to remain viable and it is the key enabler for success of the project.

So, government support and incentives are a prime requisites to enable any EOR project. Many countries are providing the needed support. For example, in Malaysia, Conventional Production Sharing Contracts (PSCs) amended to Progressive Volume Based (PVB) terms. PVB terms provide progressive profit sharing incentives to contractors to improve oil recovery and increase production as the risk & cost of developing and producing from mature fields becomes progressively higher over lifetime of the field. IRAQ rewards high production performance in mature fields with fixed fee per barrel incentive combined with agreed production targets that demand operational excellence. In UK, Mexico, Trinidad and Tobago, different forms of abatement and models of tax breaks are there like tax discounts on HC produced from Mature fields and Investment Tax Credits on capital expenditure. In Norway, Norwegian Petroleum Directorate (NPD) promotes R&D and awards a price for "Willingness and Creativity" for IOR. They engage themselves in advice on possible changes in frame conditions and other measures to achieve EOR like Tax reductions and Tail-end production pricing. In USA, Department of Energy (DOE) is funding significantly 19 CO_2 EOR projects that are being developed. UK is studying Woods Panel recommendations set by Govt. in 2014 for incentivising North Sea EOR projects. In India also, companies are looking for massive institutional & academic tie-ups for requisite R&D along with Government supported Joint Industry Program. They are also looking forward to Fiscal & Tax incentives for technology deployed and Different pricing for crude fetched from EOR schemes and a host of other Incentives to move significantly forward on EOR front.

Government Support, Incentives and resilient tax & fiscal regime is required for EOR projects to succeed and to widen its implementation.

Thankfully, Government, Industry and Academia is engaged.

In India, last year Govt, as a part of policy reform and to boost production ,has announced a new ER policy which says waiving of of 50% of the cess for incremental Oil production from the designated well and waiving of 75% of Royalty from incremental Gas production from designated wells of ER project.

Data analytics and forecasting coupled with incisive market & business-intelligence will help delivering larger volume safely and efficiently justifying the huge investments that will accrue.

End-to-end-digitalization and life-cycle-approach-digitalization is very important consideration for managing the matured fields. Though industry has embraced digitalization since long back and across all functionalities and across the entire value chain, we need to reassess whether our industry is in "sync" with the fourth industrial revolution that has start happening.

Though big data, technology, and digital innovation has been part of Oil and Gas industry since long led by early leaders in this direction like Statoil (North Sea), Saudi Aramco (across their entire value chain), Petronas and Conoco Phillips, ADNOC etc penetration has not been so significant. For example, a single drilling rig at an oilfield can generate terabytes of data every day, but only a small fraction of it is used for decision-making. Fact is that the way other capital intensive industries such as aviation and automotive have pushed themselves ahead with revolutionizing their business and operating models through a holistic application of digital technologies, the Oil and Gas industry has failed to leverage the transformational impact of digitalization to that extent.

Look at the some numbers: Around 36% of Oil and Gas companies are already investing in big data and analytics. However, only 13% use the insights to drive their approach towards the market and their Competitors. One study find that today, only 3-5% of oil and gas equipment is integrated and less than 1% of data is utilized to make decisions, leaving companies with significant potential to optimize assets and operations(World economic forum: report on Digital Transformative initiative Oil & Gas Industry, Jan 2017). Out of 93mln bpd of oil output, only 9-18mln bpd come from oil fields that are digitally enabled (Source: Ernst & Young "How ready are your assets to perform in the digital world?"). Top national oil companies, which are responsible for 40% of world oil output, produce only 15% of output using digital technology. (Source: Ernst & Young "How ready are

your assets to perform in the digital world?"). Oil & gas companies are yet to embed big data and analytics completely in their systems and they are just applying them piecemeal. This traditional approach of selectively adopting a set of technologies and implementing digitalization unsystematically will not serve our purpose. It will augur well if oil & gas industry pursue a revolutionary agenda with digital as a backbone and pursue full-scale deployment to have far-reaching impacts on productivity, operations, efficiency and cost reduction.

New digital technologies combined with data-driven insights is required to transform our operations, to boost agility and to improve strategic decision-making ability. Automation, robotics and remote operating capabilities has great depth to transform how Oil and Gas companies will operate in future. For example, by leveraging IIoT (Industry Internet of Things) could connect end-to-end operations across the life cycle of a well and ensure that all systems are communicating across the industry. IIoT can help optimization by enabling new operational insights through analysing diverse sets of operational data such as drilling parameters, and cross-disciplinary data such as geological models. Similarly, Advanced Analytics and Modelling can enables companies to quickly and automatically produce analytical models (e.g. reservoir models, drilling plans and production profiles) that can analyses bigger, more complex data, and deliver faster, more accurate results, even at a very large scale. Likewise, digitalization can help having connected workers. Providing workers with on demand real-time push and pull information through mobility apps and wearable technology can give them access to the right information at the right time, so they can make more proactive decisions, enhancing productivity and reducing costs.

Having said so, the task is not easy. To unlock the full potential of digital transformation, the Oil and Gas industry needs to tackle a series of historic and structural inhibitors.But then, we have no option but to keep riding on the current and next wave of digitalization and analytics.

To conclude,

"Revitalisation to what extent" is an important considerations that we have to make while approaching a mature field. Knowing what "recovery percentage increase" we are looking for is important. It involves huge cost. So "spread "needs to be worked out. It will serve our purpose better if we take the task in "tranches" and move working towards revitalising small areas rather than the full field at one go. "Appropriateness" & "Suitability" for our chosen target holds the key for ensuring further momentum. Also as the technology spread is across a host of functionalities and domain, creating synergy and integrating all domains to arrive at a workable proposition will be tough and pose a huge challenge.

What I feel personally that all the things which I have just written about is just a fraction of the big exercise which we have to undertake towards creating more value from the matured fields. This will require "Rebooting" our efforts in matured fields to next level. We have to see whether our industry has "Rebooted" itself sufficiently, particularly in area of Brown field management? We felt that a lot is left to be done given the remaining potential which still can be brought to the surface in much bigger volume terms. Our task, obviously, is much more complex and linear equations normally does not work here. Complex algorithms with many a variables so comprehensively interlinked to each other makes our exercise a really tougher one to devise a formulation and solution that fits into larger shoes and the one that resonates the requirement of time and the field.

Compounding our problem is the fact that the variables kept on changing so fast in the matured field that by the time we devise formulations and solutions suitable for our cause, the cause changes itself. So this changing dynamics makes our task further challenging: devising solutions "in-time" and the one which is exclusive to the cause or problem which we are addressing and inclusive of the higher aspirations that our industry is expecting from mature fields.

At the moment, momentum definitely is not matching the requirement of enhancing production & creating value from mature fields. Management interventions and strong technical leadership will pave the way we should approach our mature fields. That's why I have stated early in this article that "managing matured field is an art and a science both. "

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OUTLOOK

India's Energy Sector – An Overview

Vivek Dua,
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In this article, we discuss the uncertainties, potential trends, and implications for India's energy sector. We also take a look at how the energy transition and other disruptions will impact the downstream industry, and we examine the challenges and opportunities that will shape the future of refining.

The future of refining in India

The global outlook for oil refining is challenging. The certainty of growth has faded, and many expect to see a peak in oil consumption. Looking ahead, Asia and India will drive the growth of liquids. However, to meet the demand for traditional sources of energy while also preparing for the imminent transition to renewable sources, India's oil and gas companies will need to simultaneously add capacity while also future-proofing their investments and business models.

The global energy landscape

Throughout the 20th century, the demand for energy has been escalating—fueled by the world's expanding population, greater urbanization, and steady economic growth (see figure 1):

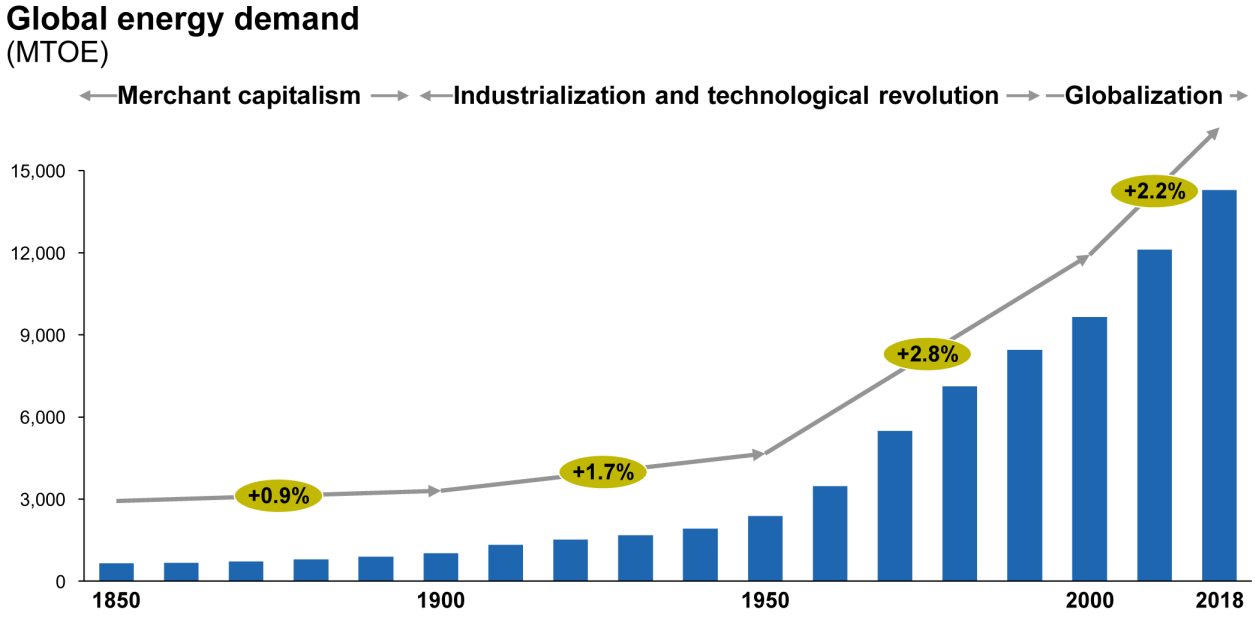


Figure 1: Energy consumption has been steadily rising

Population growth. The world has been expanding. From 1850 to 1948, the population grew from 1 billion to 2.5 billion, allowing for slow but balanced growth. But by 1973, the young and rapidly growing population reached 4 billion. Although the pace has tapered off since then, the world is now home to 7.7 billion people.

Urbanization. In 1800, less than 10 percent of the world lived in areas with a high population density. But the urban population has grown from 751 million in 1950 to 4.2 billion in 2018, with the United States and Japan leading the way. By 2050, 68 percent of the world is projected to live in urban areas, according to the United Nations.

Economic development. The world has enjoyed relatively steady economic growth. From 1950 to 1973, the GDP growth rate was 4.9 percent, led by Europe. From 1973 to 1983, it dropped to 2.9 percent, primarily because of the recession in Western economies, but it rose again to 3.5 percent from 1991 to 2015, led by Asia. Over the past 50 years, global GDP growth has been a robust 4 percent, driven by an expanding workforce and productivity improvements. Energy policies and industrial development have also fueled this growth and contributed to the rising demand for energy.

Amid these macroeconomic shifts, global energy production has changed in terms of both quantity and sources. Demand has fluctuated, and the energy mix has evolved from traditional biofuels to coal to oil and gas (see figure 2).

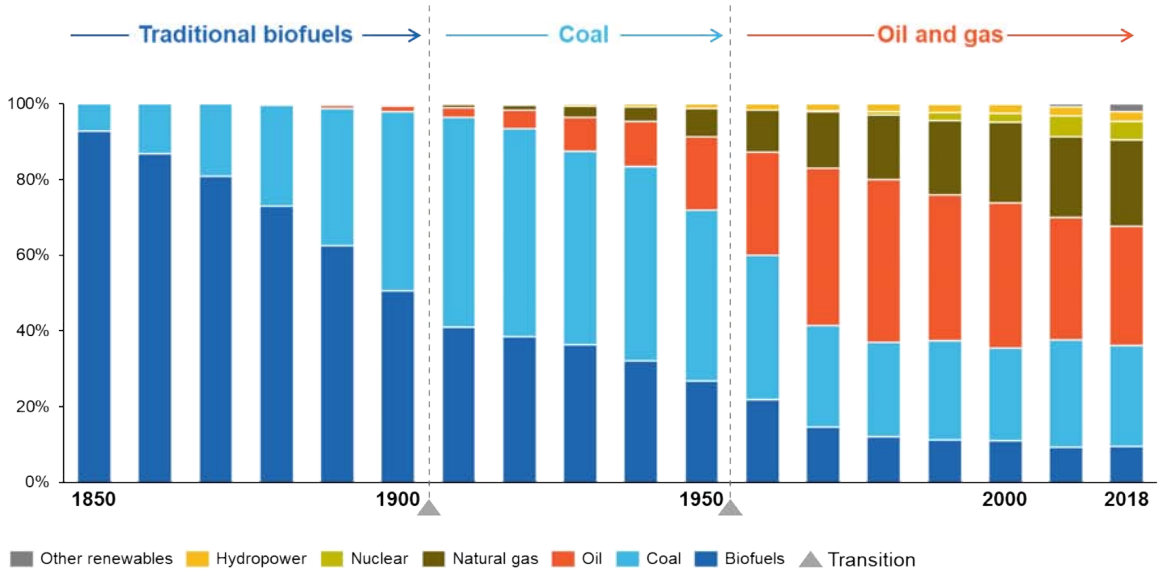


Figure 2: The global energy mix has evolved

However, with the focus on climate change and environmental impact along with rapidly changing growth dynamics encouraging a transition to cleaner energy, the future will look much different. Four moves can impact energy production, distribution, and consumption:

- Improve energy efficiency by addressing all elements of the energy value chain.
- Switch to sustainable non-fossil fuels such as biofuels and nuclear energy.
- Take advantage of cleaner and more sustainable renewable technology.
- Capture and store the carbon generated by energy consumption so less is released into the environment.

The share of oil in the energy mix and the growth forecasts will depend on how the future unfolds. Three scenarios reveal the range of possibilities (see figure 3):

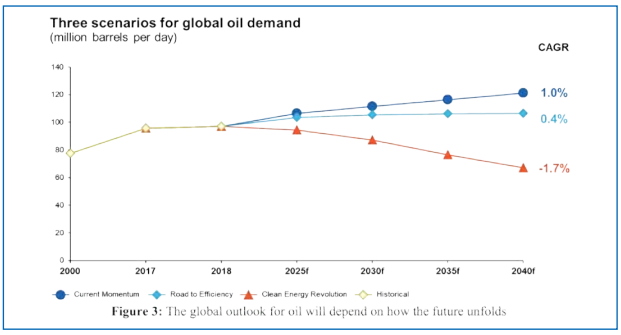


Figure 3: The global outlook for oil will depend on how the future unfolds

Continued Momentum. In this business-as-usual scenario, there is no discernible change in policies, which puts more strain on energy security. The technological evolution continues on the current trajectory with no significant disruption, and policies are not well-coordinated.

Road to Efficiency. In this scenario, efficiency measures drive energy growth, and the energy mix moves toward sustainable sources. Government action is coordinated to adhere to policies and targets, enabled by technological disruptions.

Clean Energy Revolution. In this scenario, the transition to clean energy accelerates to meet goals related to climate change, universal access, and clean air. Environmental imperatives and technological disruption shift the world energy order.

However, there is a consensus that the peak for oil may not be reached in the next two decades. Only the most extreme scenarios forecast the oil demand to start to decline; however, the action to support such scenario is yet to unfold. Thus, investments in upstream and importantly downstream are likely to continue. Historically, growth in demand for road fuels in North America and Europe has driven downstream investments. This is expected to change in future.

India's energy evolution

In the past decade, growth in Asia—especially China and India—has driven both the demand for oil and refinery capacity expansions. In 2018, 70 percent of refining investments were in Asia (see figure 4). Although demand for oil and investments in refining in Asia are likely to continue, the certainties of past years are fading.

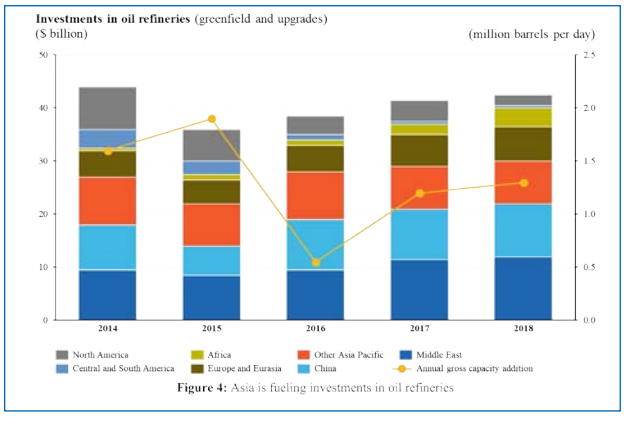


Figure 4: Asia is fueling investments in oil refineries

India's growth in energy demand is driven by strong population growth and economic development. In 2018, the country's demand rose 4 percent compared with the 2.3 percent seen worldwide. With this outlook, India's share of the world's primary energy demand is set to roughly double to about 11 percent by 2040. In fact, India will grow at more than double the global rate in each of the scenarios (see figure 5) and is expected to account for more than 25 percent of the global energy demand growth between 2017 and 2040.

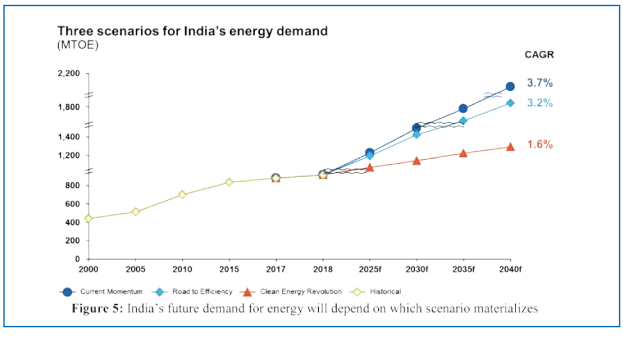


Figure 5: India's future demand for energy will depend on which scenario materializes

The source mix for India's energy demand is also changing rapidly, driven by increased electrification, growth of renewables, greater industrialization, rise in transportation, and advanced mobility (see figure 6).

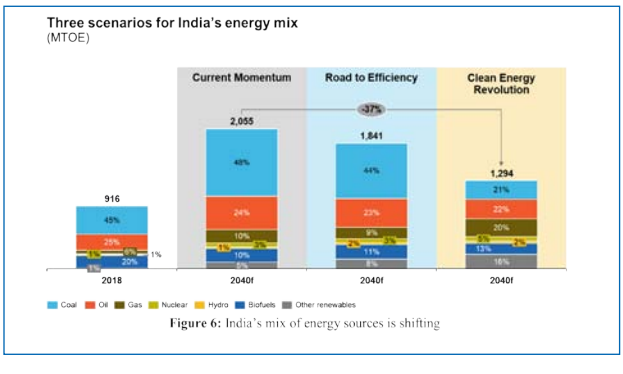


Figure 6: India's mix of energy sources is shifting

Although the share of oil varies, each scenario forecasts significant growth (see figure 7):

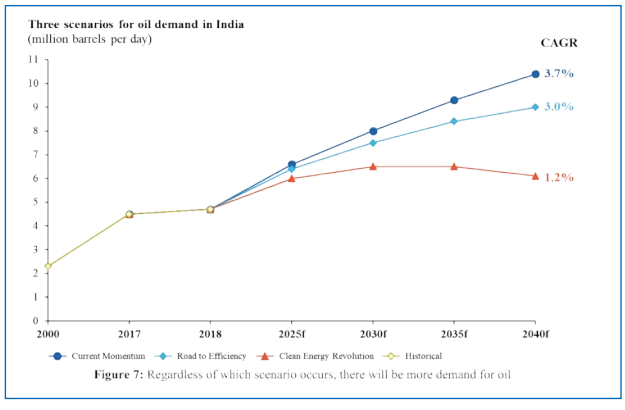


Figure 7: Regardless of which scenario occurs, there will be more demand for oil

- India's energy demand expands at two to four times the rate of global energy demand growth by 2040, becoming the world's single largest source of growth.
- By 2040, India's energy demand is around half that of China, up from less than 30 percent today.
- Demand for almost all fuels increases.

These are times of extraordinary change for the oil industry. Demand growth across products is beginning to diverge, and capacity additions are focusing on chemicals and aviation turbine fuel (not just motor spirit and high-speed diesel). In addition, growth in the crude supply is shifting toward lighter, sweeter grades, which will impact refiners' profitability and the investment case for plants that are designed to process heavy grades. Amid these uncertainties, modernization and digitalization of the sector are no longer an option; they're a requirement.

Imperatives and opportunities for downstream companies

The speed of India's energy evolution will depend on a variety of factors. But regardless of how fast the sector evolves, the transition will have a far-reaching impact on the energy landscape, resulting in demand growth from 1.8 percent CAGR in the Clean Energy Revolution scenario to 3.6 percent CAGR in the Continued Momentum scenario—a difference of more than 600 MTOE in energy demand by 2040.

More refining capacity will be needed in all three scenarios, but the extent varies from 100 to 250 MTPA of refining capacity by 2040.

The product mix is also expected to change. For example, electric vehicles will affect the demand for oil, but digitalization will impact high-speed diesel consumption. Downstream companies have two major decisions to make about how to position themselves for the future: let the energy transition play out and take a course with more certainty, which runs the risk of disrupting business models, or move beyond the core business and participate in the energy transition. The best course will be to adopt a scenario-based approach to expand their positions and move beyond their core businesses to take advantage of innovative new business models.

A structured approach can help downstream companies analyze the potential scenarios:

- Identify the uncertainties that will drive the pace of the energy transition.
- Develop an understanding of the potential evolution of these uncertainties.
- Determine the most competitive and valuable opportunities.
- Identify relevant bets and options that complement existing capabilities.
- Create an integrated portfolio with options for expanding into new business models.

To gain a clearer picture, factor in the following uncertainties:

- Rise in per capita consumption of petrochemicals to assess the end use that will drive demand for oil
- Innovation in crude-to-chemicals technology for determining the configuration of refineries and petrochemicals, especially in case chemicals demand, is driving the demand for oil.
- Renewals of liquefied petroleum gas (LPG) to schemes such as Ujjwala can be used to assess the growth in LPG demand.
- Leading indicators that impact the evolution of advanced mobility, including supplier offerings, battery innovation, infrastructure development, and policy measures, should be monitored in a structured manner.
- Track the growth in renewables and electrification, specifically for their impact on consumption from mobile towers, railways, and agriculture. Structured engagement with consumers to gain insights into the evolution will be important.
- Advancements in battery and storage technology and the impact on costs will drive adoption of

electric vehicles, which will affect the growth in demand for petrol and diesel.

- Improvements in the availability and reliability of electricity will have an impact on oil demand from industries and buildings as well as on the adoption of electric vehicles.

In the face of these uncertainties, the biggest of which is the pace of the energy transition, the winning strategies will be those that are resilient regardless of which scenario becomes reality. In this context, forward-thinking downstream players are making the following changes:

Become an efficient low-cost, low-carbon producer.

- Use digital to improve energy efficiency and optimize throughputs.
- Apply renewable technologies to reduce emissions and decarbonize.
- Build green refineries and chemical plants.
- Grow the natural gas business.

Innovate to focus on advanced fuels and sustainability.

- Focus on advanced biofuels derived from novel feedstocks.
- Invest in new technologies to make lighter and stronger plastics to minimize weight.
- Focus on sustainable products.

Diversify to capture a share of the integrated energy value chain.

- Develop a resilient strategy to create an integrated portfolio of conventional and new energy value chains.
- Create a flexible and agile operating model to integrate new businesses and adapt to change.

An eye on the future

India's transition to cleaner energy will create an array of opportunities that will change the country's energy landscape. With a concerted and sustained effort by all stakeholders, India can leapfrog the historical approach of most developed nations to become a global energy player. Over the next decade, much of the country's energy demand will need to be met with newer, cleaner sources of energy. Forward-thinking oil and gas players will focus not only on addressing the growing demand for energy in the short term but also on future-proofing their business models. In addition, the government has the power to facilitate the transition with incentives, infrastructure, and policy support and by encouraging cross-industry collaboration. With incumbents facing challenges across the value chain, the competitive landscape is shifting. However, downstream companies have a wealth of opportunities to diversify, become more efficient, and innovate. The best course will be to adopt a scenario-based approach to expand their positions and extend beyond their core business to take advantage of innovative new business models.

OIL & GAS IN MEDIA

India to invest $100 billion on energy infrastructure: Prime Minister invite investment from Saudi Arabia

Speaking at Saudi Arabia's annual investment forum, popularly known as 'Davos in the desert', Prime Minister, Sh. Narendra Modi announced the investment of as much as $100 billion in oil and gas infrastructure in next five years to meet the energy demand of growing economy set to become double to 5 trillion USD by 2024 with improvement in the quality of life of every Indian. The investment will be in creating refining capacity, laying new pipelines and building gas import terminals.

PM further highlighted the recent opening of the fuel retailing sector for non-oil companies to attract investment in the world's fastest growing consumption centre.

"India needs investments in the energy sector to meet the demand of a fast expanding economy. I request energy companies present here to take advantage of this opportunity", he said. PM stated that with rise in economic growth rate, political stability, predictable policy and diverse market, investments in India will be most profitable.

India is adopting an integrated infrastructure development approach. He also mentioned that India is gearing up to add skilled workforce of 400 million people in different stream in next 3-4 years.

CCEA approves Review of Guidelines for Granting Authorization to market Transportation Fuels

The Cabinet Committee on Economic Affairs (CCEA) chaired by Prime Minister Narendra Modi has approved the Review of Guidelines for Granting Authorization to market Transportation Fuels. This marks a major reform of the guidelines for marketing of petrol and diesel.

The existing policy for granting authorization to market transportation fuels had not undergone any changes for the last 17 years since 2002 and outlived its content. It has now been revised to bring it in line with the changing market dynamics and with a view to attract investment from private players, including foreign players, in this sector.

The new Policy will boost 'Ease of Doing Business', with transparent policy guidelines. It will generate direct and indirect employment also. Setting up of more retail outlets (ROs) will create better competition and services for consumers.

Salient features & Major Impact:

- Much lower entry barrier for private players - the entities seeking authorisation would need to have a minimum net worth of Rs.250 crore vis-à-vis the current requirement of Rs. 2000 crore prior investment.
- Non – Oil Companies can also invest in the retail sector. Requirement of prior investment in Oil and Gas Sector, mainly in exploration and production, refining, pipelines/terminals etc.,

has been done away with.

- The entities seeking market authorisation for petrol and diesel are allowed to apply for retail and bulk authorisation separately or both
- The companies have been given flexibility in setting up a Joint Venture or Subsidiary for market authorisation.
- In addition to conventional fuels, the authorized entities are required to install facilities for marketing at least one new generation alternate fuel, like CNG, LNG, biofuels, electric charging, etc. at their proposed retail outlets within 3 years of operationalization of the said outlet
- More private players, including Foreign players, are expected to invest in retail fuel marketing leading to better competition and better services for consumers
- The new entities will bring in latest technology for marketing of fuels and also encourage digital payments at the ROs.
- Entities will also encourage employment of women and ex-servicemen at the retail outlets.
- CCTV facilities will be set up at all retail outlets
- The authorised entities are required to set up minimum 5% of the total retail outlets in the notified remote areas within 5 years of grant of authorisation. A robust monitoring mechanism has been set up to monitor this obligation.
- An individual may be allowed to obtain dealership of more than one marketing company in case of open dealerships of PSU OMCs but at different sites.

Shri Dharmendra Pradhan invites US businesses to deploy technology, capital and new business models and participate in India's bio-fuel revolution

Minister of Petroleum and Natural Gas Shri Dharmendra Pradhan participated in the 2nd Annual India Leadership Summit of the US-India Strategic Partnership Forum on 21st October. While sharing his views on "India's Role in Geo-politics of Energy", in a conversation with Mr Tim Roemer, Former Ambassador of US to India, Shri Pradhan said "Today, India is the hotspot in energy investment destination in the world. Policy reforms introduced by the Government have further simplified doing business in India.

I invite all energy players to bring their technology & investment here & become a part of India's growth story." He said that the Country has moved to open, transparent, process-driven policy atmosphere, and all are welcome to invest. The investing Companies must bring technology, capital and good business models to India.

Speaking about India's efforts towards decarbonisation, he said, "Under the leadership of Hon'ble Prime Minister Narendra Modi, India is expanding its footprints in carbon-free energy, including renewables and bio-energy. Technology and innovation can become game changers for India's quest for decarbonising and developing into a gas-based economy for a cleaner & sustainable energy future." He said that India had set an ambitious target of producing 175 GW energy through renewable energy sources which has been further enhanced to 450 GW.

Dwelling upon the issues of ethanol and bio-energy, he further added, "From less than 1% ethanol blending in 2015, we have increased our EBP to 6%. We are working to push up the percentage even further. Bioenergy is also being pushed in a big way with Govt's focus on ways to monetise the 600MT

of non-fossilised biomass available in the country." He said that 10 billion dollars investment is to be made in setting up ethanol plants in the country. The US can collaborate with us through deployment of its technological innovations and capital resources in India and become partner in India's bio-fuel revolution, he added.

Talking about India-US partnership, Minister Pradhan said, "Energy is increasingly an important component of our bilateral trade. Our crude oil import from USA was almost nil in 2014. Now, the total import of petroleum products from USA including LNG in 2018-19 stood at over 7 billion dollars, and is likely to go up further this year."

On the issue of India's role in global energy landscape, he added, "Growth in global energy consumption will be driven by India. India's vibrant market presents immense opportunity. World is moving towards a new energy model. We are committed to implement Hon'ble PM Modi's vision which will ensure that India leads the global energy transition". India is going to lead energy transformation in the country, he added.

60 billion USD investment for gas infrastructure

To realise the target of share of 15 % gas in India's energy basket by 2030, from the current level of about 6.2 %, India is investing 60 billion USD in the gas infrastructure. Speaking at the third International Think Tank (ITT) on 13th October, Minister of Petroleum & Natural Gas and Steel, Shri Dharmendra Pradhan said, The Government is giving special impetus to develop gas infrastructure across the length and breadth of the country connect north to south and east to west.

City gas distribution will soon cover 70 % of India's population. Government is exploring strategic partnership for overall development of oil & gas sector. The role of private sector, both from domestic and overseas in bringing investment with innovations will remain crucial, he said.

CEOs participated in ITT meeting stated that India will continue to have increased consumption of fossil fuels and hence integrated energy policy is the urgent need of the hour.

Minister said that energy requirement is integral to achieving the target of 5 trillion economy by 2024. Energy Trilemma that is providing sustainable, secure and affordable energy is the foremost challenge. He said that the recent events in the international energy market creating uncertainty have an enormous impact on India's energy security and economic growth, specially when import depend is high and is expected to increase further.

"I am very clear that no single form of energy can meet the growing energy demand in India given the India's development imperative that aims to ensure justice to all. Mixing all exploitable energy sources is the only feasible way forward in our context", he said.

ADIPEC-2019 – Advantage India

ADIPEC has become one of the most influential global exhibition & Conference in the oil & gas sector. ADIPEC 2019 attracted enormous footfall encompassing 150,000+ trade visitors, 2,200+ exhibiting companies from 51 NOCs and IOCs across the globe showcasing the latest products, services and technologies to the world including participation of 25 country pavilions in the exhibition arena. The event brings together professionals from the global oil & gas industry to discuss the best practices followed and decide on the future course of action to meet energy transition challenges.

India Pavilion at ADIPEC 2019

ADIPEC provides one of the most important platforms for the oil and gas industry to do business and exchange information, attracting energy ministers, global CEOs and leading decision makers across four days of business discussions and knowledge exchange.

For the second time in a row, FIPI organised India Pavilion to showcase India's Oil & Gas Sector at the Abu Dhabi International Petroleum Exhibition & Conference (ADIPEC), Abu Dhabi during November 11-14, 2019. Nine Indian oil & gas companies, namely IOCL, ONGC, BPCL, HPCL, GAIL, Petronet LNG, OIL, L&T and EIL participated in the India Pavilion at ADIPEC-2019.

The theme of this year's India Pavilion was 'Synergy in Energy – Advantage India' wherein we portrayed capabilities of Indian oil & gas companies to the world.

Hon'ble Minister Dharmendra Pradhan, MoP&NG inaugurating the India Pavilion set up by FIPI at ADIPEC 2019

The Hon'ble Minister for Petroleum & Natural Gas & Steel, Shri Dharmendra Pradhan formally inaugurated the India Pavilion on November 11, 2019. The inaugural ceremony was witnessed by Shri Pavan Kapoor, India's Ambassador to UAE; Shri Sanjiv Singh, Chairman, FIPI & Chairman, IndianOil; Dr. V.P. Joy, Director General, DGH; Shri Amar Nath, Joint Secretary (Exploration), Ministry of Petroleum & Natural Gas; Ms. Esha Srivastava, Director (International Cooperation), MoP&NG and several other dignitaries from Indian and global oil & gas industry.

At the ADIPEC inaugural global discussion, Shri Dharmendra Pradhan said that we are working to make PM Modi's vision to make India a gas-based economy and working for a cleaner and greener environment. "For this we will be working on investing in gas based infrastructure like increase in CGD and PNG network and gas based industries". He said that Global energy transition is driven by Asia becoming the centre of energy consumption, greater availability of LNG, greater promise of energy independence through renewables including solar and wind energy, emergence of US a leading hydrocarbons exporter and the urgency to meet COP 21 Paris climate commitments.

Dr. R.K. Malhotra, Director General, FIPI welcoming the Hon'ble Minister for Petroleum & Natural Gas & Steel, Shri Dharmendra Pradhan

Hon'ble Minister Dharmendra Pradhan interacting with Secretary General, OPEC, H.E. Mr. Mohammed Barkindo at our pavilion

Hon'ble Minister of Petroleum & Natural Gas and Steel Sh. Dharmendra Pradhan visiting individual stalls of oil and gas companies at the India Pavilion set up

The Hon'ble Minister for Petroleum & Natural Gas & Steel had couple of meetings at FIPI's India Pavilion. The dignitaries who were seen interacting with the Hon'ble Minister at our pavilion were Secretary General, OPEC, H.E. Mr. Mohammed Barkindo and Mr. Daniel Yergin, Vice Chairman of IHS Markit and Mr. Olivier Le Peuch, CEO, Schlumberger amongst others.

Abu Dhabi CEO Roundtable

Chairman, FIPI & Chairman, IndianOil, Shri Sanjiv Singh participated in a Global Business Leaders Panel on 'New Strategies to Accelerate the Industry's Response to Environmental Pressures' in the afternoon of November 12, 2019. His co-panellists during the session were Ms. Elena Brumistrova, Director General of Gazprom Export and Mr. Mario Mehren, CEO, Winter shall Dea.

Mr. Sanjeev Singh, Chairman, FIPI and IndianOil with Dr. R.K. Malhotra and Mr. R.K Mohapatra, Director (HR), IndianOil at FIPI Pavilion

Speaking on the occasion Shri Sanjiv Singh said, "Fuels are not bad, rather the emissions need to be addressed. India is looking at innovative technologies for energy transition. Recognising the importance of gas for a country dependent on imports, the cost of coal-generated power vs gas generated power is a challenge. India is looking at increased mix of gas for energy". While profiling the growth-path of oil & gas marketing in India, Shri Singh said, "Energy solutions for the Indian market are intrinsically linked with responsible pricing, where both producers and consumers benefit".

Dr. R.K. Malhotra participated in a Panel Discussion with other panellist, Ms. Tosha Perkins, Vice President of Talent & Organizational Development, McDermott on 'Diversity Dialogues: Balance for Better: How can you be an ally, which was moderated by Ms. Eithne Treanor, Presenter, ADIPEC TV & CEO, E Treanor Media

On November 14, 2019 Director General, FIPI, Dr. R.K. Malhotra participated in a Panel Discussion with other panellist, Ms. Tosha Perkins, Vice President of Talent & Organizational Development, McDermott on 'Diversity Dialogues: Balance for Better: How can you be an ally, which was moderated by Ms. Eithne Treanor, Presenter, ADIPEC TV & CEO, E Treanor Media. Dr. Malhotra highlighted the importance of gender equality and the diverse roles being played by women in today's business world. The participation of women in oil & gas sector is substantially less compared to other sectors. The situation further deteriorate as the ladder goes up. He also outlined the role played by FIPI to recognise and promote the role of women in oil & gas sector.

MoU with API

On the sidelines of ADIPEC-2019, FIPI signed a Memorandum of Understanding (MoU) with the American Petroleum Institute (API - the only national trade association representing all facets of the oil and natural gas industry) on November 12, 2019 at Abu Dhabi in the presence of Hon'ble Minister for Petroleum & Natural Gas, Chairman-FIPI and other senior officials of MoP&NG to establish constructive working relations based on common interests regarding establishing, expanding, and strengthening a long-term cooperation.

FIPI inked a Memorandum of Understanding (MoU) with the American Petroleum Institute in the presence of Hon'ble Minister for Petroleum & Natural Gas, Chairman-FIPI and other senior officials of MoP&NG to establish constructive working relations based on common interests regarding establishing, expanding, and strengthening a long-term cooperation

India – An Investment Destination for Hydrocarbons

In the evening of November 12, 2019, the Directorate General of Hydrocarbons organized an India Session titled 'Most Favoured Investment Destination' wherein keynote address was delivered by the Hon'ble Minister for Petroleum & Natural Gas, Shri Dharmendra Pradhan. The Joint Secretary (Exploration), MoP&NG made a presentation highlighting recent policy reforms made by the Government in E&P sector. Dr. V.P. Joy, DG, DGH gave an overview of the prospects of E&P Business in India. Participants were earlier welcomed by Shri Pavan Kapoor India's Ambassador to UAE.

FIPI being conferred the Best Pavilion Award at ADIPEC 2019. The India Pavilion not only won the hearts of visitors but also highlighted India as the most preferred investment destination for global energy investors

FIPI wins Best Pavilion Award at ADIPEC-2019

The most innovative, business friendly and eye-catching stand designs were recognised with awards. The India Pavilion set up by FIPI was adjudged as Best Pavilion while the other companies recognized were Saudi Aramco, PTTEP, Al Masaood & Ali & Sons. The judges felt that the chosen five pavilions really stood out as excellent examples of design as well as displaying company products and services.

The Pavilion showcased Indian Oil & Gas sector in all segments upstream, midstream & downstream. A film for visitors showcasing achievements of the sector along with prospects with country's progress was also played. B2B meetings were also held with international Executives & Leaders.

Group Photograph with Hon'ble Minister Dharmendra Pradhan

FIPI Annual Summit and Awards 2019

Union Minister of Petroleum and Natural Gas and Steel Shri Dharmendra Pradhan addressing the gathering of FIPI's Awards Ceremony.

FIPI organised the Annual Summit and Awards 2019 on 2nd December, 2019 at New Delhi. The day also marked FIPI's third foundation anniversary. Along with the awards for the first time, FIPI organised a day-long conference with targeted discussions on key issues faced by the oil and gas industry in India.

Shri Sanjiv Singh, Chairman FIPI and Chairman IndianOil welcoming the august gathering of FIPI Awards Ceremony

Dr. R.K. Malhotra Director General, FIPI delivering the concluding remarks.

The FIPI Oil and Gas Awards are the most prestigious awards of the Indian oil and gas industry that recognise exceptional performance by companies/ individuals for contribution made by them towards the growth of Indian oil and gas industry. While FIPI

Oil and Natural Gas Corporation Ltd- recipient of Oil & Gas Exploration Company of the Year Award

awards are a regular feature, in 2019, FIPI organised an accompanying day-long conference with lectures by industry experts and panel discussion on various pressing industry issues. At the Awards ceremony held in the evening, the Hon'ble Minister handed out the awards across various categories and delivered the key note address.

The day long conference was inaugurated Mr M A Pathan, Former Chairman, IndianOil along with Dr R

K Malhotra, Director General, FIPI; Mr T K Sengupta, Director (E&P), FIPI; Mr N K Bansal, Director (Oil Refining and Marketing), FIPI and Mr Rajiv Bahl, Director (Finance, Taxation and Legal), FIPI. Speaking on the occasion, Mr Pathan lauded that the evolving role and activities of FIPI. Mr. Pathan pointed out that

Recipient of Oil & Gas Pipeline Transportation Company of the Year Award – HPCL-Mittal Energy Ltd.

Recipient of the Refinery of the Year (Capacity – Higher than 9 MMTPA) – HPCL-Mittal Energy Ltd

the oil and gas industry will have to play a crucial role in making cleaner fuel accessible to all at affordable prices. He admired the PSUs for their relentless

IndianOil-Mathura Refinery – Recipient of Refinery of the Year Award (Capacity upto 9 MMTPA)

Team BPCL receiving the Oil Marketing Company of the Year Award

efforts to make the Prime Minister Ujjwala Yojana (PMUY) successful and touching the lives of over 8 Crore under privileged families. On this occasion, Dr.Malhotra highlighted that the oil and gas sector will play a crucial role in achieving the Prime Minister's vision of USD 5 trillion economy. He mentioned that over the last few years the Government policies have

GAIL (India) Ltd – Recipient of the Project Management Company of the Year Award

Recipient of Service Provider Company of the Year Award – Schlumberger Asia Services Ltd.

metamorphosed the oil and gas sector in India and have placed the country as a preferred investment destination for the international community. He underlined the role of FIPI as a partner in growth of

Recipient of Excellence in Human Resource Management Company of the Year Award – HPCL

Dr.AjitSapre and team receiving the Innovator of the Year Award

the Indian oil and gas industry and the federation's contribution towards development of a supportive policy ecosystem for the industry.

Speaking at FIPI Annual Summit and Awards, Shri Dharmendra Pradhan, Hon'ble Minister for Petroleum

Maharashtra Natural Gas Ltd – recipient of the City Gas Distribution Growing Company of the Year Award

and Natural Gas and Steel, mentioned that owing to the GDP growth and aspirations for better standards of living, India willemerge as the epicenter for growth of global energy demand. The Minister emphasized that affordable energy is the need of the hour and it is the responsibility of the oil and gas companies to realize the Hon'ble Prime Minister's vision of making clean fuel available to all at affordable prices.

Indraprastha Gas Ltd – recipient of the City Gas Distribution Established Company of the Year Award

Recipient of Digitally Advanced Company of the Year Award - Cairn Oil & Gas, Vedanta Ltd.

The Minister underlined that technological innovation is the backbone for development and it is the responsibilityof the companies operating in the space to encourage young talent for innovation and development of new business models. In this direction, he encouraged the industry to draw inspiration from the implementation of Direct Benefit Transfer (DBT), the most successful model for digital governance globally.

Indian Oil Corporation Ltd – Recipient of the Sustainably Growing Corporate of the Year Award

Recipient of Oil & Gas Production & Development Company of the Year (Small Category) – Hindustan Oil Exploration Company Ltd.

In the recent past, Government of India has taken numerous measures to create supportive policy ecosystem for the overall growth of the industrial sector in the country. Speaking of Government's efforts Shri Pradhan informed the participants that the Government has been relentlessly working towards a paradigm of forward looking reforms.

Siemens Ltd – Recipient of Digital Technology Provider of the Year Award

Engineering Procurement Construction (EPC) Company of the Year Awarded to McDermott

Rituraj Mishra, BPCL – Recipient of Young Achiever of the Year Award (Male)

Seema Gurnani, EIL - Recipient of Young Achiever of the Year Award (Female)

Lakshmi Venkatesh, Petrofac Engineering – Recipient of Woman Executive of the Year Award

Targeted panel discussions on various pressing issues faced by the Indian oil and gas industry were held during the summit. The major takeaways from the panel discussions are as under:

Panel Discussion on Future of Refining Industry

In the 'Future of Refining Industry' session, the panelists strongly believed that refining industry is here to stay and oil will be the main stay in the energy basket. With a strong demand forecasts for petrochemical products, refineries must develop future-ready integrated structure with quick switch-over configuration to roll out products as per varying needs.

The second session 'Evolving Natural Gas Markets in India' saw discussion on the developments around India's natural gas industry. Speaking at the panel Mr D K Sarraf, Chairman, Petroleum and Natural Gas Regulatory Board (PNGRB) informed the industry members that the regulator is considering measures such as tariffs standardization, alternate model forpipeline investment, CGD model policy and establishment of natural gas trading hub.

Panel Discussion on Evolving Natural Gas Markets in India

In the upstream focused session, 'Industry Collaboration to Drive Innovation, Efficiency and Technology Adoption in Upstream Oil & Gas' panelists discussed the measures for improving exploration and production in the country.

In the session 'The tax Conundrum', panelists were of the opinion that the GST council must consider covering all five petroleum products under GST at the earliest. A supportive GST policy is absolutely essential for the overall growth of the sector in the country.

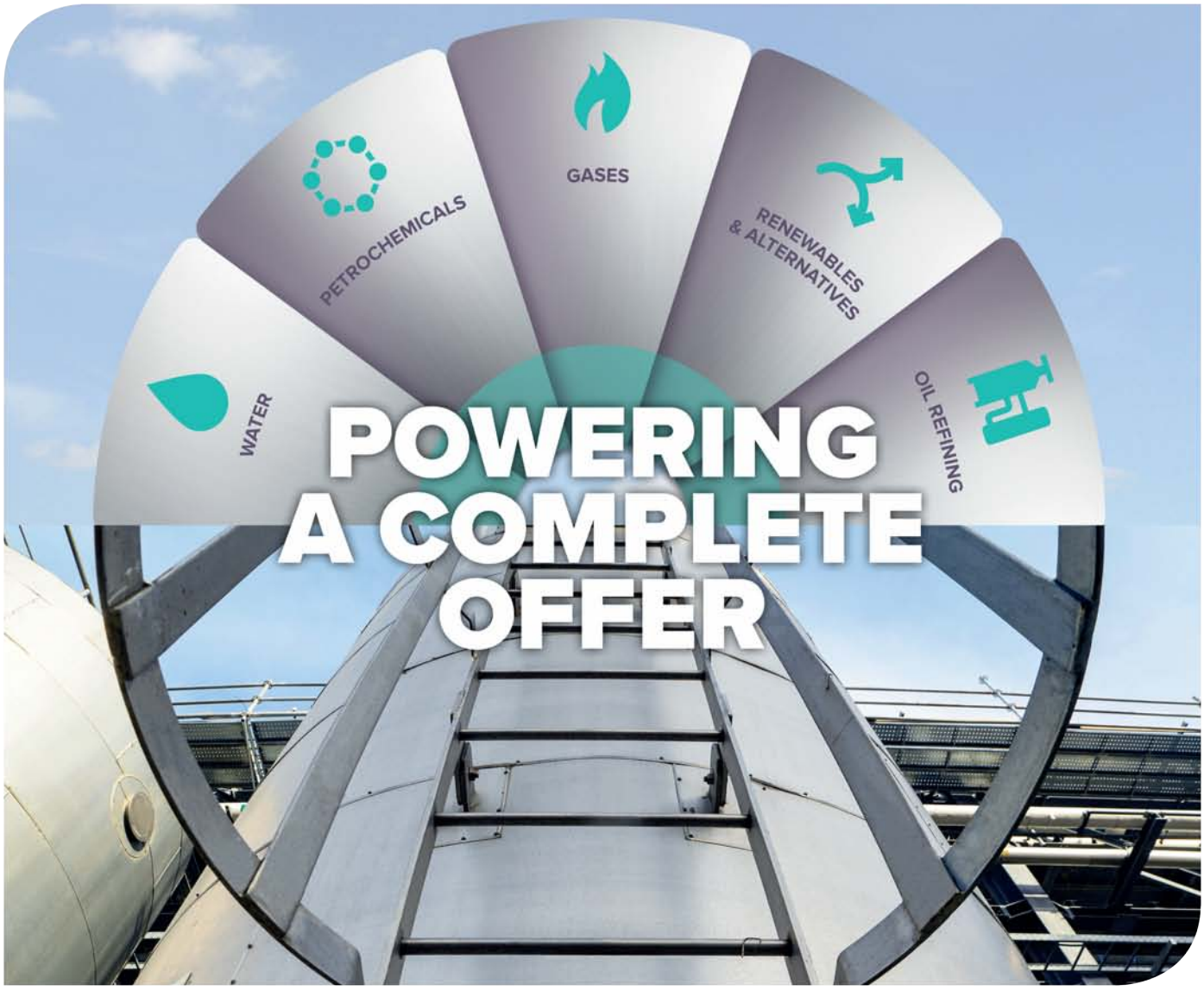
Panel Discussion on The Tax Conundrum

Over the last few years, the Government has provided an unprecedented push to Electric vehicles in the country. In this regard, Dr. Avinash Kumar Agarwal, Professor, IIT Kanpur stated thatIC engine vehicles are here to stay, in spite of the push towards EVs, due to their better optimized energy density. The new hybrid IC engines have increased efficiency and significantly lower emissions.

Dr. Avinash Kumar Agarwal, Professor, IIT Kanpur delivering lecture on "Future of the Internal Combustion Engines and Existential Threat from Battery Electric Vehicle"

In the CEO's panel discussion on energy transition, industry leaders such as Mr. Sanjiv Singh, Chairman IndianOil; Mr. Sashi Mukundan, Regional President, Head of country – India, BP; Mr. Prabh Das, MD & CEO, HMEL; Mr. M K Surana, CMD, HPCL and Dr. Ashutosh Karnatak, CMD, GAIL concluded that energy transition will depend on country's energy sources and own need for development. The panelists agreed that the fourth energy transition is inevitable, however, hydrocarbons will continue to play an integral role globally in making energy accessible to all at affordable prices.

CEO's Panel Discussion on Energy Transition



Axens continues its development and takes on a new identity

Building on the acquisition of Heurtey Petrochem and Prosernat, Axens expands its portfolio of solutions

Natural Gas Treatment:

- By combining Axens' catalysts & adsorbents products with Prosernat's portfolio of gas treatment technologies, Axens is now offering one of the most complete portfolio on the market of advanced technological solutions for all types of gas treatment applications.

Modular Units:

- Axens now offers modularization options, providing Axens' clients fully integrated solutions with associated guaranteed process-equipment packages.

Furnaces:

- Heurtey Petrochem's industrial legacy expands Axens offer in the field of process furnaces. Capacity to work on multiple licensor technologies and strong regional network, for project execution, will be maintained.

Axens becomes the global brand for all its activities represented by the following commercial brand names:

Axens SOLUTIONS

- Catalysts & Adsorbents and Process Licensing activities, including the modular units business.

Heurtey Petrochem SOLUTIONS

- Furnace business including waste heat recovery units.

Axens HORIZON

- Auditing, consulting and digital applications activities.

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Powering integrated solutions

Digital Transformation in Oil and Gas Sector

Dr. R.K. Malhotra, Director General, FIPI delivering the Welcome Address

The Federation of Indian Petroleum Industry (FIPI), in knowledge partnership with A T Kearney, organized the second edition of 'Digital Transformation in Oil and Gas Sector' on 20 November, 2019 at New Delhi. In its second edition, alongside the conference, the event also hosted an exhibition allowing both Indian and international technology providers with a unique platform to showcase their cutting-edge digital offerings for the oil and gas industry. The conference

Mr. Vikas Kaushal, AT Kearney addressing the participants

and the accompanying exhibition attracted much interest from the industry and transpired into an overwhelming participation at the event. The event was attended by Mr Amar Nath, Joint Secretary (Explorations), MoPNG; Mr L K Vij, Director (Operations), EIL; Mr. Anand Laxshmivarahan R, Chief Digital officer, Cairn Oil and Gas, Vedanta ltd; Mr. Vikas Kaushal, Managing Partner, A.T. Kearney Ltd. (India) among other dignitaries and industry leaders.

Delivering the Welcome Address at the conference, Dr R K Malhotra, Director General, FIPI underlined the role of digitization in enabling the oil and gas industry in taking better decisions and creating new ways for safer and more efficient operations in the industry. He further mentioned that savings from the Internet of Things (IoT) has the potential of making oil companies profitable even in a low price

Mr. Anand Laxshmivarahan R, Chief Digital officer, Cairn Oil and Gas, delivering the Keynote Address

scenario. Speaking on a practical approach for digital transformation for the oil and gas industry, Mr. Vikas Kaushal pointed out that the three pillars for driving digitalization in the industry are increasing productivity, extending the core business and creating new value streams. He mentioned that for successful implementation of digital technologies it is important that the organization sets a proper direction, involves all stakeholders and educates the workforce in the technologies and enables them to take decisions. Mr. Anand Laxshmivarahan R sharing

Mr. Amar Nath, Joint Secretary (Exploration), MoPNG delivering the Inaugural Address

Cairn Oil & Gas's experience with digital technologies underlined that there is no one single digital solutions that will fit all companies but will depend on the organization's culture and strategic priorities. The chief guest at the event was Mr Amar Nath, Joint Secretary (Explorations), MoPNG. Speaking at the Inaugural session he mentioned that the oil and gas industry worldwide has been a laggard in adopting digital technologies. However, climate change has now forced the industry implement

Mr. T.K. Sengupta, Director (E&P), FIPI delivering the Vote of Thanks during the Inaugural Session

digital technologies to curb emissions and reduce wastes. Going forward, the use of technology in the sector will be imperative to solve business problems and create new value. Delivering the closing remarks at the Inaugural Session, Mr T K Sengupta, Director (Explorations), FIPI mentioned that the oil and gas industry has fallen behind other industries in adopting digital technologies and there is a need for the leadership teams to drive the change and set

From L to R – Mr. Kshitiz Kurrey, Cairn Oil and Gas, Vedanta Ltd; Mr. Karthik Shivaprasad, Siemens Ltd.; Mr. Purav Bhatt, Siemens Ltd.; Mr. Nubeel Ansari, SAP; Mr. Ajay Deshmukh, Honeywell; Mr. Janardhan Parthasarathy, Yokogawa

examples. He mentioned the importance of adoption of 'innovation is our obsession' ideology for the oil and gas industry and predicted that such attitude will go a long way in ensuring safe and efficient operations and adding business value.The daylong

From L to R - Mr. Saurabh Singh, A.T. Kearney; Dr. Pradeep N, ESRI; Mr. Shammi Malik, IndianOil; Mr. Sanjay Thakker, Emerson; Mr. B Sivarama Krishnan, Bahwan Cybertek

conference witnessed deliberations on various digital technologies that have benefitted the industry across the value chain. The speakers at the three sessions organized during the conference came from both digital technology providers and the industry. While the technology providers apprised the audience with their latest offerings for the sector and its benefits, the speakers from the industry shared their experience of adopting new technologies in operations and creating an accepting culture for digital technologies through interesting anecdotes. Some of the notable topics touched upon during the conference were use of digital technologies in Asset management,

From L to R – Mr. Tommy Kers AspenTech; Mr. Akshay Gupta Honeywell; Mr. Kumar Aditya, Schlumberger; Mr. Navanith Mohan, AVEVA; Mr. Dharam Raj, ONGC

supply chain, changing enterprise systems, digital refineries, role of GIS and intelligent pipelining. The audience made the experience further engaging through asking various questions and sharing experiences from their respective organizations. Taking account of the overwhelming interest shown by the technology providers at the first edition of the event in 2018, the second edition hosted the exhibition 'Digital Experience' on the sidelines of the conference. Large number of technology providers, ranging from start-ups to international technology

giants, participated at the exhibition. The exhibition provided the technology providers with a unique opportunity to display their latest technologies, which could benefit the oil and gas sector and helped explore the business opportunities with prospective clients. The exhibition received an awe inspiring response from the participants and helped the industry participants explore the technologies best fit for their organization.The concluding remarks at the conference were delivered by Mr N K Bansal, Director (Oil Refining and Marketing), FIPI. Mr Bansal summarized the proceedings of the day and underlined that though there are a range of digital solutions being made available by technology providers, it will require prudent decision making by the oil and gas companies on investing in technologies best fit for their needs

Mr. N. K. Bansal, Director (Oil Refining & Marketing), FIPI summarizing the Conference

FEDERATION OF INDIAN PETROLEUM INDUSTRY

CORE PURPOSE STATEMENT

To be the credible voice of Indian hydrocarbon industry enabling its sustained growth and global competitiveness.

SHARED VISION

- A progressive and credible energy advisory body stimulating growth of Indian hydrocarbon sector with global linkages.
- A healthy and strong interface with Government, legislative agencies and regulatory bodies.
- Create value for stakeholders in all our actions.
- Enablers of collaborative research and technology adoption in the domain of energy and environment.
- A vibrant, adaptive and trustworthy team of professionals with domain expertise.
- A financially self-sustaining, not-for-profit organization.

For more details kindly visit our website www.fipi.org.in

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NEW APPOINTMENTS

Mr. S M Vaidya takes over as Director (Refineries) of IndianOil

S M Vaidya

Mr. Shrikant Madhav Vaidya has taken over as the Director (Refineries) of IndianOil on 14th October 2019. He is also a Director on the board of Chennai Petroleum Corporation Ltd. (CPCL) & the 60 MMTPA West Coast Refinery and Petrochemicals Project, the world's largest grass root refinery project, coming up in Maharashtra.

A Chemical Engineer from the National Institute of Technology, Rourkela, Mr. SM Vaidya has 33 years of extensive experience in refining & petrochemicals operations. Mr. Vaidya has had a decade-long association with India's largest Cracker Plant-the Panipat Naphtha Cracker Complex-right from its commissioning stage, which is one of the major drivers of IOC's petrochemicals business.

Prior to his elevation, Mr. Vaidya was heading the Operations Dept. of the Refineries Division, ensuring healthy gross refining margins, smooth supply of products and eco-friendly business operations. During his tenure, the Refineries Division registered a record performance on all major physical parameters. He also steered the timely roll-out of BS-VI grade auto fuels in NCR, and has expanded green energy options with bio-fuel & ethanol-blended fuel related projects in refineries.

Mr. Rakesh Misri takes over as Director Marketing of HPCL

Mr. Rakesh Misri took over as Director-Marketing of HPCL on October 17, 2019. Prior to his appointment as Director-Marketing, Mr. Misri was Executive Director-Marketing Coordination in HPCL.

A Gold Medallist in Civil Engineering from REC Srinagar (now NIT Srinagar), Mr. Misri has a rich and varied professional exposure of over 36 years in HPCL. He has held various senior level positions in the organization heading the North Zone Retail, Executive Director-Direct Sales, Executive Director-Human Resources, Executive Director-Corporate Strategy & Business Development, and Executive Director-LPG.

He has various academic distinctions to his credit and is a key technical speaker in In-house capability building seminars and workshops.

Rakesh Misri

Ms. Pomila Jaspal takes charge as Director-Finance, MRPL

Pomila Jaspal

Ms. Pomila Jaspal, has taken charge as Director (Finance), Mangalore Refinery and Petrochemicals Limited (MRPL) on 15th October 2019.

Mrs. Pomila Jaspal a fellow member of The Institute of Cost Accountants of India (ICMAI) and Gold medallist joined ONGC on 1st April 1985 as Finance & Accounts Officer. Before her appointment in MRPL, she was Executive Director-Chief Corporate Finance, ONGC. She handled varied assignments including corporate finance functions such as Direct tax, Indirect tax, Investor relations, Corporate Budget & Project Appraisal etc. Mrs. Jaspal is also on the Board of ONGC Petro additions Limited.

STATISTICS

INDIA: OIL & GAS

DOMESTIC OIL PRODUCTION (MILLION MT)

		2013-14	2014-15	2015-16	2016-17	2017-18 (P)	2018-19 (P)	April - Sept. 2019 (P)	
									% of Total
On Shore	ONGC	6.7	6.1	5.8	5.9	6.0	6.1	3.0	36.4
	OIL	3.5	3.4	3.2	3.3	3.4	3.3	1.6	19.4
	Pvt./ JV (PSC)	9.4	9.1	8.8	8.4	8.2	8.0	3.7	44.2
	Sub Total	**19.6**	**18.5**	**17.8**	**17.6**	**17.5**	**17.3**	**8.3**	100
Off Shore	ONGC	15.5	16.2	16.5	16.3	16.2	15.0	7.2	89.8
	OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pvt./ JV (PSC)	2.7	2.7	2.5	2.1	1.9	1.9	0.8	10.2
	Sub Total	**18.2**	**18.9**	**19.1**	**18.4**	**18.1**	**16.9**	**8.0**	100
Total Domestic Production		37.8	37.5	36.9	36.0	35.7	34.2	16.4	100.0
	ONGC	22.3	22.3	22.4	22.2	22.2	21.0	10.3	62.6
	OIL	3.5	3.4	3.2	3.3	3.4	3.3	1.6	9.9
	Pvt./ JV (PSC)	12.1	11.8	11.3	10.5	10.1	9.9	4.5	27.5
Total Domestic Production		**37.8**	**37.5**	**36.9**	**36.0**	**35.7**	**34.2**	**16.4**	100

Source : PIB/PPAC

REFINING

Refining Capacity (Million MT on 22nd October 2019)

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
Paradip	15.00
Total	**69.20**

Chennai Petroleum Corp. Ltd.	
Chennai	10.50
Narimanam	1.00
Total	**11.50**

JV Refineries	
DBPC, BORL-Bina	7.80
HMEL,GGSR	11.30
JV Total	**19.10**

Bharat Petroleum Corp. Ltd.	
Mumbai	12.00
Kochi	15.50
Total	**27.50**

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	**142.10**

Private Refineries	
RIL, (DTA) Jamnagar	33.00
RIL , (SEZ), Jamnagar	35.20
Nayara Energy Ltd. , Jamnagar #	20.00
Pvt. Total	**88.20**

Total Refining Capacity of India 249.4 (4 .99 million barrels per day)
Nayara Energy Limited (formerly Essar Oil Limited)
Source : PPAC

CRUDE PROCESSING (MILLION MT)

PSU Refineries	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	April-Sept. 2019 (P)
IOCL	53.13	53.59	58.01	65.19	69.00	71.81	34.82
HPCL	22.97	23.20	24.10	25.30	28.20	30.82	15.21
BPCL	15.51	16.20	17.20	17.80	18.20	18.44	8.48
CPCL	10.70	10.70	9.60	10.30	10.80	10.69	5.19
MRPL	14.60	14.60	15.53	15.97	16.13	16.23	6.05
ONGC (Tatipaka)	0.10	0.05	0.07	0.09	0.08	0.07	0.04
NRL	2.60	2.78	2.52	2.68	2.81	2.90	1.39
SUB TOTAL	**119.61**	**121.12**	**127.03**	**137.33**	**145.22**	**150.96**	**71.18**

JV Refineries	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	April-Sept. 2019 (P)
HMEL	9.27	7.34	10.71	10.52	8.83	12.47	5.86
BORL	5.40	6.21	6.40	6.36	6.71	5.71	3.78
SUB TOTAL	**14.67**	**13.55**	**17.11**	**16.88**	**15.54**	**18.18**	**9.64**

Pvt. Refineries	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	April-Sept. 2019 (P)
NEL	20.20	20.49	19.11	20.92	20.69	18.89	10.40
RIL	68.03	68.10	69.50	70.20	70.50	69.14	34.50
SUB TOTAL	**88.23**	**88.59**	**88.61**	**91.12**	**91.19**	**88.03**	**44.90**

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	April-Sept. 2019 (P)
All India Crude Processing	**222.40**	**223.26**	**232.90**	**245.40**	**251.90**	**257.17**	**125.72**

Source : PIB Release/PPAC

CRUDE CAPACITY VS. PROCESSING

	Capacity On 22/10/2019 Million MT	% Share	Crude Processing Million MT April-Sept. 19 (P)	% Share
PSU Ref	142.1	57.0	71.2	56.6
JV. Ref	19.1	7.7	9.6	7.7
Pvt. Ref	88.2	35.4	44.9	35.7
Total	**249.4**	**100**	**125.7**	**100**

Source: PIB/PPAC

POL PRODUCTION (Million MT)

	2013-14	2014-15	2015-16	2016-17	2017-18 (P)	2018-19 (P)	April-Sept. 2019 (P)
From Refineries	216.4	217.1	227.9	239.2	249.8	257.4	125.7
From Fractionators	3.9	3.7	3.4	3.5	4.6	4.9	2.4
Total	**220.3**	**220.7**	**231.2**	**242.7**	**254.4**	**262.4**	**128.1**

DISTILLATE PRODUCTION (Million MT)

	2013-14	2014-15	2015-16	2016-17	2017-18 (P)	2018-19 (P)	April-Sept. 2019 (P)
Light Distillates, MMT	62.7	63.2	67.1	71.0	74.7	70.4	34.5
Middle Distillates , MMT	112.8	113.4	118.3	122.5	127.5	130.8	64.2
Total Distillates, MMT	175.5	176.6	185.4	193.5	202.2	201.2	98.7
% Distillates Production on Crude Processing	**78.9**	**79.1**	**79.6**	**78.9**	**80.3**	**78.2**	**78.5**

Source: PIB/PPAC

PETROLEUM PRICING

OIL IMPORT - VOLUME AND VALUE

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	April-Sept. 2019 (P)
Quantity, Million Mt	189.2	189.4	202.9	213.9	220.4	226.6	111.4
Value, INR ₹000 cr.	864.9	687.4	416.6	470.6	566.0	783.4	366.8
Value, USD Billion	143.0	112.7	64.0	70.2	87.8	112.0	52.5
Average conversion Rate, INR per USD (Calculated)	60.5	61.0	65.1	67.0	64.5	70.0	69.8

OIL IMPORT - PRICE USD / BARREL

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	April-Sept. 2019 (P)
Brent (Low Sulphur - LS-marker) (a)	107.5	85.4	47.5	48.7	57.5	70.0	65.2
Dubai (b)	104.6	83.8	45.6	47.0	55.8	69.3	64.2
Low sulphur-High sulphur differential (a-b)	2.9	1.7	1.8	1.7	1.6	0.7	1.0
Indian Crude Basket (ICB)	105.52	84.16	46.17	47.56	56.43	69.88	61.73
ICB High Sulphur share %	69.90	72.04	72.28	71.03	72.38	74.77	74.77
ICB Low Sulphur share %	30.10	27.96	27.72	28.97	27.62	25.23	25.23

INTERNATIONAL PETROLEUM PRODUCTS PRICES EX SINGAPORE, ($/bbl.)

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	April-Sept. 2019 (P)
Gasoline	114.3	95.5	61.7	58.1	67.8	75.3	71.6
Naphtha	100.2	82.2	48.5	47.1	56.3	65.4	56.0
Kero / Jet	121.2	66.6	58.2	58.4	69.2	83.9	71.6
Gas Oil (0.05% S)	122.0	99.4	57.6	58.9	69.8	84.1	78.6
Dubai crude	104.6	83.8	45.6	47.0	55.8	69.3	64.2
Indian crude basket	105.5	84.2	46.2	47.6	56.4	69.9	61.7

CRACKS SPREADS ($/ BBL.)

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	April-Sept. 2019 (P)
Gasoline crack							
Dubai crude based	9.7	11.7	16.1	11.1	12.0	5.9	7.4
Indian crude basket	8.8	11.3	15.6	10.6	11.4	5.4	9.9
Diesel crack							
Dubai crude based	17.4	15.7	12.0	12.0	13.9	14.8	14.4
Indian crude basket	16.5	15.3	11.5	11.4	13.4	14.2	16.9

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
October 17 - March 18	2.89	6.30
April 18 - September 18	3.06	6.78
October 18 - March 19	3.36	7.67
April 19 - September 19	3.69	9.32
October 19 - March 20	3.23	8.43

Source: PIB/PPAC/OPEC

GAS PRODUCTION

Qty in MMSCM

	2015-16	2016-17	2017-18 (P)	2018-19 (P)	April-Sept. 2019 (P)
ONGC	21177	22088	23429	24675	12072
Oil India	2838	2937	2882	2722	1384
Private/ Joint Ventures	8235	6872	6338	5477	2549
Total	**32250**	**31897**	**32649**	**32873**	**16005**

		2015-16	2016-17	2017-18 (P)	2018-19 (P)	April-Sept. 2019 (P)
Onshore	Natural Gas	8845	9294	9904	10046	5027
	CBM	393	565	735	710	326
	Sub Total	**9237**	**9858**	**10639**	**10756**	**5353**
Offshore		23012	22038	22011	22117	10652
	Sub Total	**23012**	**22038**	**22011**	**22117**	**10652**

	2015-16	2016-17	2017-18 (P)	2018-19 (P)	April-Sept. 2019 (P)
Total	**32249**	**31897**	**32649**	**32873**	**16005**
(-) Flare loss	1120	1049	918	817	466
Net Production	31129	30848	31731	32056	15539

	2015-16	2016-17	2017-18 (P)	2018-19 (P)	April-Sept. 2019 (P)
Net Production	31129	30848	31731	32056	15539
Own Consumption	5822	5857	5806	6017	3049
Availabilty	25307	24991	25925	26039	12490

AVAILABILTY FOR SALE

	2015-16	2016-17	2017-18 (P)	2018-19 (P)	April-Sept. 2019 (P)
ONGC	16076	17059	18553	19597	9440
Oil India	2314	2412	2365	2207	1114
Private/ Joint Ventures	6917	5520	5007	4235	1936
Total	**25307**	**24991**	**25925**	**26039**	**12490**

CONSUMPTION (EXCLUDING OWN CONSUMPTION)

	2015-16	2016-17	2017-18 (P)	2018-19 (P)	April-Sept. 2019 (P)
Total Consumption	46695	49677	52253	53054	28766
Availabilty for sale	25307	24991	25925	26039	12490
LNG Import	21388	24686	26328	27015	16276

GAS - IMPORT DEPENDENCY

	2015-16	2016-17	2017-18 (P)	2018-19 (P)	April-Sept. 2019 (P)
Net Gas Production	31129	30848	31731	32056	15539
LNG Imports	21388	24686	26328	27015	16276
Import Dependency (%)	40.7	44.5	45.3	45.7	51.2
Total Gas Consumption*	**52517**	**55534**	**58059**	**59071**	**31815**

* Includes Own Consumption

Source:PIB/PPAC

SECTOR WISE DEMAND AND COMSUMPTION OF NATURAL GAS

Qty in MMSCM

		2016-17 (P)	2017-18 (P)	2018-19 (P)	2019-20 (P)						
					April	May	June	July	August	Sep-tember	Total
Fertilizer	R-LNG	7592	7781	8711	611	716	769	784	815	784	4479
	Domestic Gas	7802	6862	6258	541	525	499	519	588	574	3246
Power	R-LNG	2410	2645	2869	265	336	687	313	272	321	2194
	Domestic Gas	9131	9375	9194	711	700	641	620	646	598	3916
City Gas	R-LNG	3030	3881	3981	290	322	328	447	449	423	2259
	Domestic Gas	4276	4659	5240	471	472	463	492	486	478	2862
Refinery Petro-chemical Others	R-LNG	12440	11109	12650	1021	1056	1030	1131	1116	1008	6362
	Domestic Gas	3978	5225	5225	432	438	448	502	635	449	2904

Source:PPAC

Member Organizations

S No	Organization	Name	Designation
1	Axens India (P) Ltd.	Mr. Philippe Bergault	Managing Director
2	Baker Hughes, A GE Company	Mr. Ashish Bhandari	CEO (Oil & Gas) South Asia
3	Bharat Oman Refineries Ltd.	Mr. Mahendra Pimpale	Managing Director
4	Bharat Petroleum Corporation Ltd.	Mr. D. Rajkumar	Chairman & Managing Director
5	BP Group	Mr. Sashi Mukundan	Regional President and Head of Country, India
6	Cairn Oil & Gas, Vedanta Limited	Mr. Ajay Kumar Dixit	Chief Executive Officer
7	Chandigarh University	Mr. Satnam Singh Sandhu	Chancellor
8	Chennai Petroleum Corp. Ltd.	Mr. S.N. Pandey	Managing Director
09	CSIR-Indian Institute of Petroleum, Dehradun	Dr. Anjan Ray	Director
10	Deepwater Drilling & Industries Ltd	Mr. Naresh Kumar	Chairman & Managing Director
11	Delonex Energy Advisors India Private Ltd.	Mr. Rahul Dhir	Managing Director
12	Dynamic Drilling & Services Pvt. Ltd.	Mr. S. M. Malhotra	President
13	Engineers India Ltd.	Mr. J.C. Nakra	Chairman & Managing Director
14	Ernst & Young LLP	Mr. Rajiv Memani	Country Manager & Partner
15	ExxonMobil Gas (India) Pvt. Ltd.	Mr. Bill Davis	CEO
16	GAIL (India) Ltd.	Dr. Ashutosh Karnatak	CMD & Director (Projects)
17	GSPC LNG Ltd.	Mr. Anil K. Joshi	President
18	Haldor Topsoe India Pvt. Ltd.	Mr. Alok Verma	Managing Director
19	Hindustan Petroleum Corporation Ltd.	Mr. M.K. Surana	Chairman & Managing Director
20	HPCL Mittal Energy Ltd.	Mr. Prabh Das	MD & CEO
21	IHS Markit	Mr. James Burkhard	Managing Director
22	IIT (ISM) Dhanbad	Prof. Rajiv Shekhar	Director
23	IMC Ltd.	Mr. A. Mallesh Rao	Managing Director
24	Indian Oil Corporation Ltd.	Mr. Sanjiv Singh	Chairman

S No	Organization	Name	Designation
25	Indian Strategic Petroleum Reserves Ltd	Mr. H.P.S. Ahuja	CEO & Managing Director
26	Indraprastha Gas Ltd.	Mr. E.S. Ranganathan	Managing Director
27	Indian Oiltanking Ltd.	Mr. Vivek Venkatachalam	Managing Director
28	IPIECA	Mr. Brian Sullivan	Executive Director
29	Jindal Drilling & Industries Pvt. Ltd.	Mr. Raghav Jindal	Managing Director
30	LanzaTech	Dr. Jennifer Holmgren	Chief Executive Officer
31	Larsen & Toubro Ltd	Mr. S.N. Subrahmanyan	CEO & Managing Director
32	Maharashtra Institute of Technology (MIT), Pune	Dr. L.K. Kshirsagar	Principal
33	Mangalore Refinery & Petrochemicals Ltd.	Mr. M. Venkatesh	Managing Director
34	Nayara Energy Ltd.	Mr. B. Anand	CEO
35	Numaligarh Refinery Ltd.	Mr. S.K. Barua	Managing Director
36	Oil and Natural Gas Corporation Ltd.	Mr. Shashi Shanker	Chairman & Managing Director
37	Oil India Ltd.	Mr. Sushil Chandra Mishra	Chairman & Managing Director
38	Petronet LNG Ltd.	Mr. Prabhat Singh	Managing Director & CEO
39	Pipeline Infrastructure Limited	Mr. Akhil Mehrotra	Chief Executive Officer
40	Rajiv Gandhi Institute of Petroleum Technology	Prof. A.S.K Sinha	Director
41	Reliance Industries Ltd.,	Mr. Mukesh Ambani	Chairman & Managing Director
42	SAS Institute (India) Pvt Ltd.	Mr. Noshin Kagalwalla	CEO & Managing Director-India
43	Shell Companies in India	Mr. Nitin Prasad	Country Chair
44	South Asia Gas Enterprise Pvt. Ltd.	Mr. Subodh Kumar Jain	Director
45	Total Oil India Pvt. Ltd.	Mr. Dilip Vaswani	Chairman & Managing Director
46	University of Petroleum & Energy Studies	Dr. S.J. Chopra	Chancellor
47	UOP India Pvt. Ltd.	Mr. Mike Banach	Managing Director
48	VCS Quality Services Private Ltd.	Mr. Shaker Vayuvegula	Director
49	World LPG Association	Mr. James Rockall	CEO and Managing Director

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