FIPI

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FIPI

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## From the Desk of the

# Director General

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

Dear Members,

I feel honoured and privileged to assume the role of Director General at Federation of Indian Petroleum Industry (FIP). As Director General, FIPI, I look forward to contributing in resolution of issues faced by the Indian oil and gas industry and evolution of policies in the sector for sustained growth and global competitiveness.

As I look back over the past quarter, the global economic recovery is set to continue through 2022 as International Monetary Fund (IMF) has projected the global growth rate at 4.4 % in 2022. Over the last quarter, despite the emergence of Omicron variant and its short lived and limited nature, the global economy continued to grow amidst upbeat consumer and business confidence along with an uptick in aggregate demand conditions. Global demand for oil outpaced production as economies rebound from the worst of the pandemic. Further, Brent crude oil surged past USD 105 per barrel for the first time since August 2014, following Russia's invasion of Ukraine.

Russia's invasion of Ukraine has increased geopolitical tensions thereby posing pressures of high inflation and supply chain bottlenecks. Russia is the world's third-largest oil producer and second-largest producer of natural gas, ranking among the top energy suppliers to the US and China. In January 2022, Russia's total oil production was 11.3 mb/d. Russia is the world's largest exporter of oil to global markets and the second largest crude oil exporter behind Saudi Arabia. In December 2021 Russia exported 7.8 mb/d of crude oil and petroleum products. About 60% of Russia's oil exports go to OECD Europe, and another 20% go to China. According to IEA, roughly 750 kb/d of crude oil is delivered to Europe via the Druzhba pipeline system. Most immediately at risk are the ~250 kb/d of Russian oil transiting Ukraine via the southern branch of the Druzhba pipeline to supply Hungary, Slovakia and the Czech Republic. Further, Nord Stream 1 pipeline has been supplying natural gas from Russia to Germany since 2011. Nord stream 2 is an additional $11 billion pipeline designed to deliver natural gas to Germany from Russia via the Baltic Sea. Recently, due to the ongoing crisis, German Chancellor has suspended certification of Nord Stream 2, effectively putting the project on permanent hold. Due to this geopolitical uncertainty the energy prices have been soaring in recent months. The price for crude oil has twice soared as high as $105 a barrel, and the European gas prices have risen 50%-60% soon after Russian invasion of Ukraine.

As far as India is concerned, India accounts for a negligible (less than 1%) share of Russia's crude oil exports, however due to the supply situation, the crude prices are expected to remain in the $ 100 per bbl range. Since India imports more than 83% of its crude oil requirement, high crude prices will lead to higher inflation, increase in current account deficit, and depreciation of the Indian Rupee thus impacting overall economic growth. Sanctions and exclusion of Russian lenders from the SWIFT system, the most important international payment network, will hurt Indian state-run firms' ability to repatriate dividends from Russian oilfields and block possibilities of investments in the massive Vostok project. Further, following Russia's invasion of Ukraine, many companies like BP, Shell and Exxon Mobil have decided to exit Russian joint venture oil field projects in which ONGC Videsh Ltd (OVL) and three other state-owned Indian firms hold stake, thus putting these Indian companies into major investment risk.

Despite the above concerns, IMF has projected Indian economy to grow at 9 % for current financial year and 7.1% for FY 2022-23. India's growth prospects for 2023 are marked by expected improvements to credit growth, infrastructural investment, consumption and robust growth in manufacturing sector and exports.

On 1st February, Smt. Nirmala Sitharaman, the Hon'ble Finance Minister delivered the much-awaited union budget. The Budget delivered a pro-growth budget with a significant push to capital expenditure to boost infrastructural development and attract private investment. The Union Budget 2022-23, rested on mainly four pillars - productivity, climate action, financing investments and PM Gati Shakti plan. The spendings as laid down in the Budget - a 35% step up in public capital expenditure to Rs 7.5 lakh crore, housing allocation Rs 48,000 crore, interest-free loan to state government for infrastructure expenditure of Rs 1,00,000 crore, rural jobs guarantee of Rs 78,000 crore, Jal Jeevan Mission of Rs 60,000 crore are all drivers to lift the Indian economy. Further, the thrust to digitise India and the focus on the fintech segment will help enhance financial inclusion. Also, the containment of the fiscal deficit of the Budget of last year to 6.9% is a remarkable feat in light of the Covid pandemic and reflects fiscal consolidation.

The Union Budget focussed on introducing policies for clean energy transition and sustainability for future. The launch of sovereign green bonds as part of government's borrowing programme in FY23, a battery-swapping policy to boost EV ecosystem, to facilitate domestic manufacturing for the ambitious goal of 280 GW of installed solar capacity by 2030, an additional allocation of Rs 19,500 crore for PLI scheme for manufacturing of high-efficiency solar modules are all steps in right direction.

According to World Oil Outlook 2021, publication by Organisation of Petroleum Exporting Countries (OPEC), the oil demand in India is expected to reach around 11 million barrels per day by 2045 as compared to approximately 4.9 million barrels per day in 2021. As the fastest growing economy in the world, India requires access to abundant energy, delivered in new and affordable ways. In this regard, Government is taking various steps to provide for the country's energy security, though, diversifying energy sources beyond traditional hydrocarbons' to emerging fuels like Ethanol, Compressed Bio Gas, Hydrogen etc through schemes such as National Hydrogen Mission, Ethanol Blending Program (EBP), Sustainable Alternative Towards Affordable Transportation (SATAT) etc.

India is expeditiously moving forward on its energy transition journey: the government's plan to establish a National Hydrogen Mission is a step in the right direction. The National Hydrogen Policy released by Government in February 2022 aims to facilitate production of 5 million tonnes of green hydrogen by 2030 and the related development of renewable energy capacity. Further, the commitment to climate change goals announced by Prime Minister Narendra Modi at the COP26 summit has further strengthened the investment prospects for renewables. In 2022, according to MNRE estimates, the country's renewable energy sector is expected to boom with a likely investment of over USD 15 billion as the government focuses on electric vehicles, green hydrogen, manufacturing of solar equipment as well as achieving the ambitious 175 GW renewable capacity target.

In the Indian upstream sector, bid submission for Special CBM Bid Round-2021 which was launched by DGH in September 2021, started on 15th February, 2022. The government has offered 15 blocks in Maharashtra, Madhya Pradesh, West Bengal, Jharkhand, Odisha and Chhattisgarh for extracting gas from coal seams (CBM). Further, domestic crude oil production for the month of January stood at 2511.66 TMT, while cumulative crude production during April-January, 2021-22 was 24890.07 TMT. Natural gas production during January 2022 was 2861.09 MMSCM and the cumulative production during April-January 2021-22 was 28535 MMSCM. Recovery in economic activity has helped in the recovery of crude oil demand.

In the Indian downstream sector, fuel consumption in January 2022 totalled 17.61 million tonnes, recovered to 99.8% on volume of 17.64 MMT in January 2021 as the Omicron wave during the month could not dampen the economic momentum. The products which registered a growth in the month of January 2022 were LPG 3.2%, Naphtha 6.3%, Aviation Turbine Fuel (ATF) 3.3%, Furnace Oil & Low Sulphur Heavy Stock (FO/LSHS) 5.4%, Lubes & Greases 1.0%, Light Diesel Oil (LDO) 6.0% and Pet coke 41.0% while the products which registered de-growth during the month were Diesel (HSD) -6.4%, Petrol (MS) -5.3%, Bitumen -1.9%. Despite the above trend, with, robust growth outlook on continued reopening momentum, fuel demand outlook remains upbeat going into 2022.

Further, Petroleum and Natural Gas Regulatory Board (PNGRB) had launched the 11th CGD bidding round for 65 Geographical Areas (GAs) covering 208 districts. This round attracted overwhelming response from investors and a total of 439 bids were received from 26 bidders against 61 out of 65 GAs offered. The bids for CGD licenses were opened during the month of January 2022 where both private and public sector units emerged as winners. Further, PNGRB on 07.01.2022 has invited electronic bids under "11A CGD Bidding Round" for additional five GA's. Upon finalization of bids under these rounds, approximately

88% of the country's area would be authorized for development of CGD Network to provide access of natural gas to approximately 98% of country's population. This initiative would help in creating a robust CGD infrastructure, play a significant role in transforming to a gas-based economy and provide a push to government's plan for raising the share of natural gas in the country's energy basket to 15% by 2030.

During the quarter, FIPI had participated in various knowledge sharing events and webinars. FIPI on behalf of industry members had conducted an interactive session with Deputy Secretary, MoP&NG to discuss possibility of utilisation of gas in power sector. The session saw active participation of senior level officials from gas-based industry players and suggestions were made to MoP&NG for increasing share of natural gas in India's primary mix.

On 2 February, 2022, FIPI organized its flagship post budget analysis session. Observing the pandemic related guidelines, the session was organized on a virtual platform this year. The session was organized with Deloitte India as the knowledge partner. The session witnessed fruitful deliberations on the recently announced budget and its short-, medium- and long-term impacts on the oil and gas sector. The attraction of the FIPI Post Budget Analysis 2022 was the moderated panel discussion on the hits and misses of the budget and the future support required for an accelerated growth of the industry. The session was attended by CFOs/Finance Heads of leading public & private sector companies among other industry leaders and participants. The Federation of Indian Petroleum Industry firmly believes in evidence-based policy advocacy. Over the last few years, FIPI has successfully completed targeted studies on key policy areas. The findings of the FIPI studies have provided meaningful inputs to key Government officials and policy makers. FIPI will continue to further consider the industry request of bringing natural gas under the GST ambit which will allow cross utilisation of tax credits, and help curb inflation.

On 3rd February, 2022, NITI Aayog has organized a consultative meeting to discuss a set of recommendations for a more robust future of the upstream oil and gas sector in India. In this meeting, FIPI and its upstream oil & gas member companies participated in detailed discussions on the reforms initiatives by NITI Aayog. Based on the discussions, FIPI has consolidated comments/suggestions from each member company and has further submitted to the government for its consideration to bring constant reforms in the upstream sector.

Further, FIPI in collaboration with Platts convened a knowledge sharing session on Carbon Credit and Intensity. The session covered detailed analysis on aspects related to voluntary carbon credits, carbon market assessments, carbon pricing methodology, carbon offset trades etc. The discussion on carbon credit mechanisms was quite informative for the delegates as it talked about the pathways that can enable companies to support decarbonization thus accelerating to a lower-carbon future. The session was attended by more than 100 delegates and was appreciated by all.

Towards the end of the quarter, FIPI organised the Annual Convention for the year 2021-22 held at Dibrugarh University on 31st March 2022. All the participating chapters made presentations on the activities conducted during the previous year and on the theme "Enhancing the Energy Value Chain through Innovation and Digital Ecosystem" assigned by FIPI. The best presentations were awarded with a cash prize and trophy. The convention organised by FIPI provided a platform to the students to interact, compete and share knowledge with each other and also an opportunity to listen to the industry experts, academicians etc.

During the last quarter, FIPI has conducted various Committee meetings with our industry members to discuss the relevant issues pertaining to oil and gas sector and have been continuously working to address their issues with the Ministry from time to time.

**The way forward**

As we close the financial year, the spirit of the country is high. The Union Budget 2022-23 has already set the tone for an accelerated growth in the next year. The Indian oil and gas industry is well prepared to service the fuelling needs of this ever-expanding economy.

It is a matter of great pride for all industry participants for being associated with a sector that could provide energy and serve people of the nation selflessly during the toughest of times. The oil and gas companies in the country are looking forward to the opportunities that the new financial year holds for this sector. As we embrace the new year, I assure you that FIPI will be at the forefront advocating the industry issues while working closely with all stakeholders including Government in scripting the growth story of Indian oil and gas industry.

Gurmeet Singh

**Gurmeet Singh**

# Temporal study of Petroleum Hydrocarbon Content in the Sediments of Four Blocks of ONGC's Eastern Offshore Asset, Bay of Bengal, India (2014-2020)



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**Abstract**

With the increase in exploration and production (E&P) activities for hydrocarbons in the Bay of Bengal, marine environment monitoring becomes an essential module in the region. The present paper aims to study the temporal distribution of PHC (Petroleum Hydrocarbon Content) in the sediments of ONGC's blocks in the east coast of India, from 2014 to 2020.

The data generated in this study can be used to evaluate the marine environmental health with respect to mentioned parameter, in the future, against any change in concentration by any anthropogenic sources.

Petroleum hydrocarbon contents in sediments in the area is also compared to the values of hydrocarbon found in sediments of other seas of the world.
***Keywords:*** *ONGC, PHC, sediments, temporal*

## 1. Introduction

Govt. of India has been encouraging upstream hydrocarbon industry to increase the domestic production. As a part of these efforts, ONGC, India's largest oil and natural gas exploration and Production Company, has significantly increased the exploratory drilling activity for petroleum hydrocarbons, especially from the Krishna-Godavari (KG) Basin, along the coast of Andhra Pradesh, in the Bay of Bengal.

These E&P activities include; exploration, development, production and transportation activities etc. may have adverse impact on marine environment. Therefore, being India's most prestigious public sector unit and "India's energy anchor'' as its tagline, Oil and Natural Gas Corporation Limited (ONGC) has formulated a self-environment protection policy to protect environment. Subsequently, Institute of Petroleum Safety Health and Environment Management (IPSHEM), a premier institute of ONGC is conducting deep water environmental monitoring survey of the country in its allocated blocks of the KG-PG Basin of Bay of Bengal on the Indian east coast, since 2014.

Petroleum is one of the top priority pollutants in the ocean. In aquatic system, petroleum hydrocarbon may partly assimilate or partly absorbed on suspended solids whereby it can sink down to bottom or it may suspended for a long. Though minor concentration of it is tolerated by the marine organism, it affects their health at higher concentrations.

• Amongst individual organism, young stages are more sensitive than adults.
• Fresh eggs hatch irregularly in water contaminated with only 0.01ppm (10µg/l). and their larvae are killed at concentration bellow 5ppm.(5000 µg/l)
• The larvae of lobster show abnormal development at about 1ppm (1000 µg/l).

• Oil at about 10ppm (10,000 μg/l) interferes with the food-seeking behavior of adult lobster apparently due to noxious smell.
• Exposure to low boiling hydrocarbons at 12ppm (12,000 μg/l) halves the rate at which mussels can assimilate food.
• The death of adult members of the zooplankton can be accelerated at a concentration of about 1ppm crude oil(1000 μg/l), while division of single cells inhibited at as low as 0.01ppm.(10 μg/l)
• The higher concentration of petroleum hydrocarbon ( soluble from 0.15% Kuwait crude ) may completely inhibit primary production in a typical estuarine ecosystem.

There is also mention of toxicity limit (96hrs LC50 values) for some fish species towards hydrocarbon. For fish species Myagropsis myagroides, Oncorhychus gorbuscha and Clupea horengus the LC50 values are 10—10000ppm, 0.7—2.4 ppm and 3—200ppm respectively (Ref no. 6.3)

Hydrocarbon contamination into sediments brings adverse effects on benthic organisms. As benthic communities play an important role in the transfer of materials from primary production through the detrital pool into higher tropic levels, including commercially exploitable fish, the hydrocarbon pollution in sediment can effect the entire food web of marine organisms as well as it can affect even human being also.

Hence in the present study, petroleum hydrocarbon content of the sediments have been studied from 2014-2020.

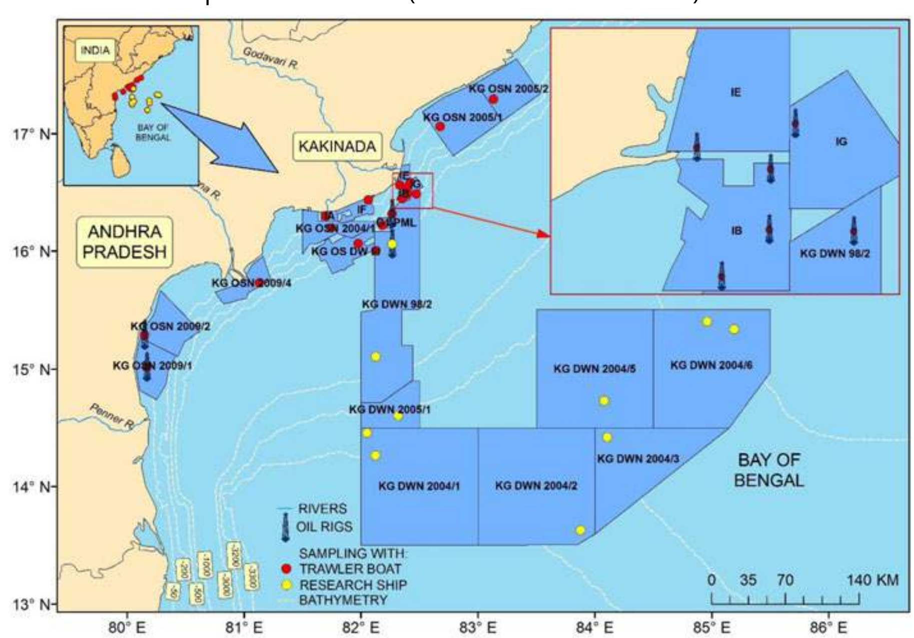
**2. Study Area**

In the present paper, the study area (between $80^0$ E to $83^0$ E latitude and $15^0$ N to $16.5^0$ N longitudes) comprises of ONGC's following 4 blocks in the Bay of Bengal:

KG OSN 2009/2
KG OSN 2004/1
KG OS DW III
KG DWN 98/2

KG OS DW III and KG-DWN-98/2 are deep water blocks with water depths ranging from 600-700m & 300m to 3,200m, respectively.

These blocks can be located in Map 1 for reference (marked with red arrows).




*Map 1: Showing the location of sampling stations in the study area*

## 3. Materials and Methods

### *3.1 Sample Collection and Pre-treatment*

The exact sampling coordinates in each block can be found in Table 1-6. The sediments were sampled using a Van Veen Grab Sampler in the shelf/slope regions and a box corer in the deep waters. Sediments of the upper 5 cm were collected with a plastic spoon and stored in clean vinyl bags to prevent the possible contamination. As soon as the field work was finished, sediment samples were carefully shipped and preserved at laboratory.

### *3.2 Laboratory Analysis*

Sediment samples were homogenized and oven-dried (60°C) before extracting. About 5 g of dried and homogenized sediment samples were extracted with 50 mL 2:1 dichloromethane (DCM) and methanol for 24 hours in an orbital shaker. The extract was filtered and transferred to a collection flask containing activated copper granules to remove elemental sulfur for 36 hours. Following this, the extract was concentrated to dryness using a rotary evaporator and re-dissolved in 2 mL hexane. A 1:2 alumina/ silica gel column was used to clean up and fractionate the extract. The first fraction containing aliphatic hydrocarbons was eluted with 20 mL of hexane. The second fraction containing PHCs was collected by eluting with 60 mL of hexane/ dichloromethane (1:1) mixture. This fraction was analyzed for PAHs using a fluorescence spectrophotometer with Saudi Arabian crude residue/Chrysene as standard.

## 4. Results and Discussion

The concentrations of PHC in sediments have been recorded in Tables 1 to 6. The average values have been tabulated in Table 7 and used for the temporal trend analysis in Graph 1.

From Table 7, we can observe that,

• In the shallow water block, KG OSN 2009/2, average PHC varies between minimum of 3.5 µg/g in 2019-20 to a maximum of 18.2 ug/g in 2015-16. The overall concentration shows a decreasing trend from 2014 to 2020.
• In the shallow water block, KG OSN 2004/1, average PHC varies between minimum of 3.9 µg/g in 2019-20 to a maximum of 18.7 ug/g in 2015-16. The overall concentration shows a decreasing trend from 2014 to 2020.
• In the deep water block, KG OS DW III, average PHC varies between minimum of 0.5 µg/g in 2019-20 to a maximum of 21.7 ug/g in 2015-16. The overall concentration shows a decreasing trend from 2014 to 2020.
• In the deep water block, KG DWN 98/2, average PHC varies between minimum of 2.9 µg/g in 2019-20 to a maximum of 19.2 ug/g in 2015-16. The overall concentration shows a decreasing trend from 2014 to 2020.

Graph 1 shows that though there is no clear temporal trend in PHC concentrations in sediments in the studied blocks, they are decreasing with time, and the temporal variations are similar in all the four study areas.

Table 8 lists the values of PHC in various sea sediments over the world, and it can be observed that PHC in sediments of ONGC's eastern offshore blocks are comparatively quite low.

| | 2014-15 | |
|---|---|---|
| BLOCK | Latitude (°N) ; longitude (°E); depth (m) | PHC in sediment (ug/g) |
| KG OSN 2009/2 | 15.2883; 80.1469; 30 | 5.6367 |
| KG OS DW III | 16.0652; 81.9766; 600 | 5.2583 |
| KG OSN 2004/1 | 16.1983; 81.7461; 35 | 12.8683 |
| KG DWN 98/2 | 16.0830; 82.2344; 980 | 16.1850 |
| | 16.4880; 82.4747; 650 | ND |
| | 16.3180; 82.2666; 250 | ND |
| | 15.9619; 82.1394; 1200 | 5.1067 |
| | 15.1080; 82.1266; 2870 | 4.1000 |

*Table 1:Values of PHC in sea sediments in Eastern Offshore Blocks in 2014-15*

| BLOCK | 2015-16 | |
|---|---|---|
| | Latitude (°N) ; longitude (°E); depth (m) | PHC in sediment (ug/g) |
| KG OSN 2009/2 | 15.2883; 80.1466; 20 | 18.1667 |
| KG OS DW III | 16.0658; 81.9788; 600 | 21.7557 |
| KG OSN 2004/1 | 16.1963; 81.7463; 16 | 18.7460 |
| KG DWN 98/2 | 16.4758; 82.4525; 500 | 37.4486 |
| | 16.0825; 82.2444; 999 | 10.1000 |
| | 15.1119; 82.1297; 2008 | 9.9600 |

*Table 2: Values of PHC in sea sediments in Eastern Offshore Blocks in 2015-16*

| BLOCK | 2016-17 | |
|---|---|---|
| | Latitude (°N) ; longitude (°E); depth (m) | PHC in sediment (ug/g) |
| KG OSN 2009/2 | 15.2882; 80.1468; 20 | 8.9260 |
| KG OS DW III | 16.066; 81.9788; 600 | 10.1317 |
| KG OSN 2004/1 | 16.1965; 81.7463; 16 | 7.1714 |
| KG DWN 98/2 | 16.0926; 82.2823; 562 | 6.3350 |
| | 16.4759; 82.4526; 358 | 8.5543 |
| | 16.4471; 82.3548; 1265 | 3.9825 |
| | 16.0826; 82.2445; 999 | 12.8500 |
| | 15.1119; 82.1296; 2008 | 6.5400 |

*Table 3: Values of PHC in sea sediments in Eastern Offshore Blocks in 2016-17*

| BLOCK | 2017-18 | |
|---|---|---|
| | Latitude (°N) ; longitude (°E); depth (m) | PHC in sediment (ug/g) |
| KG OSN 2009/2 | 15.5078; 80.3287; 8 | 10.5194 |
| | 15.3148; 80.2040; 9 | 9.1756 |
| | 15.3373; 80.4117; 44 | 9.4459 |
| | 15.2434; 80.4905; 145 | 11.8012 |
| KG OS DW III | 16.0654; 81.9766; 672 | 2.0835 |
| | 16.0294; 81.8244; 800 | 1.5847 |
| | 15.9489; 81.6862; 1000 | 0.6371 |
| | 15.8640; 81.8349; 1080 | 0.7982 |
| KG OSN 2004/1 | 16.3036; 81.5642; 9 | 6.9444 |
| | 16.2075; 81.5640 | 9.5551 |
| | 16.1220; 81.5637; 175 | 4.6747 |
| | 16.1995; 81.6713; 33 | 7.4786 |
| | 16.1990; 81.8245; 327 | 6.3176 |
| | 16.2026; 81.9968; 200 | 9.0465 |
| KG DWN 98/2 | 16.5031; 82.4929; 650 | 6.7015 |
| | 16.4021; 82.4359; 760 | 8.2312 |
| | 16.2696; 82.4048; 1087 | 3.8418 |
| | 16.1444; 82.3243; 1300 | 8.8100 |
| | 15.9807; 82.3283; 1877 | 8.5400 |
| | 15.8473; 82.3240; 2200 | 8.5300 |
| | 15.6355; 82.3210; 2469 | 8.0450 |
| | 15.3828; 82.1880; 2700 | 5.4000 |
| | 15.1079; 82.1266; 2907 | 5.7000 |
| | 15.0380; 82.3058; 3001 | 6.1350 |
| | 14.8438; 82.2353; 3104 | 4.6950 |

*Table 4: Values of PHC in sea sediments in Eastern Offshore Blocks in 2017-18*

| BLOCK | 2018-19 | |
|---|---|---|
| | Latitude (ºN) ; longitude (ºE); depth (m) | PHC in sediment (ug/g) |
| KG OSN 2009/2 | 15.5079; 80.3288; 16 | 11.1453 |
| KG OS DW III | 16.0654; 81.9766; 647 | 4.3441 |
| KG OSN 2004/1 | 16.3036; 81.5642; 8 | 14.7563 |
| KG DWN 98/2 | 16.4021; 82.4359; 736 | 10.0306 |

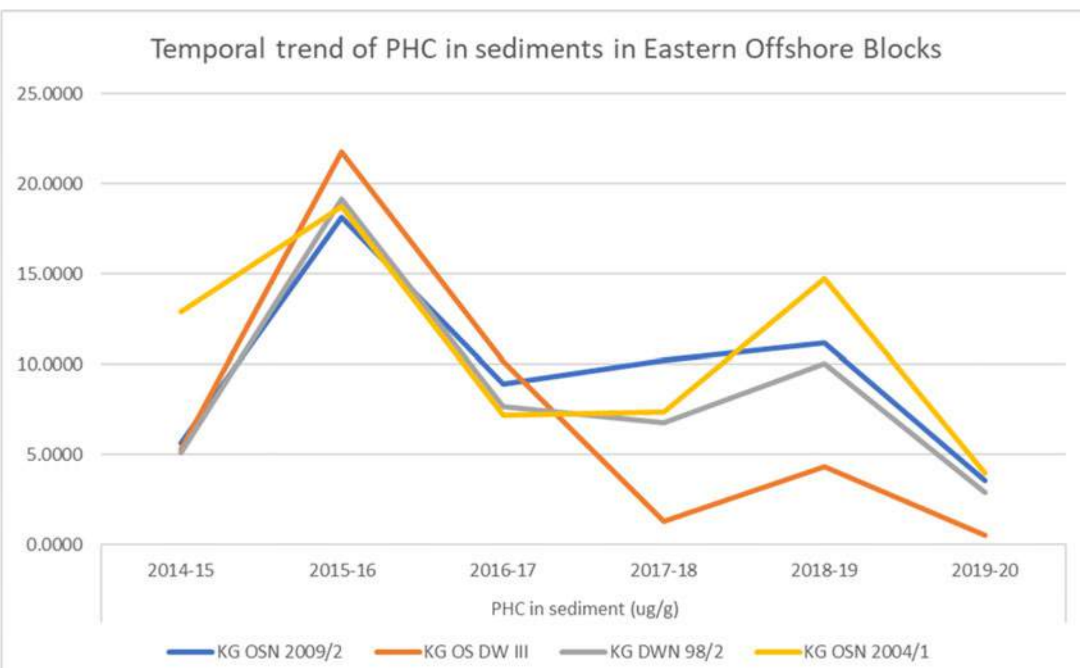
*Table 5: Values of PHC in sea sediments in Eastern Offshore Blocks in 2018-19*

| BLOCK | 2019-20 | |
|---|---|---|
| | Latitude (ºN) ; longitude (ºE); depth (m) | PHC in sediment (ug/g) |
| KG OSN 2009/2 | 15.5079; 80.3288; 16 | 3.5535 |
| KG OS DW III | 16.065; 81.977; 647 | 0.5382 |
| KG OSN 2004/1 | 16.2075; 81.5640; 27 | 3.9365 |
| KG DWN 98/2 | 16.4021; 82.4359; 736 | 2.9147 |

*Table 6: Values of PHC in sea sediments in Eastern Offshore Blocks in 2019-20*

| BLOCK | average PHC in sediment (ug/g) | | | | | |
|---|---|---|---|---|---|---|
| | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 |
| KG OSN 2009/2 | 5.6367 | 18.1667 | 8.9260 | 10.2355 | 11.1453 | 3.5535 |
| KG OS DW III | 5.2583 | 21.7557 | 10.1317 | 1.2758 | 4.3441 | 0.5382 |
| KG DWN 98/2 | 5.0783 | 19.1695 | 7.6524 | 6.7845 | 10.0306 | 2.9147 |
| KG OSN 2004/1 | 12.8683 | 18.7460 | 7.1714 | 7.3361 | 14.7563 | 3.9365 |

*Table 7: Average Values of PHC in sea sediments in Eastern Offshore Blocks from 2014-2020*




*Graph 1: Temporal trend of PHC in sea sediments in Eastern Offshore Blocks*

| Area | Survey year | Total Petroleum hydrocarbons( µg/g) | Reference |
|---|---|---|---|
| Saudi Arabia, Gulf | 1991–1993 | 11-6900 | Readman et al. (1996) |
| Kuwait, Gulf | 1992–1993 | 40–240 | Readman et al. (1996) |
| Xiamen Harbour, China | 1993 | 3.1–33a | Hong et al. (1995) |
| Victoria Harbour, Hong Kong | 1992 | 60–646a | Hong et al. (1995) |
| Western Coast, Taiwan | 1990 | 869–10300a | Jeng and Han (1994) |
| Rhone River, France, Mediterranean Sea | 1985–1986 | 25–170 | Bouloubassi and Saliot (1993) |
| Kuwait, Gulf | 1991 | 28 | Fowler et al. (1993) |
| Saudi Arabia, Gulf | 1991 | 19–671 | Fowler et al. (1993) |
| Great Barrier Reef, Australia | 1984 | 0.5–2 | Volkman et al. (1992) |
| New York Bight, USA | 1971–1975 | 35–2900 | Farrington and Tripp (1977) |
| Black Sea | 1988–1990 | 7–153a | Wakeham (1996) |
| Bosphorus, Black Sea, Turkey | 1995 | 12–76 | J W Readman and G Fillmann |
| Sochi, Black Sea, Russia | 1995 | 7.6–170 | J W Readman and G Fillmann (1995) |
| Odessa, Black Sea, Ukraine | 1995 | 110–310 | J W Readman and G Fillmann (1995) |
| Danube Coastline, Black Sea, Ukraine | 1995 | 49–220 | J W Readman and G Fillmann (1995) |

*Table 8: Values of PHC in various sea sediments*

### *Conclusion*

Though oil is lighter than water, due to down welling movement of ocean and in the process of food cycle by planktons and benthos petroleum hydrocarbon reaches to bottom and stay permanently in sediments for which PHC in sediment is a better environment indicator.

The results of present study emphasise that PHC concentrations in sediments of given blocks are on the lower side, inspite of extensive E&P activities in the region. As such no permissible limits for the hydrocarbon content in sediments are documented, but the PHC content in most of the sediments of the study area are comparable to/less than the literature values of other oceans. This indicates ONGC's sustainable practices. The results of this study also supply valuable baseline information about the PHC contents in sediments from different sampling stations of the Bay of Bengal. This can be considered as a bio-indicator of the environmental contamination in this zone and also be used for assessing environmental health of the region in the years to come.

### Acknowledgement

The authors are grateful to the ONGC's management for encouraging the preparation and presentation of this paper. They also wish to acknowledge ED-Head IPSHEM for his continuous guidance and support.

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# Delineation of Geochemical Anomalies Using pH Variation and its Integration with Existing Technique in the Domain




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## Abstract

The long-term seepage of hydrocarbons, either as macro-seepage or micro-seepage, can set up near-surface oxidation reduction zones that favour the development of a diverse array of chemical and mineralogical changes. The bacterial oxidation of light hydrocarbons can directly or indirectly bring about significant changes in the values of pH and Eh of the surrounding environment, thereby also changing the stability fields of the different mineral species present in that environment. The study defines the role of hydrocarbon micro-seepage in surface alterations which are manifested by pH variations. The present work uses indirect method for estimation of pH variation in surface sediments for defining the geochemical anomalies in two different frontier areas of exploration which aids in establishing relationship between the geochemical signatures of the trace elements and other prevailing techniques. pH variations were mapped that appear to be associated with hydrocarbon micro-seepage in the oil/ gas fields. It was observed that pH was acidic where the gas adsorption phenomenon and trace elemental concentrations were high. The increase in concentrations of trace metals near oil/ gas producing areas, suggests a reducing environment presumably due to the influence of hydrocarbon micro-seepage, which could be applied with other geo-scientific data to identify areas of future hydrocarbon exploration in frontier area.

## 1. Introduction

Oil and gas accumulations and mature source rocks are known to expel hydrocarbons, which may rise to the surface through imperfect seal or along faults, joints or fractures. This leakage may be macro-seepage in form of visible oil and gas outflow that has reached the surface and can be found at faults, fractures and outcrops. In the case of micro-seepage, hydrocarbon leakage is not noticeable, but its surface manifestations are detectable (Khan and Jacobson, 2008). Micro-seepage effects are detected in the form of anomalous hydrocarbon concentration in soils, microbiological anomalies, mineralogical changes, bleaching of red beds, radiation anomalies, electrochemical changes, biogeochemical changes and geo-botanical anomalies (Schumacher, 1996, Figure-1).The surface geochemical methods are based on the premise that the hydrocarbon gases ($CH_4$, $C_2H_6$, $C_3H_8$, $C_4H_{10}$ and $C_5H_{12}$) tend to migrate to the surface from the sub-surface regions through faults and fractures with different mechanisms as diffusion, effusion, buoyancy etc. These gases get adsorbed near surface soil matrix, which on evaluation can help in defining prospectivity of the area. These hydrocarbon seepages may be detected directly through adsorbed gas or free gas in near surface soil samples and indirectly using microbial indicators and trace elemental geochemistry through the geomicrobial/ geochemical changes induced at the surface.

The long-term hydrocarbon seepage, whether macro or micro-seepage, can set up a near-surface oxidation reduction zones that results in development of a diverse range of chemical and mineralogical changes. The bacterial oxidation of light hydrocarbons can bring significant changes in the pH and Eh of the surrounding environment, thereby also changing the stability fields of the different mineral species present in that environment (Rasheed et al;2013). Mineral stability in any environment is dependent on, and is a function of pH and Eh.

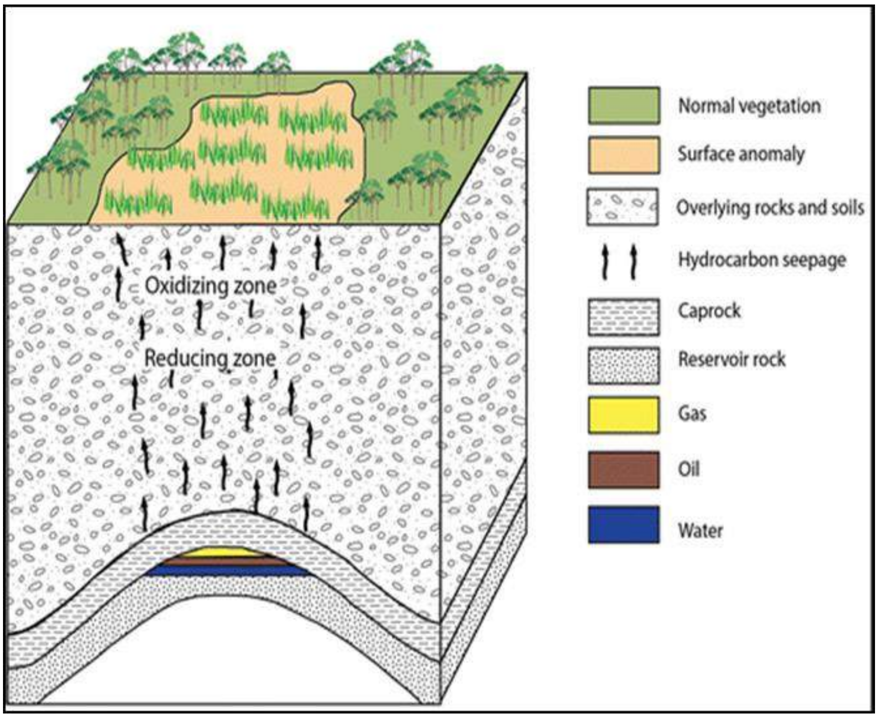


*Figure:1 Diagrammatic view showing the vertial migration of elements and compounds, mineralogical haloes (modified after Schumacher,1996)*

***1.1 Effect on pH around hydrocarbon accumulation***

Hydrogen-ion concentration: The relative acidity or alkalinity of an aqueous solution may be quantitatively expressed in terms of the concentration of hydrogen or hydroxyl ions in solution. Pure water under standard conditions is neutral; that is, it has an equal concentration (10-7 moles per litre) of both hydrogen and hydroxyl ions.

pH of a solution may be measured quantitatively by determining the electrical potential developed between a special electrically conducting glass electrode and a reference electrode when both are immersed in the same solution. Portable pH meters employing this principle are best suited for the measurement of the pH of natural waters.

pH of soil implies that the pH of an aqueous mud prepared by adding distilled water to the soil. A similar measurement can be made for pure minerals by pulverizing the mineral grains in pure water and testing the pH of the resulting suspension.

The normal pH of surface water ranges including acid rain, from about 4.5 to 8.5, and most of the chemical reactions in the weathering cycle take place within this range. It is observed that, the pH of soil ranges between 6 and 8, above the oil and gas accumulations. It is below 6 around the periphery. The average range of pH for soils lies between 4.0 and 9.0. (Hortvitz., 1985).

Most of the soil samples are alkaline in nature. It is observed that, petroleum seeps into the soil substrate alter the existing Eh and pH conditions which cause a reducing environment (alkaline pH), where solubility increases and transportation of trace metals occurs. (Horvitz, 1985). Therefore, highly alkaline nature around the periphery involves in the mobilization of certain major (viz; Ca, K, Al, Fe etc) and trace (Zn, Mn, V, Ni, Cu, Cr etc) elements to the oxidizing areas (acidic pH) and precipitation as oxides and hydroxides, due to which the concentration of certain elements above oil field areas increases. Similarly, electrical conductivity is a supporting parameter to locate gas and gas associated reservoirs. There is significant increase in electrical conductivity above area of gas accumulation (Heemstra et al, 1979).

The present study intends to study variation in pH as indicator in locating the hydrocarbon micro-seepage in the two areas viz., Sundalbari area, Tripura fold belt, Assam and Assam Arakan Basin and Lambagraon Syncline areas, Himalayan Foothills, Frontier Basin. The surface geochemical and geomicrobial prospecting studies have been carried out in the areas.

## 2. Geological setting of studied areas

### *2.1 Geology of the Sundalbari area, Tripura fold belt, Assam and Assam Arakan Basin*

Tripura area constitutes the southern part of frontal fold Belt of Assam-Arakan basin and is characterized by a series of north-south trending; double plunging, elongated, narrow anticlines in en-echelon pattern and separated by broad synclines. The intensity of folding along with the structural complexities increases from West to East. The meridional sutures zone and the presence of Ophiolite and Blue schist Facies of rock suggest that Arakan orogenic belt had a collision type margin towards east. The origin of this collision zone has been attributed to the north-eastern drift of Indian plate during early Oligocene and subsequent subduction below the Burmese plate at the end of Paleogene and early Neogene. A thick alternating sequence of shale and sandstone is the primary sedimentary deposits of Tripura area. Sundulbari field is located to the south of the Agartala Dome in west Tripura district with an area of about 10.75 Km$^2$. The structure-oriented NE-SW is an asymmetric plunging anticline on the south-western part that constitutes the northern plunging part of the broader Tichna structure in south west. This structure is considered as a northern culmination of the Tichna anticline.

### *2.2 Geology of the Lambagraon Syncline areas, Himalayan Foothills, Frontier Basin area*

Himalaya is a part of an arcuate orogenic belt extending over about 2500 km on the northern part of the Indian plate, resulting from a collision between the Indian and Eurasian plates. The tectonic setting of the Himalayan mountain belt can best be described in terms of four prominent structural breaks running along the entire length of the Himalayan strike, viz., The main frontal thrust (MFT), The main boundary thrust (MBT), The main central thrust (MCT) and The Indus Tsangpo Suture (ITS). Siwaliks are the Late Tertiary sediments deposited between the MFT and MBT and are present over almost the entire length of the Himalayan foothills. These sequences have been stratigraphically grouped into the Upper, Middle and Lower Siwaliks by Pilgrim (1913). Many thrusts and fold belts have developed in this region as a result of the post-collision compressional forces, which were subsequently covered by various sedimentary deposits brought down by the rivers and streams in this vast mountain chain. The Lambargaon syncline flanked by the Sarkaghat anticline on the NE and the Bahl anticline to the SW, is about 10 km deep.

## *3. Methodology*

Total number of 413 soil samples from 502 locations on a grid pattern of 0.5 Km X 0.5 Km, covering about 110 Km$^2$ area were studied from Sundalbari area (sample grid is depicted in figure:2). Total number of 260 soil samples from 503 locations on a grid pattern of 0.5 Km X 0.5 Km, covering about 115 Km$^2$ area were studied from Lambargaon Syncline areas (sample grid is depicted in figure:3) for laboratory analysis. Approximately 50 g of sub-soil sample was collected from the depth of 1-1.5 m of each dry hole. Samples were collected under sterilized and aseptic conditions and transferred in pre-sterilized whirl pack bags and stored at low temperature till analysis.

These samples were dried in oven at temperature 60oC, dried sample were grinded in agate mortar and pestle. Grinded samples were taken in beaker and triple distilled water was added to it in a ratio of 1:5 (w/v). These samples were kept for 24 hrs with some manual stirring. Filtered the sample using Whattman Filter paper No.1. Measured pH of filtrate using pH meter.

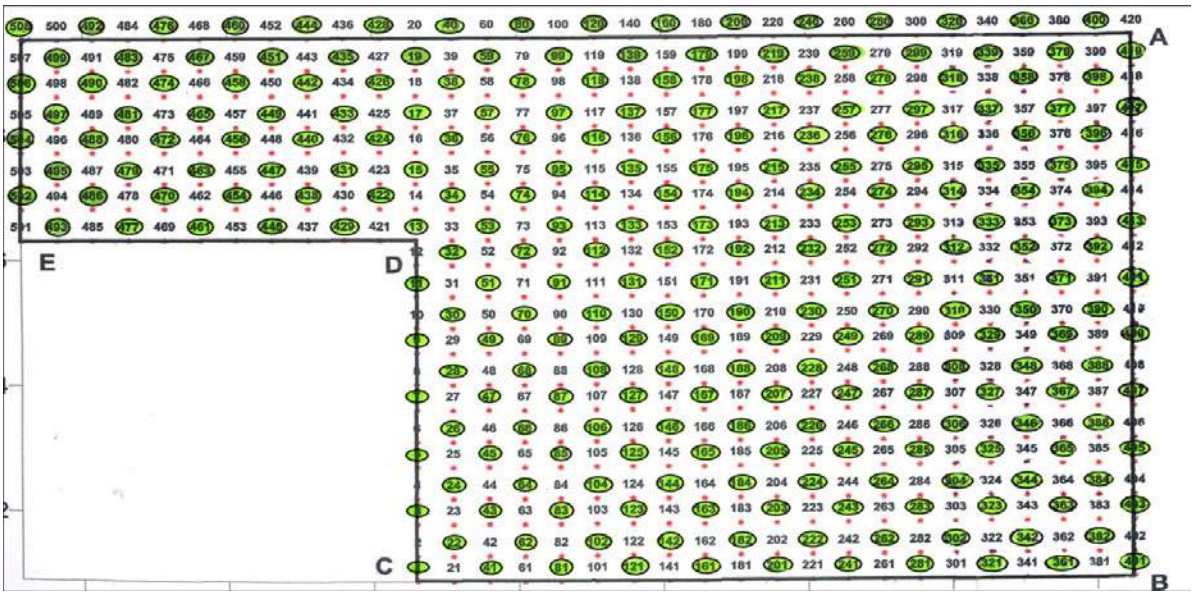


*Figure:2 Grid of sample collected and selected for the study in Sundalbari area, Tripura fold belt, Assam and Assam Arakan Basin*

### 4. Results and Discussion

#### *4.1 Sundalbari area, Tripura fold belt, Assam and Assam Arakan Basin*

The pH observed in the studied area is acidic in order of 2.71- 6.65 and has average value of 4.39 which promotes migration of trace elements. The contouring of the pH variation is carried out on Surfer 7 which shows that pH varies from western to eastern direction and changing from acidic to normal which suggests that western and central part is more acidic compared to the eastern part of the area (Figure:4). Therefore, from pH variation it can be concluded that western and central part is more prone for oil and gas accumulations.

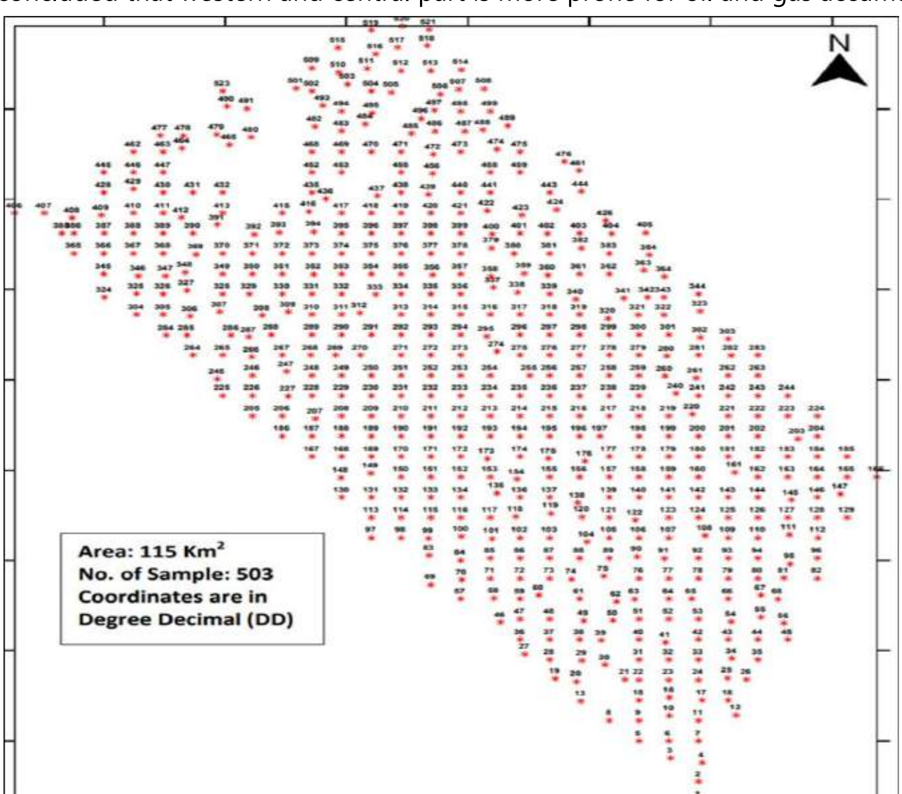


*Figure:3 Representing the grid of sample collected and selected for the study in Lambargaon Syncline areas, Himalayan Foothills, Frontier Basin area*

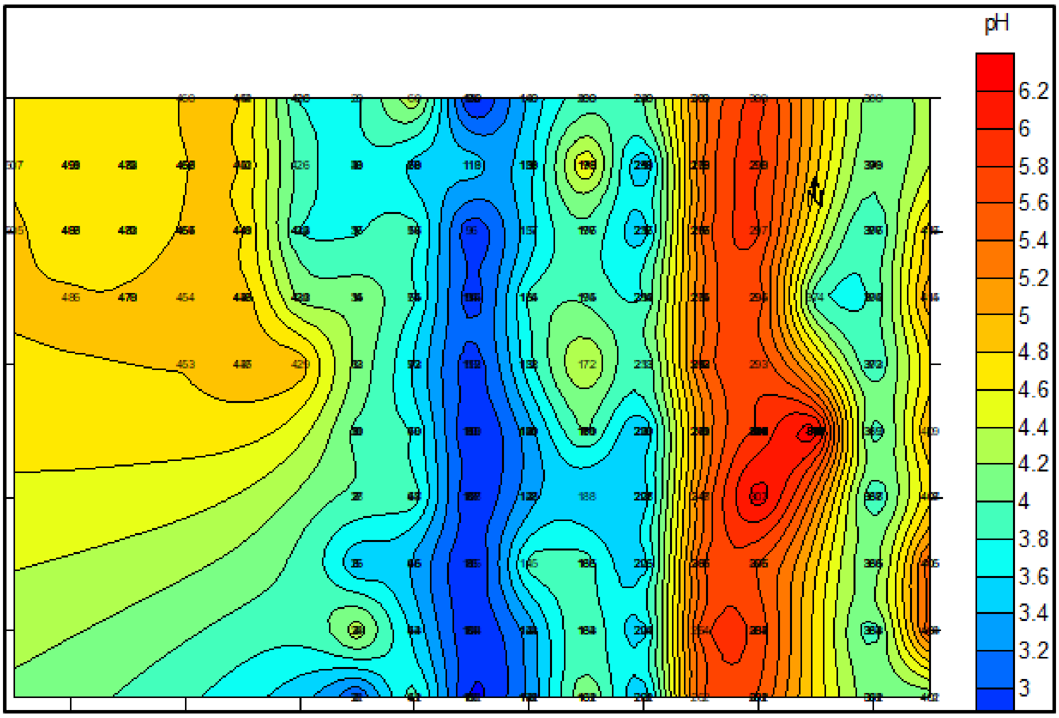


*Figure:4 pH variation in Sundalbari area, Tripura fold belt, Assam and Assam Arakan Basin*

When the pH variation is correlated with the trace element concentrations the western and central area are found to be more enriched in trace elemental concentration (Av. Zn=32.83 ppm, Av.Mn=180.25 ppm, Av. V=58.61 ppm, Av. Ni= 21.03 ppm, Av. Cu= 14.14 ppm, Av. Cr=45.75 ppm, Av. Co= 8.90 ppm, Av. Sr- 23.29 ppm, Av. Ba=178.92, and Av. Sc=6.7 ppm which is depicted in figure:5. Similar trends are found in the other existing techniques such as $C_2$+ adsorbed gas and microbial (Propane and butane oxidizing Bacteria) anomalies which are lying towards western and central part of the study area (Figure: 5)

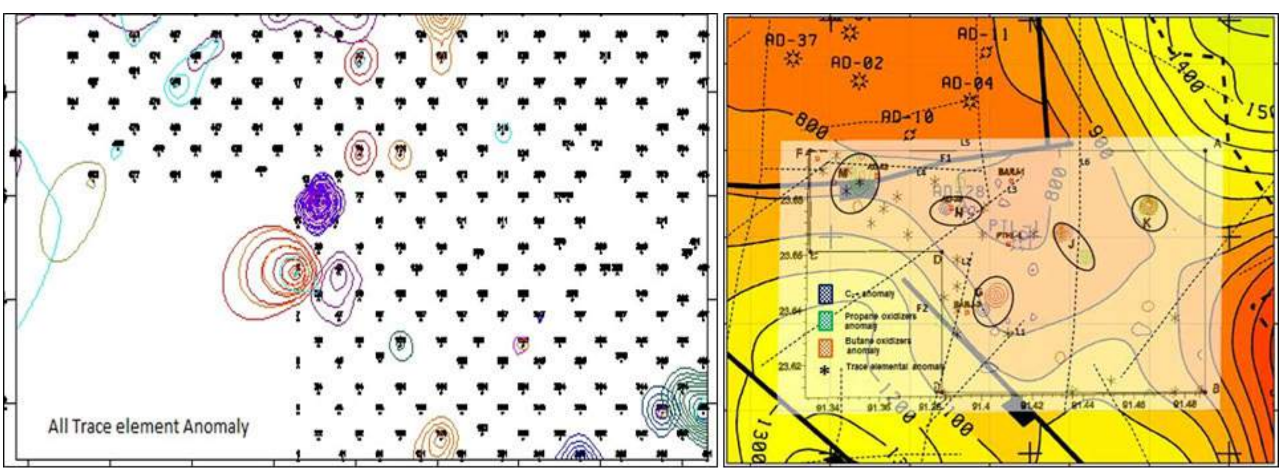


*Figure:5 Trace elemental concentrations(left) and C2+ adsorbed gas and microbial (Propane and butane oxidizing Bacteria) anomalies superimposed on time structure map of the Sundalbari area, Tripura fold belt, Assam and Assam Arakan Basin (right)*

#### *4.2 Lambargaon Syncline areas, Himalayan Foothills, Frontier Basin area*

The pH observed in the studied area is predominantly alkaline. pH range is between 4.8 to 11.1 and has average value of 7.34 which may not be a promising area for oil and gas accumulation. The contouring of the pH variation is carried out on Surfer 7 which shows that pH towards north is slightly acidic compared to southern part of the study area which suggests that north western part is more acidic compared to the southern part of the area (Figure:6). Therefore, from pH variation it can be concluded that North western part is more prone for oil and gas accumulations.

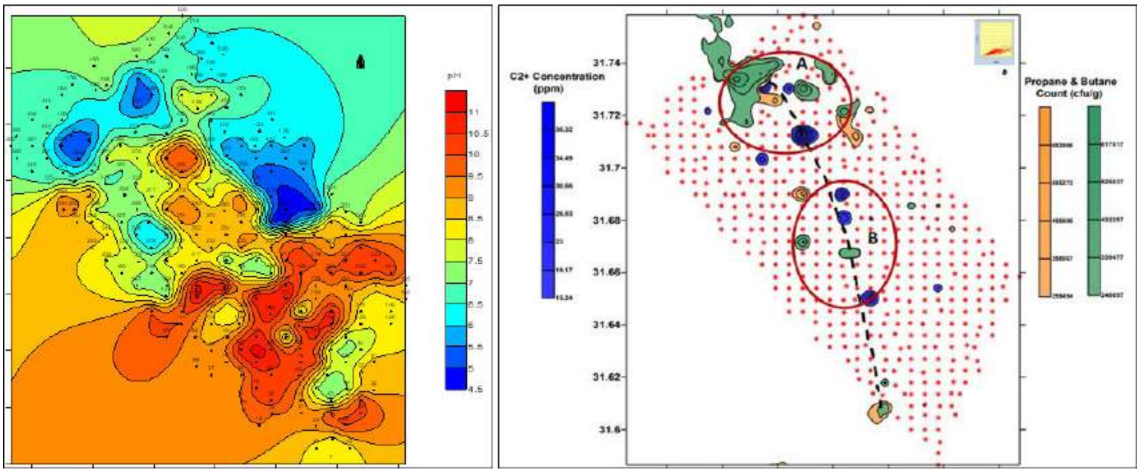


*Figure:6 pH variation(left) and C2+ adsorbed gas and microbial (Propane and butane oxidizing Bacteria) anomalies(right) in Lambargaon Syncline areas, Himalayan Foothills, Frontier Basin area, Himalayan Foothills*

The pH variation is very well correlated with other existing techniques such as C2+ adsorbed gas and microbial (Propane and butane oxidizing Bacteria) anomalies which are also lying towards North western part of the study area.

Therefore, analysing the samples for pH variations can be used in curtailing the number of samples to be analysed by other techniques such as trace elemental, microbial and adsorbed gas analyses. This consequently results in less use of strong chemicals ($HNO_3$, HF and $HClO_4$) and infrastructure (Gas Chromatograph and Gases such as Argon, Helium and Nitrogen) which make this technique more cost effective and eco-friendly. It is the most environmentally sensitive of all the existing technique as only distilled water is used to deliver almost identical results. The time taken to deliver results significantly shrinks with this technique.

## 5. Conclusion

pH anomaly plays pivotal role in delineation of geochemical prospecting zones. It validates the results identical to those derived through conventional techniques (viz $C_2$+ adsorbed gas and microbial) and the cost involved is comparatively minimum. It is the most environmentally sensitive of all the existing technique delivering almost identical results. The technique yields results with significant reduction in time and is cost effective. This study recommends a technique which deliver potent results having probability of prospects with miniscule resources in cost effective manner and highly safe to environment.

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Views expressed in this paper are of authors only and not necessarily of the organization they belong to.

# Enhancing Oil Recovery for Offshore Carbonate Reservoir through Low Salinity Water Flood

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**Summary**

As per Ministry of Petroleum & Natural Gas (India) Annual report 2020-21, India is the third largest energy consumer in the world, consuming around 806.1 million tonne of oil equivalent (MTOE) in 2019. Oil and gas sector fulfills one third of requirements within this energy mix. With continued strong growth in oil demand against falling domestic production, India has become more reliant on oil imports, which hovered 226.95 MMT in 2019-20.Currently Oil production in India comes primarily from the brown Fields. Maximizing recovery from these existing brown fields has become imperative to meet the challenges of energy requirements of the country. To increase the oil production, ONGC is implementing low salinity water flood (LSWF) enhanced oil recovery (EOR) first time in India in its offshore reservoir.

This article elaborates efforts made by ONGC in planning LSWF pilot to the field. It includes short listing the actual field for implementation, lab studies, core scale simulation study, Single Well Chemical Tracer Test (SWCTT) and planning pilot to the field through its success in terms of oil recovery.

**Introduction**

Virtually all oil reservoirs (light to medium gravity) go through water flood after diminution of reservoir natural energy. It is assessed that after the first two categories of production, the average oil recovery can only reach 10-50% of original oil in place (OIIP) and substantial amount remains trapped in reservoir either due to poor sweep efficiency or a stronger attraction between rock surface, oil and water in some of the pores. This trapped oil could be recovered through enhanced oil recovery (EOR).

**Low salinity Water Flood-EOR**

LSWF is a complex multi ion exchange mechanism, which alters the wettability of the reservoir to more water wet by lowering the residual oil saturation. The change in wettability also affects the oil-water relative permeability and improves the sweep efficiency. The process has been reported to yield significant incremental benefits (up to 10% OIIP) in laboratory as well as field trials in carbonate reservoir. Numerous literature (laboratory scale and a handful of field cases) elaborates that the applicability of LSWF to improve oil recovery in carbonates requires some general favorable screening guidelines (barring few one reported in literature) such as (a) High reservoir temperature (70+ °C); (b) higher Swi (Initial water Saturation); (c) the injection water containing PDI i.e.$Ca^{2+}$ and/ or $Mg^{2+}$ and $SO4^{2-}$ and d) low acid number of oil.

**Key Controlling Parameters: LSWF**

- Injection Rate
- Interfacial behavior / interactions
- Wettability (Contact Angle)
- Quantity and quality of injected water

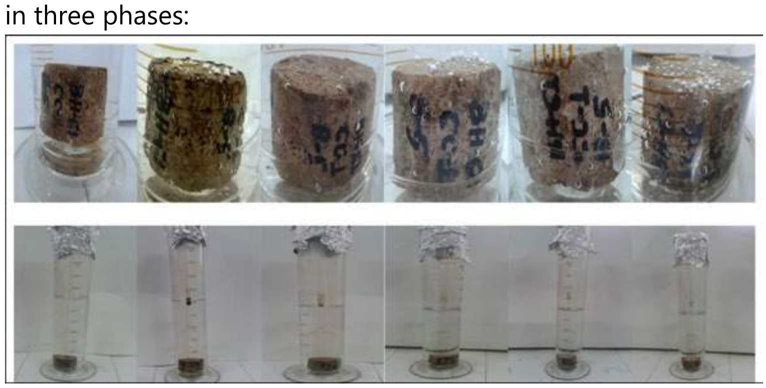
### Field under implementation in ONGC

The field under implementation is a carbonate reservoir 176 km off the west coast of India and put on production in October 1980.The main producing zone is a limestone reservoir with OIIP of 991.96 MMt and ultimate reserves of 367.47 MMt holds 94% of OIIP of Field. Since the start of production it has undergone several rounds of development. Water injection is being carried out since March 1987 in the field however, reservoir pressure has been observed to be declining continuously and thereby affecting production performance of the field. A number of steps were taken to arrest the decline such as installation of gas lift, water shut-off jobs, side tracking of poor producers, enhancement of water injection support and infill drilling through clamp-on structures on existing platforms. Significant efforts were made in the past to identify suitable EOR techniques for field but depleted pressure scenario (80-110 kg/cm$^2$) and high reservoir temperature remained a challenge for conventional EOR implementation. Based on literature screening criteria for carbonate reservoir, field was screened. The field has a high reservoir temperature of 116°C, acid number of crude oil is 0.56 and injected sea water in field contains PDI i.e.$Ca^{2+}$ (481 ppm), $Mg^{2+}$ (1323 ppm) and $SO4^{2-}$ (2650 ppm). Along with above properties reservoir has favorable mobility ratio (0.5), good water flood response, low free gas saturation areas & crude oil has presence of polar compounds and high Sor (>20%) conditions. The field has also well-developed water flood pipeline & surface infrastructure facilities.

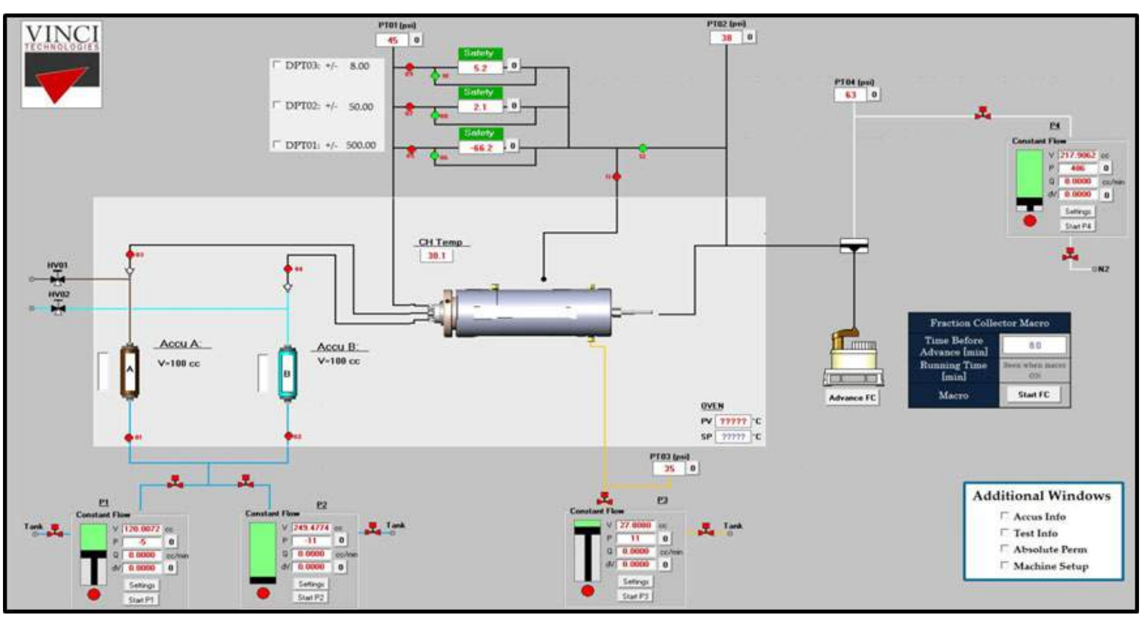
### Study conducted at IRS to shortlist the field

The implementation of any low salinity project normally involves the screening mechanism, pilot scale implementation and full field implementation after a successful pilot. During screening, it is particularly important to assess, model and simulate various EOR scenarios through feasibility study. EOR implementation in offshore fields is always more challenging than the on land fields. After screening of field, laboratory studies were conducted on core plugs of fields in three phases:

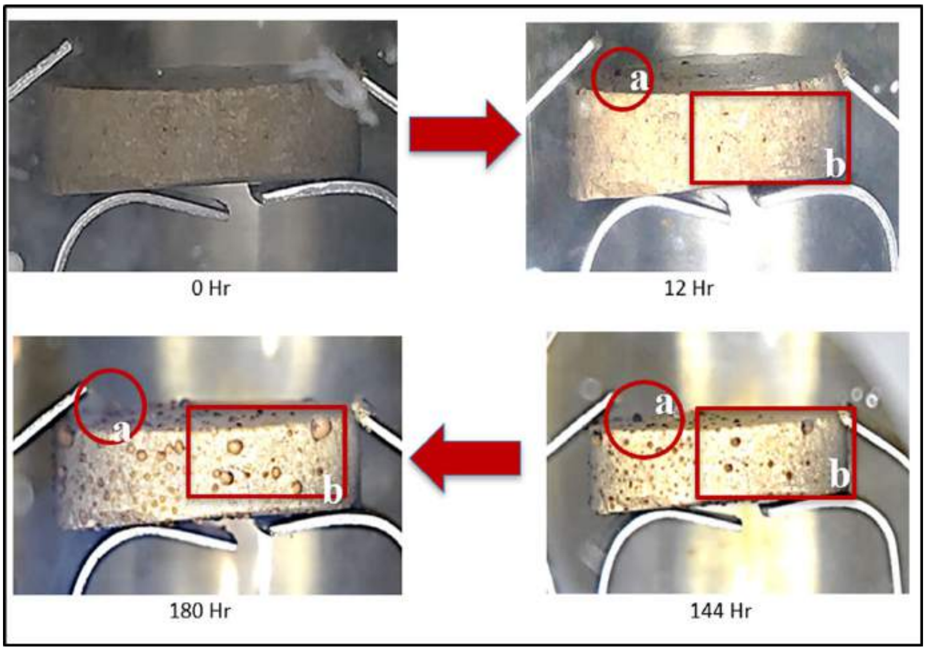
*Core plugs used for study*



*Spontaneous Imbibition Studies*




*Core Flood Experimental design setup at IRS*




*Oil droplets observed during the imbibition under HPHT inside the HPHT cell (Study conducted with collaboration with University of Calgary)*

**Phase-1:** Spontaneous Imbibition and Displacement studies
**Phase-2:** Salinity optimization on target layer through sequential dilution of water in core flood experiment
**Phase-3:** Generation of salinity dependent relative permeability curves for simulation.

In first phase during multi step spontaneous imbibition studies a recovery of 4.3-10% found over sea water flooding which further validated through displacement studies with the help of five core flood experiments in terms of incremental recoveries (5.6-15.9% HCPV) with diluted versions of sea water (100%, 50% 25%, & 10% having salinity ranging from 33640 ppm to 336 ppm). In second phase studies revealed that there is an optimum dilution level (25% SW) at which the wettability is most favorable for enhanced oil recovery. Finally in third phase salinity dependent relative permeability curves were drawn for simulation. Oil-water relative permeability curves for both oil and water confirms a shift towards more water-wet state and a reduction in residual oil saturation by 10 saturation units under low salinity flooding. Further core scale simulation study replicate the displacement efficiencies observed in one of the core flood process.

Based on encouraging lab and core flood simulation results, pilot scale simulation study was carried out to design multi-well pilot for LSWF in the field. Multi-Disciplinary Team (MDT) from different work center of ONGC was assigned to identify suitable area/sector in field for pilot scale implementation. Western flank of field was selected, as the pilot area as it consist of mainly single layer completions in both injectors & producers and show good water flood response. Further to boost our confidence in this process prior to multi-well pilot, a single well pilot involving Single Well Chemical Tracer Test (SWCTT) successfully executed in identified pilot area.

**Conclusions**

LSWF has added recognition as developing EOR technique to extract more oil in sandstone or carbonate reservoir. The process requires extra surface facilities for water sourcing and disposal; it has low capital and operating cost and environmentally friendlier than other EOR techniques. Under present water flood assisted recovery, simulation studies indicate that Field under study is envisaged to have a recovery factor of about 35% by 2035. Hence, significant potential exists for upside recovery through application of Enhanced Oil Recovery (EOR). Summary of LSWF experimental and simulation studies are following:

- Core flood studies recorded incremental oil recoveries (5.6-15.9% HCPV) in terms of linear core displacement efficiency with diluted versions of sea water.

- Core flood studies observed that 25% sea water salinity gave maximum recovery of 7.5% ILDE.

- Simulation studies on incremental recovery at different salinities in one core plug are observed to be 6.67%.

- SWCTT results show a decrease in saturation units from 12% to 7% due to smart water injection.

- The multi well pilot low salinity water flood has been planned with salinity of 8250 ppm.

**Way forward in LSWF**

• Expansion of LSWF in terms of Smart water flood process in which both the ionic composition and the salinity in water are optimally changed in a way that the initial equilibrium of the oil/brine/rock (OBR) interaction is changed while modifying the rock wettability favorably resulting in improved oil recovery.

• Hybrid approach by coupling LSWF with $N_2$ & $CO_2$ gas injection, surfactants and nanoparticles to achieve favorable (higher) capillary number to raise recovery factor even higher.

• Application of foam-enhanced gas injection in conjunction with smart water flooding for enhanced mobility control and sweep.

**Acknowledgement**

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# Failure of a Reactor Inlet Line Flange in a Continuous Catalytic Reforming Unit (CCR) by High Temperature Hydrogen Attack-A Case Study




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**Indian Oil Corporation Limited**
Research & Development Centre

**Abstract**

Refineries and petrochemical industries consist of several interconnected process units which run in sync to produce myriads of products. Interruption even in one particular unit may have cascading effect on the operability of several other units and associated productivity losses. Hence, operators in these units always strive to run their plant free from any interruption, for this planned shutdowns are a necessary part of the refining process to ensure safe and reliable operation. But, many a times such shutdowns prove to be an eye openers when failures are encountered during startup, which otherwise may go unnoticed and may prove to be catastrophic in near future during full fledged operation of the refinery.

One such unit, Continuous Catalytic reforming Unit (CCRU) at a refinery was taken under planned shutdown for reactor inspection and internal repair jobs. During startup post the maintenance a leak was observed from the flange (P11 Grade) of the reactor inlet line (Service: H2+Naptha).

A detailed laboratory investigation consisting of study of crack morphology, microscopic examination, Inclusion analysis, fractographic study, EDAX analysis etc. has been carried out on failed flange to establish the root cause of the failure.

***Keywords:***
High Temperature Hydrogen Attack (HTHA), Flange, Inclusions, Fissures, Cracking

The study attributed root cause of the failure to High Temperature Hydrogen Attack (HTHA). This case of flange failure presents a peculiar example of combined interaction of secondary stress risers (such as inclusions/segregations in the flange, improper heat treatment of the flange and induced brittleness during service) with high temperature hydrogen rich environmental leading to failure at much lower partial pressure of Hydrogen than required for HTHA failure at present operating temperature.

## 1.0 Introduction

Continuous Catalytic reforming (CCR) is a chemical process that converts petroleum refinery naphtha distilled from low-octane oil into high-octane liquid products called reformates(a premium blending stocks for high-octane gasoline). Hydrogen is used along with naphtha as a feed in this process.

One such Continuous Catalytic reforming Unit (CCRU) at a refinery was taken under planned shutdown for reactor inspection and internal repair jobs. During startup post the maintenance a leak was observed from the flange (P11 Grade) of the reactor inlet line (Service: Naphtha+ 5 wt% H2). The failed flange was operating at 518-523$^{\circ}$C with 4-4.5 $kg/cm^2$ of operating pressure and was in service since 22 years.

Although the above flange grade comes under susceptible material for high temperature hydrogen attacks (HTHA), the operating pressure of the flange was much low for any possibilities of HTHA at given operating pressure. Such a peculiar failure attracted the concerns of the operators.

The present study presents a peculiar example of combined interaction of mechanical factors (inclusions/ segregations in the flange, improper heat treatment of the flange, induced brittleness during service) with high temperature hydrogen rich environmental factors to cause HTHA failure(even at lower pressures of hydrogen to cause attack).

## 2.0 Laboratory Investigation:

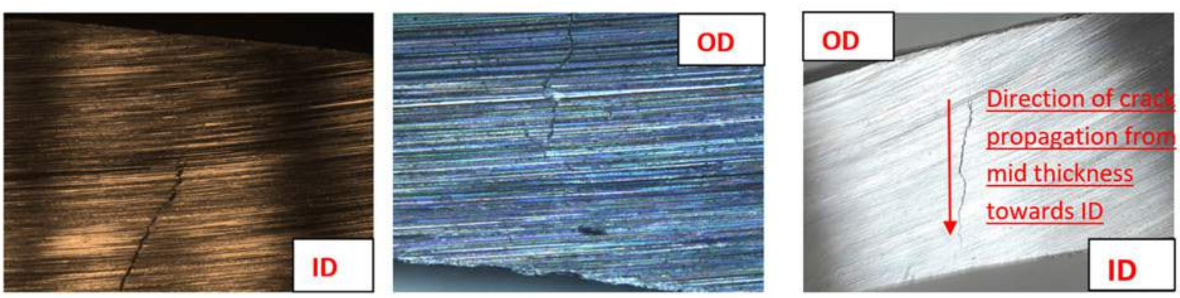
### *2.1 Visual Inspection:*

No corrosion & thickness loss were noticed (Fig.1-2).
Multi branch cracks of brittle morphology were noticed on OD & ID surface.

*Fig.1-2: Multi-branched cracks at leakage location*

### *2.2 Stereoscopic Examination:*

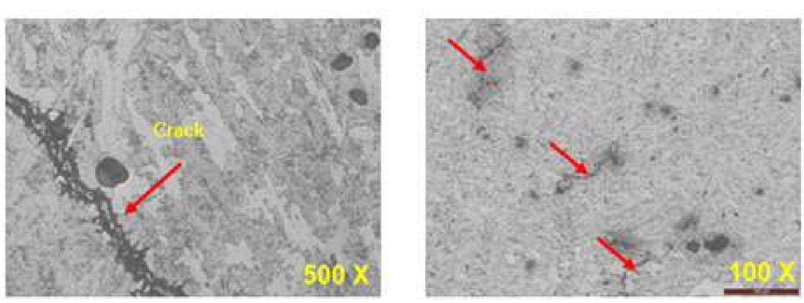
Stereoscopic observations revealed crack initiation from centre and propagated toward ID (in faster way) as well OD direction, resulting into final leakage (Fig. 3-5).

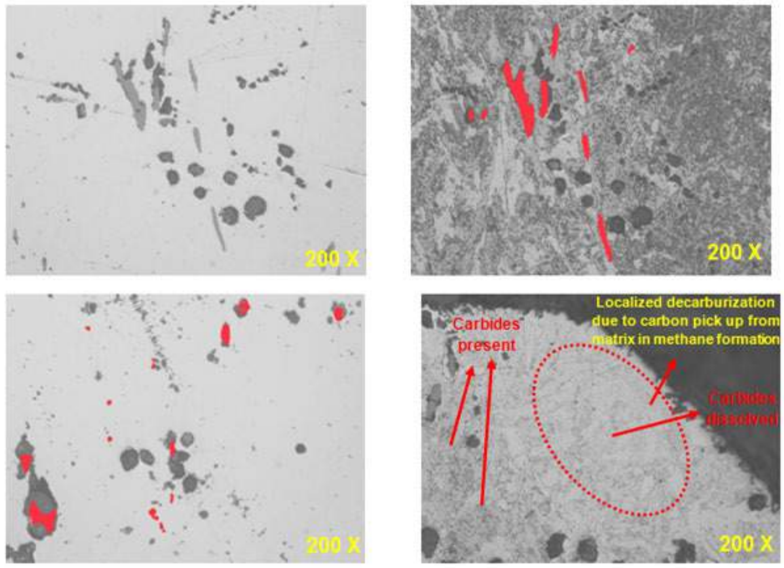



*Figs. 3-5: Crack propagation, towards ID, OD and Bothways*

### *2.3 Microscopic Examination:*

The Microscopic examination on the representative sample along the C-T (circumferential thickness) section of the flange from near to the failure revealed, general microstructure as tempered bainitic structure corresponding to P11 grade alloy steels (Fig. 6) with presence of cracks of microscopic fissures in the matrix (Fig.7), cluster of cavities / voids in close association with inclusions in the matrix (Fig.8-10), and localized Decarburization in the matrix near to the failure region (Fig. 11).






*Figs. 6-11: Microstructures showing, fissures, inclusions and localized decarburization*

***2.4 Chemical Composition Analysis:***

The analysis conformed flange metallurgy to P11 grade but carbon content was found to be more than nominal (0.23 % against the max. limit 0.15%) at ID, indicting the carbon pick up by the material during service

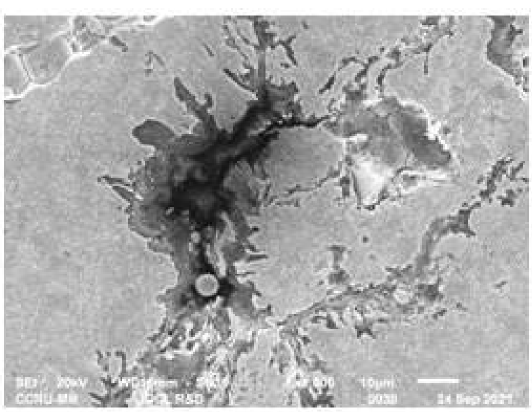
***2.5 Hydrogen Determination Analysis:***

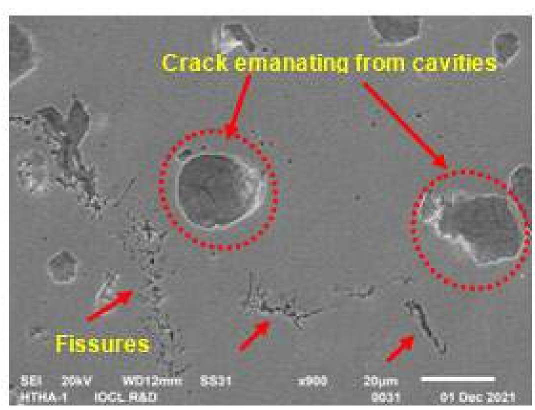
Hydrogen determination analysis on the sample prepared as per code IS: 228-Pt-22-2003 (RA 2008), revealed presence of Hydrogen of 0.9 PPM in the sample indicating some entrapment of Hydrogen in the sample.

***2.6 Fractographic Study:***

A cut piece of the sample from near the failure location was taken under Scanning Electron Microscope (SEM) for fractographic study.

Fractographic examination revealed presence of Cavities along the cracks with multiple micro cracks emanating from the cavities in radial direction (Fig. 12), very fine fissures in the matrix (Fig. 13), microscopic defects such as Stringers / inclusions / segregations along the cold working direction (Fig.14-15) and formations of cavities / voids (possibly the sitting place of methane) near to the interface of inclusions (Fig. 16).





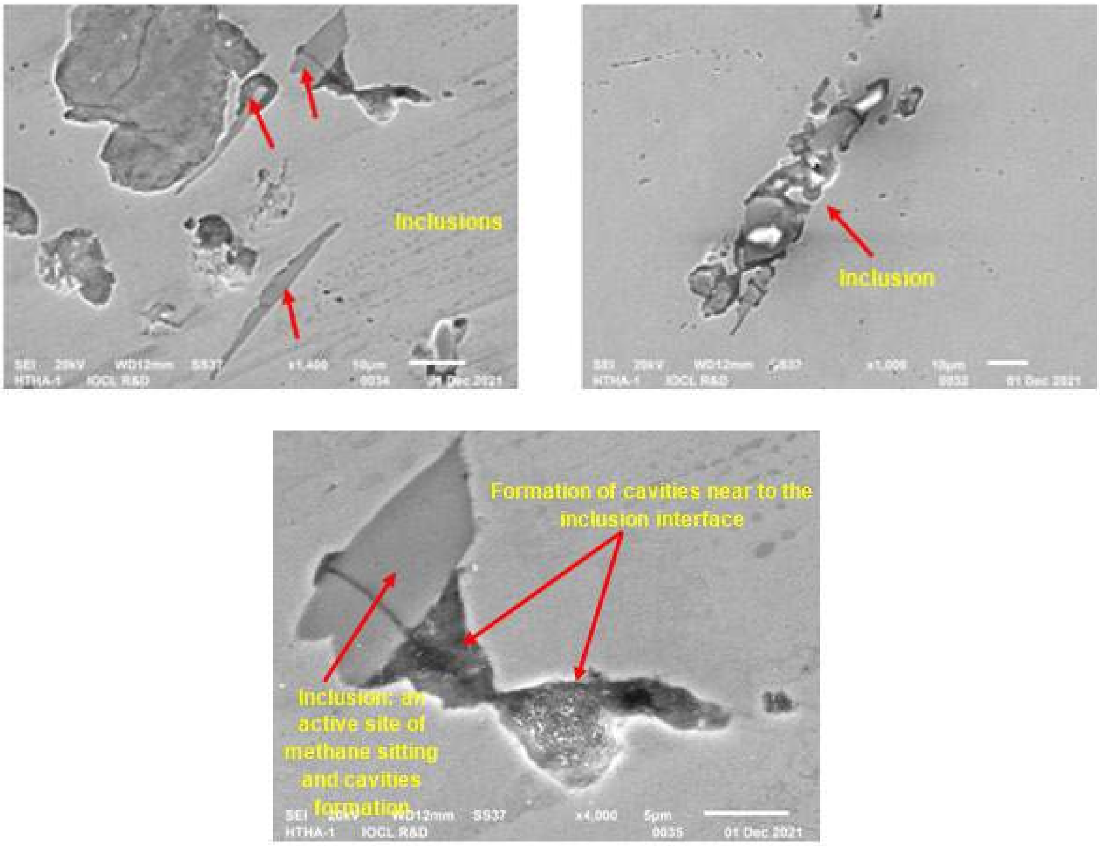



*Fig.12-16: Fractographic images under SEM at THE failure location*

***2.7 Hardness Survey:***

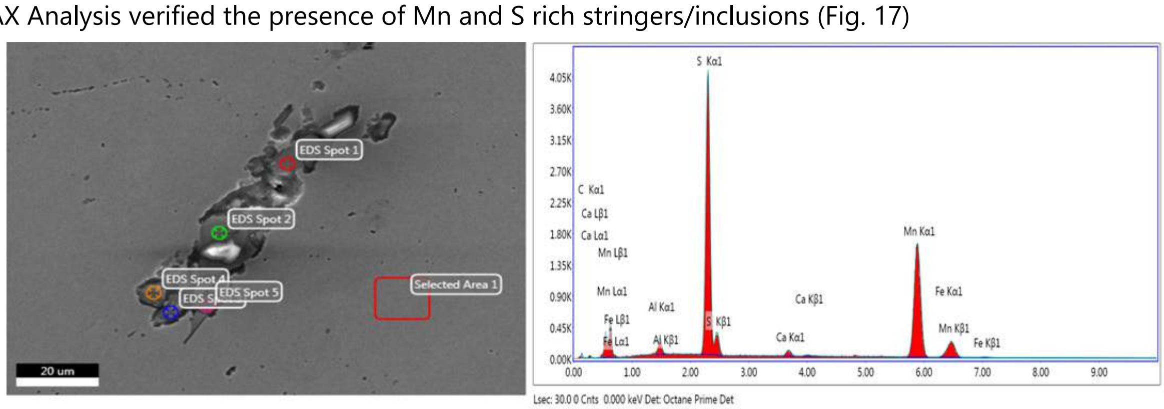
The bulk hardness of the Flange samples was found in the range 192-195 BHN and falls beyond acceptable range as per ASTM SA 182 F11 CL1 (121-174 BHN).

***2.8 Inclusion Rating:***

Inclusion rating near leak location and away from leaked region as per ASTM E45-18a (Method A) indicated Type-A Sulphide inclusions (thin and heavy) in both the locations pointing towards uncleaned steel.

***2.9 EDAX Analysis:***

EDAX Analysis verified the presence of Mn and S rich stringers/inclusions (Fig. 17)




*Figs. 17: EDAX analysis of the inclusion showing Mn and S peaks*

**4.0 Results and Discussions:**

- The inspection indicated Multi branch cracks of brittle nature originating from centre of flange.
- Higher carbon at ID indicated carburization of material with service exposure.
- Inclusion rating and EDAX analysis indicated towards unclean steel.
- Presence of diffused Hydrogen probably at the fissure location or adjacent locations noted.
- Various kinds of degradations such as microscopic fissures, cluster of round / bubble shaped cavities / voids in close association with inclusions / stringers / segregations aligned in cold working direction in the matrix and Localized Decarburization in the matrix near to the failure region was noted. Cracking and fissuring observed to be mixed (both intergranular and transgranular) in nature.
- Profound inclusions and forged rolling marks attracted nascent hydrogen to accumulate and further combined with nascent hydrogen to form hydrogen molecules or reacts with available carbon to form Methane bubble to cause high temperature hydrogen attack during service. The microstructural analysis by optical microscopy and SEM study clearly indicated manifestation of hydrogen attack.
- Though possibility of HTHA in P11 under the given service condition is low (very low partial pressure of hydrogen), failure took place after a long service exposure. Brittleness in the flange material due to C pickup and high hardness further accentuated brittle crack propagation causing failure.

**5.0 Conclusion:**

From the all above lab investigations, the failure of the reactor inlet piping flange of CCRU is attributed to Environment–Assisted Cracking as a High temperature hydrogen attack (HTHA). Profound thick Mn ans S rich inclusion in the flange acted as potential site for hydrogen accumulation which reacted with available C to form methane ($CH_4$) bubbles and caused fissuring / cracking. Brittleness in the flange material due to C pickup and high hardness further accentuated brittle crack propagation causing failure.

***6.0 References:***

*[1]. API 571, API RP 579, API RP 941*
*[2]. Materials Property Council Report FS-26, "Fitness-for Service Evaluation Procedures for Operating Pressure Vessels, Tanks, and Piping in Refinery and Chemical Service," Draft 5, Materials Properties Council, NY, 1995.*
*[3]. Practical experience in the early detection and assessment of vessels with HATA Degradation William R Sharp Cooperheat*
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*[6]. Failure of a hydrogenerator reactor inlet piping by high temperature hydrogen attacks Kioumars Poorhaydari.*
*[7]. A general overview of hydrogen embrittlement Adri_an Del-Pozo1, Julio C. Villalobos2, Sergio Serna1 1Ciicap.*

# Valorisation of Reactor Purge Gas

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## 1) About the Organisation

• OMPL Aromatic Complex, a subsidiary of MRPL and group organisation of ONGC, produces Para-xylene as its product and Benzene as a Co-product.

• Aromatic Complex is designed to produce 914 KTPA Para-xylene and 283 KTPA Benzene.

• The complex processes Naphtha as well as Aromatics (A7+A9) as feed from Refinery to produce Para-xylene and Benzene.

• M/s UOP is a Process Licensor of Aromatic Complex.

## 2) Para-xylene production at the Aromatic Complex

The Aromatic Complex processes middle and heavy naphtha along with the Aromatics in the following units to produce Para-xylene and benzene:

***• Continuous Catalytic Platforming Unit:***
Naphtha is processed in the Platformer Reactor and converted to Aromatic rich Reformate followed by Hydrogen Recovery Section.

***• Trans-alkylation Unit :***
The C7 and C9 aromatics from the Refinery along with the C7 and C9 aromatics produced in platformer from Naphtha feed are converted to Xylenes and Benzene in the Trans-alkylation Reactor.

***• Fractionation Unit:***
Benzene is separated from other C7-C10 aromatics in the Benzene fractionation columns with the aid of integrated heat system. Similarly, toluene is also fractionated and sent to Trans-alkylation unit.

***• Xylene Fractionation Unit:***
Xylenes along with C9+ aromatics formed in the trans-alkylation reactor and Reformer are sent to Xylene column where xylenes are separated in the overhead and routed to Para-xylene extraction unit. C9 and C10 aromatics are recycled back to trans-alkylation reactor after separation from the remaining heavier compounds.

***• Para-xylene Extraction unit:***
Paraxylene is separated from its isomers (meta-xylene, ortho-xylene and ethyl benzene) via desorbent extraction.

***• Isomerisation Unit:***
Isomer Reactor catalyst is a bi-functional catalyst that converts xylene isomers as follows:

1) Ethyl-Benzene is converted to Benzene which is then routed to Benzene fractionation column.

2) Other Xylene isomers like ortho-xylene and meta-xylene are converted to para-xylene which are then routed back to the paraxylene extraction chamber.

After all above processes, 99.8% pure Paraxylene is obtained as our final product.

**3) Purge Gas generation from the Reactors**

In trans-alkylation and Isomerization unit, some amount of gas is purged off (2000-6000 Nm3/hr) to the fuel gas system in order to maintain recycle hydrogen gas purity which reduces under the following conditions:

***1) High severity operation***
Maintaining high overall conversion of feed by increasing the Reactor Inlet Temperature (RIT). High temperature operation increases the cracking.

***2) Processing C9 aromatics rich feed in Trans-alkylation Reactor***
More A9 processing gives more xylene yield than the benzene yield with high fuel gas generation and reduced recycle gas purity.

***3) Catalyst Ageing***
With the ageing of catalyst, catalyst loses its activity due to which higher temperatures are required in order to get the required Overall conversion. Thereby, leading to increased cracking of the feedstock in the reactor.

Above conditions lead to the increased cracking in the reactors that result in the generation of lighters and reduces recycle gas purity. In order to maintain hydrogen purity as per design, some amount of gas is purged to remove non condensable from the recycle gas loop. With hydrogen make-up and purge of lighter ends, recycle gas purity is being maintained

The Process design has provided two options for the routing of this purged gas:

1) To Fuel gas system
2) To Flare header

This purge gas is highly rich in hydrogen which used to burn in fired heaters as fuel in the Aromatic Complex, depreciating the valuable hydrogen.

Therefore, a pathway was worked out in order to utilise this off gas.

Standalone aromatic complex generally requires hydrogen for reactors and generated either by hydrogen unit or as a by-product from the platformer unit which contain high purity hydrogen recovery section.

***As a part of "OMPL SUGGESTION SCHEME – Ideas for Positive Change and Act on Great Ideas", a scheme was suggested to route these purge gases to PSA unit for hydrogen recovery.***

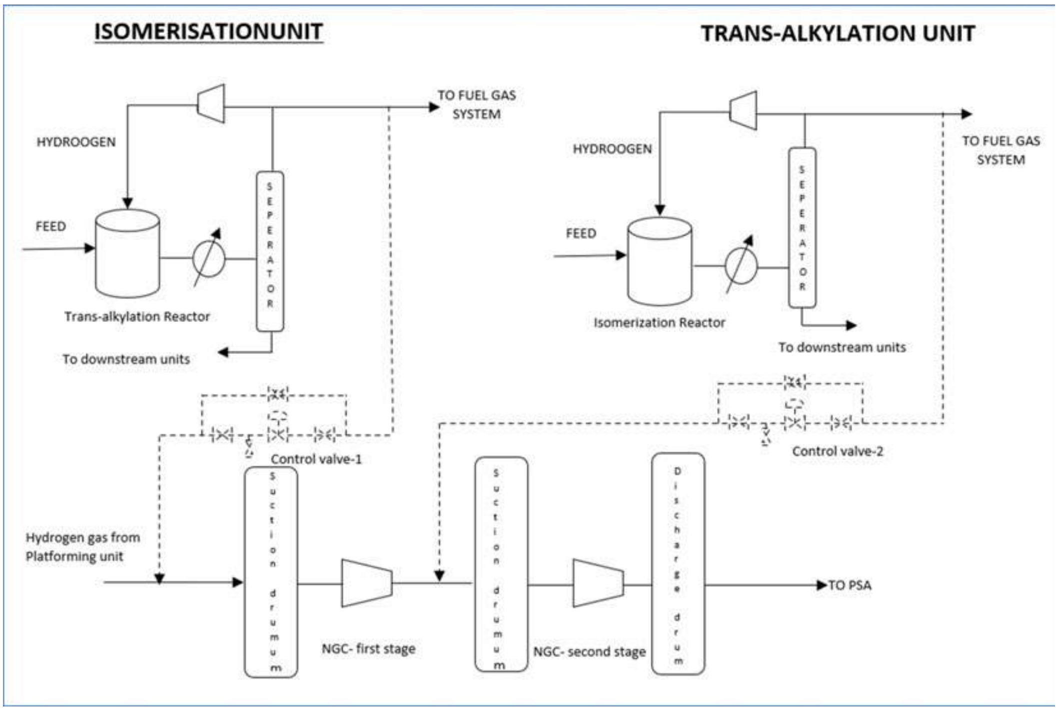
A modification was carried out at the Aromatic Complex to route these purge gases to Hydrogen recovery system before routing to fuel gas header. The scheme was commissioned in September-2021 and 88% of hydrogen was recovered.

***4) Modification Details***

In Process units, there are two sources of purge gas generation:

- Trans-alkylation Reactor
- Isomerisation Reactor.

As the purge gases from Trans-alkylation unit and isomerisation unit are coming at different pressures, Trans-alkylation unit purge gas was routed to second stage suction drum of Net Gas Compressor whereas Isomerization unit purge gas was routed to the first stage suction drum of NGC. The NGC discharge is routed to Hydrogen recovery system to recover Hydrogen from Platformer net gas along with purge gases from both reactors.




## 5) BENEFITS ACHIEVED

Prior to the modification, the reactor purge gases were sent to Fuel gas system resulting which Hydrogen value depreciated to lower value.

With the implementation of this scheme at the Aromatic Complex, the recovery of Hydrogen from the purge gases has provided a monetary benefit of rupees 3 lakhs per day by recovering 250 kg/hr of hydrogen from these reactor purge gases at low purge gas generation of about 2000 Nm3/hr from reactors

Considering maximum generation (depending on operating conditions) and recovery of hydrogen from the purge gas, the estimated benefit is rupees 23 crores per annum.

## 6) SUMMARY

• OMPL aromatic Complex is designed to manufacture Para-xylene and Benzene

• Purge gas generation from reactors is a consequence of cracking which needs to be utilised in a more economical way as it is highly rich in hydrogen. Therefore, it was routed to the existing Hydrogen recovery system via small modification in order to recover hydrogen as economic entity rather than mixing it with the fuel gas.

• A monetary benefit of rupees 3 lakhs per day has been observed at the Aromatic Complex by recovering hydrogen from the purge gases.

# Reactor-Regenerator Supporting Structure: Creating an Engineering Marvel

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## Overview of Reactor-Regenerator Section

A recently designed refinery, a grass-roots CDU, is the largest single train refinery in the world; wherein a single crude column has been provided to process about 30 million MMTPA of crude (600,000 barrels/ day). The Refinery has been designed with the primary objective to produce high quality transportation fuels for use in domestic market and for export. To maximize the gasoline component in the Refinery, large CCR, PENEX, Mild Hydrocracker and an Alkylation Unit is provided. The crude that is processed in the upstream CDU fractionates various components from LPG down to diesel which are routed variously to MS block & Mild Hydrocracker converting diesel partly into naphtha. The bottoms of the crude column referred to as Reduced Crude Oil (RCO) forms the feed to the Resid Fluidized Catalytic Cracking Unit (RFCCU), which is in today's norms one of the biggest RFCC unit in the world. Beyond a certain unit capacity, mechanical design of equipment was a challenge/ limiting factor.

The regenerator of this plant, with the diameter of around 20 meters is perhaps the biggest regenerator in the world and beyond this diameter of the equipment, there was problem perceived in terms of simulation of the plant for designing the unit. Consequently, the RFCC capacity was restricted to 10 MMTPA.

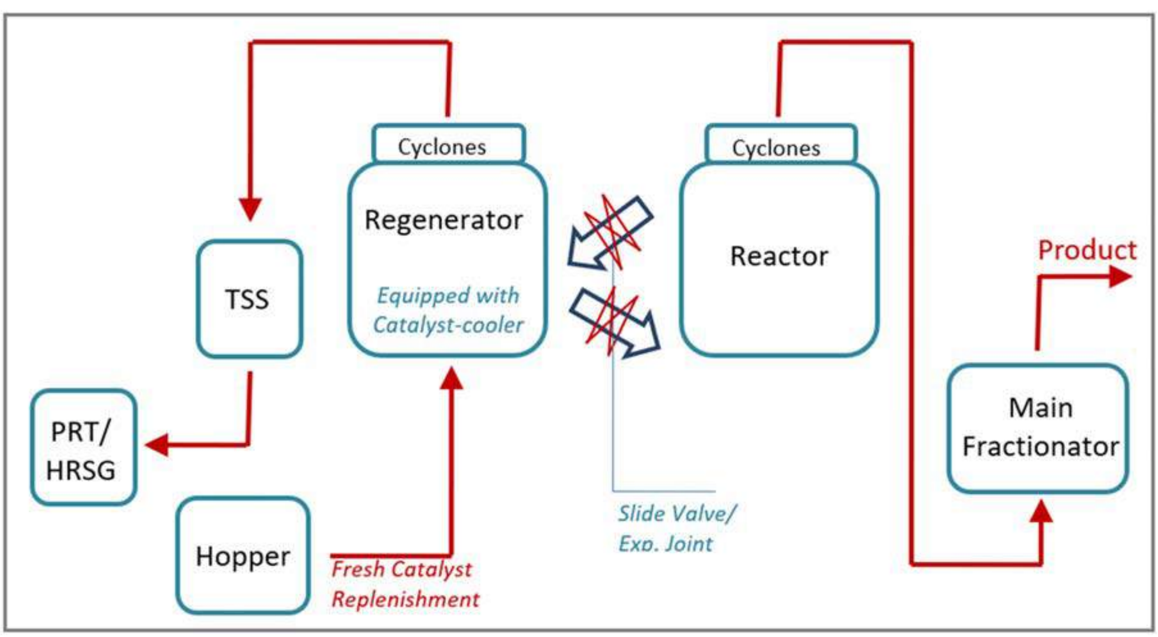



*Fig.-1: Reactor-Regenerator – A Bird's Eye View*

Further, the feed to the unit being very high, a lot of cracked LPG was produced in the refinery, which provided an avenue for recovery of propylene in a downstream propylene recovery unit, and the propylene so recovered, was made to fed to the polypropylene unit.

The basic process of the RFCC unit comprises of reactor and regenerator vessels, which are equipped with internal cyclones, a typical stand-pipe arrangement, wherein the spent-catalyst stand-pipe from Reactor to Regenerator and the fresh catalyst pipe from the Regenerator to Reactor Riser are connected. In normal process, the fresh catalyst from the regenerator flows through the Wye-section into the riser, where it comes in physical contact of the hydrocarbon and steam. The Steam/hydrocarbon ratio is meticulously maintained through the various injection nozzles, provided in the riser. The residence time of the reactor is in the range of two seconds or so, that is by the time the catalyst and the hydrocarbon comes in contact with each other and till such time as it comes out of the riser pipe inside the reactor vessel, the entire reaction is completed; all products starting from fuel gas down to the heavies are all produced inside the reactor vessel. The overhead of the reactor vessels through the cyclones recovers all the hydrocarbons which are fed into the fractionator column, where through multiple draw off streams, various cuts of the products are recovered. The top product being the fuel gas, side products being LPG, cracked LPG, cracked Naphtha, heavy cracked Naphtha, Diesel, cracked Diesel, and of course the pitch or part of the Pet coke forms the bottom product.

Upon completion of reaction inside the reactor vessel, the residual carbon, which is liberated out of cracking of the hydrocarbon, is deposited on the pores of the catalyst and thereby deactivates the catalyst. This is known as the spent catalyst. This catalyst from the Reactor flows, through a slide valve, into the regenerator vessel; where it comes in intimate contact with air. The carbon reacts with air to produce CO and in presence of excess air produces $CO_2$. The overhead product of the regenerator, predominantly $CO_2$ at very high temperature is led into the Tertiary Separator System (TSS), wherein the attrited catalyst particles are recovered and the hot gases are fed to the expander where power is recovered. Thereafter, the hot gases from the expander are routed through the HRSGs so as to produce high pressure steam, which drives the major machinery of the RFCC unit, namely the main air blower and the wet gas compressors.

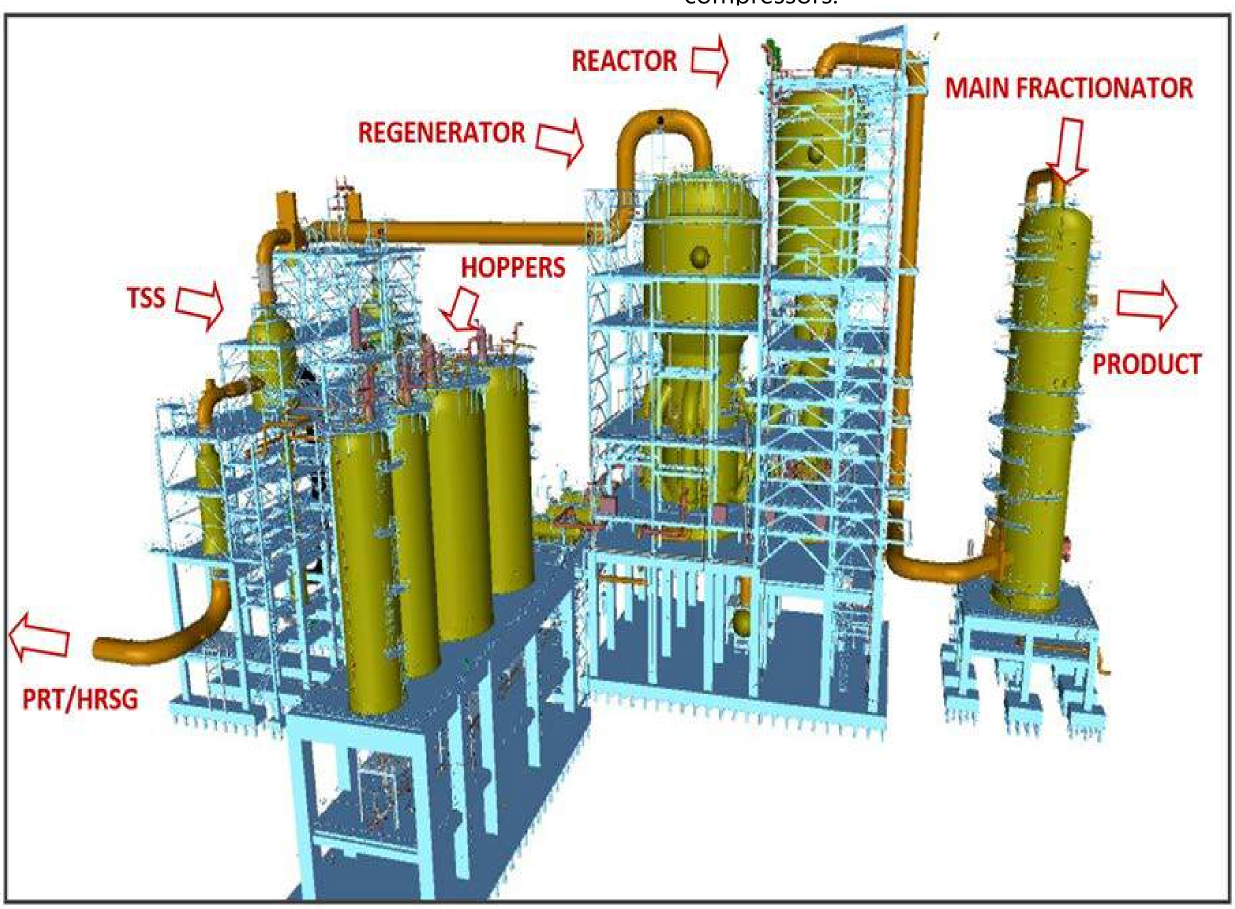



*Fig.-2: Reactor-Regenerator Section – 3D View*

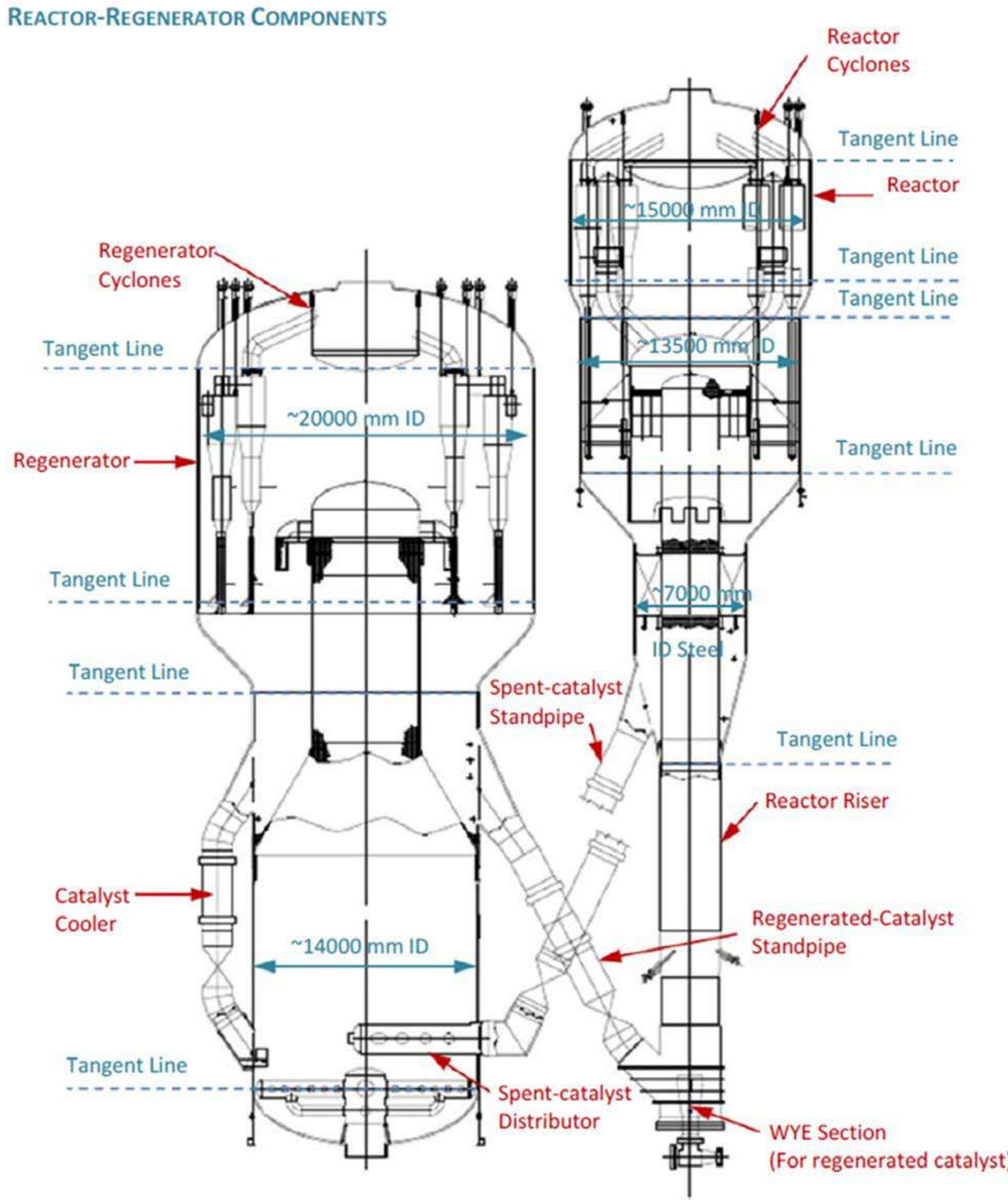



*Fig. 3: Sectional View of Reactor Regenerator*

***Main components of Reactor-Regenerator consist of:***

- Reactor vessel and Internals
- Reactor Riser pipe
- Regenerator vessels and internals equipped with catalyst-cooler
- Wye-section along with regenerated catalyst standpipe
- Spent-catalyst standpipe along with spent catalyst distributor

Dimension and weight of various components are given in the Table-1 below;

TABLE-1: DIMENSION AND WEIGHTS OF VARIOUS REACTOR-REGENERATOR COMPONENTS

| S.N. | DESCRIPTION | COMPONENTS | |
|---|---|---|---|
| | | REACTOR | REGENERATOR |
| 1 | DIAMETER (MM) | ~15000/ 13500 | ~20000/ 14000 |
| 2 | TL-TL (MM) | ~38000 | ~45000 |
| 3 | WEIGHT (TON) | 1250 | 4000 |
| 4 | REFRACTORY WEIGHT (TON) | 200 | 500 |
| 5 | CYCLONES–NOS. | 25 | 25 |
| 6 | CYCLONE WEIGHT (TON) | 325 | 725 |
| 7 | WEIGHT WITH REFRACTORY &CYCLONES (TON) | 1800 | 5250 |
| | | RISER PIPE | |
| 10 | DIAMETER – EXTERNAL/ INTERNAL RISER (MM) | ~7000/ 3750 | |
| 11 | HEIGHT – EXTERNAL/ INTERNAL RISER (MM) | ~21000/ 24500 | |
| 12 | TOTAL WEIGHT (TON) | 280 | |
| | | SPENT CATALYST STANDPIPE | Y-SECTION (FOR REGENERATED CATALYST) |
| 13 | DIAMETER (MM) | ~2000 | ~2000 |
| 14 | TL-TL(MM) (EXCLUDING EXPANSION JOINT & SLIDE VALVE) | ~11000 | ~6500 |
| 15 | WEIGHT (TON) (EXCLUDING EXPANSION JOINT & SLIDE VALVE) | 17.5 | 10.5 |

**Structural Design Criticality**

Extreme loading, tall structure, very high elevations of major equipment support warranted a thorough look on various design aspects.

TABLE-2: REACTOR LOADING DATA

| | | |
|---|---|---|
| WEIGHT | ERECTION | 1525 TON |
| | EMPTY | 1800 TON |
| | OPERATING | 2800 TON |
| WIND LOAD AT EQUIPMENT SUPPORTING LEVEL | SHEAR | 650 TON |
| | MOMENT | 5200 TON-M |
| SEISMIC LOAD AT EQUIPMENT SUPPORTING LEVEL | SHEAR | 400 TON |
| | MOMENT | 5400 TON-M |

TABLE-3: REGENERATOR LOADING DATA

| | | |
|---|---|---|
| WEIGHT | ERECTION | 2680 TON |
| | EMPTY | 5250 TON |
| | OPERATING | 6375 TON |
| WIND LOAD AT EQUIPMENT SUPPORTING LEVEL | SHEAR | 450 TON |
| | MOMENT | 18530 TON-M |
| SEISMIC LOAD AT EQUIPMENT SUPPORTING LEVEL | SHEAR | 470 TON |
| | MOMENT | 22050 TON-M |

Regenerator was supported at the height of 18 m, whereas Reactor was supported at the height of 58 m above high pavement point (HPP). On account of increased heights, the net seismic and wind loadings on the foundation/structure also increased significantly. Total system load including structural weight at the foundation level was of the tune of vertical load 23,000 ton, shear force 1650 ton, moment 137,000 ton-m due to wind/seismic load.

During maintenance, the catalyst coolers, attached to the regenerator vessel, were planned to be taken out in a single piece from the bottom of regenerator supporting floor. Due to which structure had to be planned free of any beam or bracing up to the level of 18 m above HPP. Structural steel column, even the highest H-section, needed to be tied across its weaker axis at a height of around 4-5 m. So RCC frames were planned up to regenerator supporting level. Regenerator vessel being the heaviest part of the assembly with around 6400 ton vertical weight, 470 ton maximum shear and 22,000 ton-m maximum moment, this replacement of structural material proved to be a great cost economizer apart from its sole purpose of functionality during maintenance.

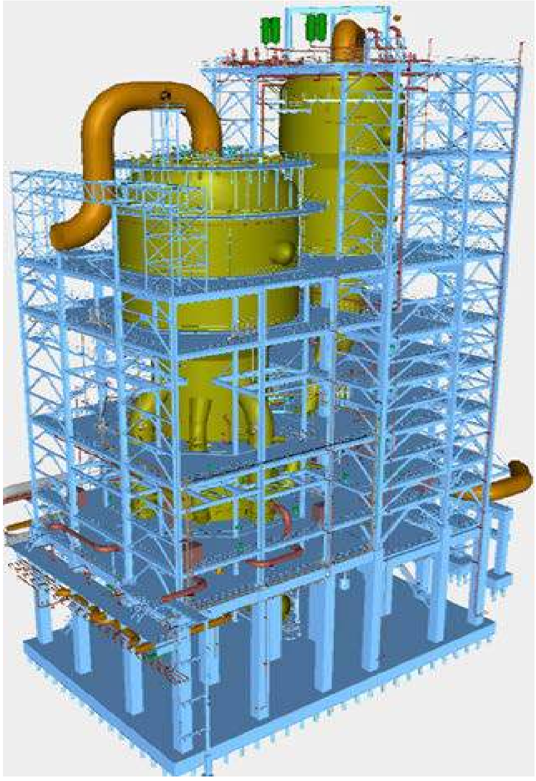


*Fig. 4: RR Supporting Structure – 3D View*

The entire structural design was performed as per British-Euro codes (BSEN) along with applicable country specific annexures.

Regenerator supporting RCC columns were carrying almost 2650 ton axial load along with 1150 ton-m bending moment about each direction. Due to space constraint, cross sectional dimension was restricted to 1750x1750 mm, 128 nos. of 32 mm diameter reinforcement bars were placed in bundles.

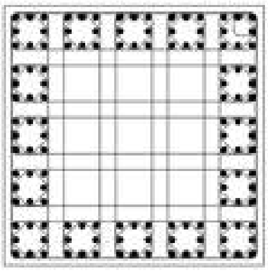


*Fig. 5: Cross-section of column*

On account of huge size of reactor and regenerator vessel, conventional braced framing arrangement of steel structure, for supporting reactor, catalyst cooler, stand pipes and other parts of the RR system was not feasible to provide. Alternatively, vertical bracings were provided in the peripheral frames only and internal frames were conceptualized with gravity columns. Stability of the structure against huge wind/ seismic lateral loading was ensured by proper distribution of lateral loads from gravity columns to braced frame columns through sets of horizontal bracings.

Actual axial loading experienced by the reactor supporting columns was 1750 ton along with associated bending moments, which were around double of capacity of maximum H-section available in the market. Composite column made up of two H-section of 900 mm depth along with flange plates were provided immediately beneath the reactor support. Vertical bracings of the peripheral frames were made up of square hollow section of maximum up to 300x300 mm. Regenerator supporting beam was designed for a bending moment of 3560 ton-m and 1750 mm wide x 2500 mm deep beam with 24 nos. of 32 mm diameter reinforcement bars in both of the top and bottom face were provided.

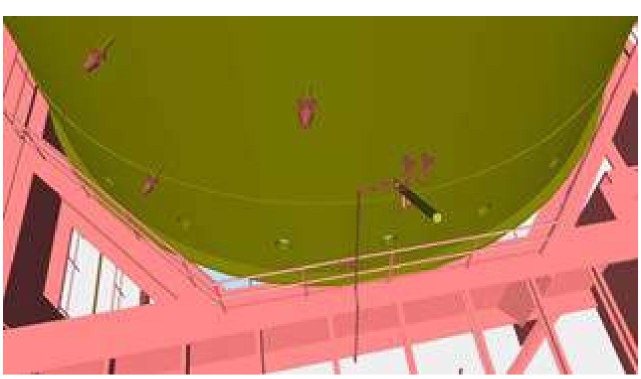


*Fig. 6: Reactor Supporting Floor*

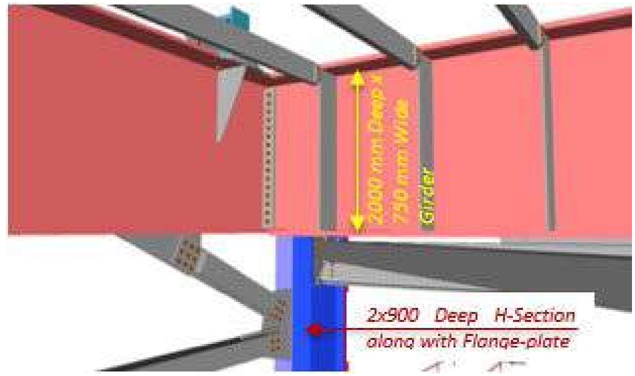



*Fig. 7: Reactor Supporting Girder and Column*

Reactor supporting plate girder, designed for a bending moment of 2680 ton-m, was 2000 mm deep and 750 mm wide along with continuous plate at top and bottom to accommodate 72 nos. of 72 mm dia. bolts. Planning of bolt arrangement by avoiding overlapping with web of the plate girder and maximizing shop fabrication of the girder including top and bottom circular plate with complete penetration joint was extremely critical. Entire conceptualization of the reactor supporting girder was done keeping in view of the erection scheme of various structural components.

Stringent operation and maintenance requirement of the structure caused the overall structural design extremely critical. Each of the catalyst-coolers was around 200 ton weight. Substantial amount of free space was required around the catalyst-coolers for easy and effective operation, causing design of the supporting column sections extremely difficult. One of the heaviest 300 mm deep H-section, with substantive lateral ties, was planned for supporting the coolers. Similarly, designing the standpipe supports was equally crucial.

**Fabrication and Transportation of eactor` and Regenerator**

Reactor and regenerator vessels along with all other components of Reactor-Regenerator (RR) package were fabricated overseas and transported to the site. Both of the reactor and regenerator vessels were transported in single piece at site, along with the internals duly hydro-tested at shop, and Refractory lining applied on Reactor & Regenerator. Cyclones were also pre-fixed with the reactor and regenerator before transporting to site. Minimum site welding was involved for joining the Reactor & Regenerator Sections along with some other parts, such as catalyst-coolers, reactor riser, standpipes etc.

*Fig. 8: Reactor Transportation in Single Piece*

*Fig. 9: Regenerator Transportation in Single Piece*

The Refractory lining in the RR Package forms an extremely critical component of the total work. The Refractory lining in the Reactor and Regenerator vessels and the associated piping were carried out predominantly at vendor's workshop before dispatch of the equipment; only the Refractory for the joints was planned to be performed at site.

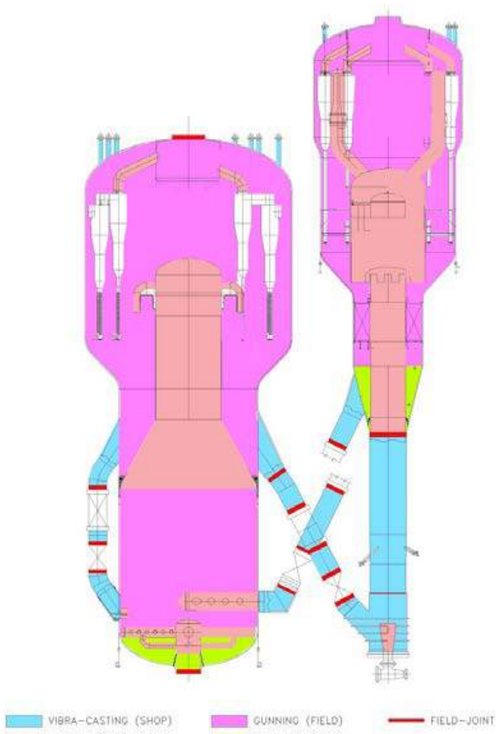



*Fig. 10: Refractory and Joint*

Various sections of the RR System were equipped with different refractory materials. The critical basis in the entire system design was essentially that, wherever the catalyst was in motion, such as stand pipes, Risers, Internal Riser overhead piping the systems were essentially vibro-lined. On the other hand, at those sections where the attrition and catalyst movement in the system was restricted, such as reactor and regenerator vessels, castable refractory was applied through gunning. All the Reactor and Regenerator Sections & Piping were transported through special barges to the job site, where it was unloaded at a specially constructed Jetty. From Jetty to site the Reactor & Regenerator was transported on axles.

**Construction and Fabrication of Structure**

The structure was supported over a huge pile cap (54 m x 36 m x 2 m thick) with 384 nos. piles and 5000 cum of RCC.

Ready mix concrete were brought from four ready mix plants; two numbers at the rate of 180 cum/hr. and one of 120 cum/hr. along with one at the rate of 120 cum/hr. in spare. Four concrete boom placers with boom length of 42 m and capacity of 60 cum/hr. along with one spare boom spacer were engaged for the construction. Two vibrators for each boom spacer along with five vibrators in spare were used. Concrete pouring was done in layers; with maximum depth of each layer of 500 mm. The raft was cast in continuous stretch of 24 hrs. Fixing bolts accurately within the layers of dense reinforcement was quite challenging.

*Fig. 11: Casting of RR Structure Foundation*

*Fig. 12: Casting of Regenerator Supporting Beams*

Erection of the structure was sequenced in sync with equipment erection. Entire structure was designed keeping in view of the modular erection. All shop fabricated connections were welded, whereas connections made at site were bolted in nature. Reactor supporting plate girder, being circular in nature and due to its huge dimension, was one of the most critical fabrication tasks. Parts of the girder were connected through Complete Penetration Joint to ensure seamless connection and to simulate its integrated behavior against load transfer. The entire girder was fabricated in four parts, each part weighing 30 ton were lifted at a height of 57 m and jointed together.

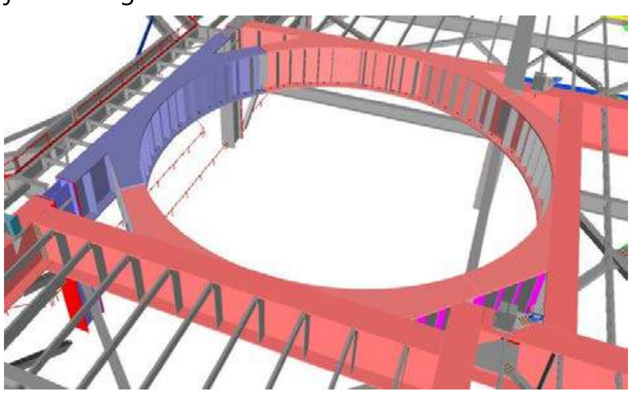


*Fig. 13: Reactor Supporting Plate Girder*

**Erection of Reactor-Regenerator**

Erection of reactor and regenerator was extremely critical task. A specialized agency was engaged for erection of the equipments. World's largest ringer crane mobilized by Mammoeth, along with some other heavy cranes, was used for the rigging of equipment & lined piping in position.

TABLE-4: RINGER CRANE DATA

| DESCRIPTION | DETAILS |
|---|---|
| BASE DIAMETER | 55M |
| COUNTER WEIGHT | 3500 TON |
| MAIN-BOOM LENGTH | 95 M |
| FIXED-JIB LENGTH | 25 M |

*Fig. 14: Regenerator Erection*

*Fig. 15: Reactor Erection*

**Conclusion**

On a concluding note, critical aspects of the RR structure may be summarized as follows;

Resid Fluidized Catalytic Cracking Unit (RFCCU) is one of the most important secondary processing units and Reactor-Regenerator section is the heart of the RFCC Unit. Reactor-Regenerator is not only a long lead item but also one of the most expensive and intricate components of any refinery, strategic planning and successful implementation of this section leads to cost/ schedule optimization and overall success of the projects.

Refractory lining is extremely critical for reactor-regenerator in terms of conserving heat and rationalizing metallurgy. Application of refractory is a specialized affair as well as time-taking activity. Maximizing the task in the workshop ensures its quality, at the same time proves to be a time savior.

*Fig. 16: World's largest Reactor-Regenerator Supporting Structure*

Of course, a lot of precautions in application and anchorage system of the refractory have to be taken to prevent transportation damages.

Regenerator in general is heavier than reactor and due to its relative location at a lower elevation; it is always a wiser choice to plan part of the supporting structure, up to regenerator supporting level in concrete. This not only eliminates substantial fabrication effort by rationalizing the steel section sizes but also optimizes cost of the structure. Modularization of the supporting structure speeds up structural work by reducing site activity. It also facilitates equipment erection activities.

Truly, the Reactor-Regenerator system is an Engineer's paradise, a fabricator cum transporter's challenge and a constructor's desire. Being associated with this challenge was certainly a dream come true!


*Ms. Papia Mandal - The recipient of FIPI 'Woman Executive of the Year Award' (Special Commendation) for the year 2021.*

*This award honours Papia Mandal for her courage, grit and determination in pursuing a professional career path with competence and balance in other walks of life.*

# Pipeline 4.0 : Digital Transformation of Oil & Gas Pipelines

**Safil Sunny**
Chief Executive Officer & Founder

**Tranzmeo IT Solutions Private Limited**

Pipelines are rivers of growth and development for a nation playing a vital role in the fast and economical transportation of oil and gas that fuels all the industries and lives of everyone. The waves of Digitization are currently empowering the age-old industry to surf into new heights. Democratizing new technologies, starting with the Industrial revolution 4.0 (IR 4.0) has opened a new paradigm of solutions that were previously beyond imagination. The impact of IR 4.0, Every aspect of lives is getting impacted in a 360 Degree. The use of Artificial Intelligence, Big Data, Machine learning, Analytics, the Internet of Things, Edge computing, etc have brought unconventional solutions to obstacles in every Industry.

Oil and gas, even though being the powerhouse of all the industries, still have been struggling in adopting these technologies and hugely leveraging the capabilities. Pipelines are the distribution backbones of the oil & gas industries. These arteries have to work 24x7 with high efficiency, safety, and security. These pipelines are generating millions of data every second from their traditional sensors, PLC's, Supervisory control and data acquisition control systems (SCADA), Leak detection systems, Cathodic protection systems, Pumps etc. Most of this data is generated in the pipelines are for monitoring purposes and taking quick operational decisions. But most of these generated data is not stored or analyzed or derived any insights.

## Digitizing the Pipelines

***The digitisation process of an oil & gas pipeline consists of five phases.***

- Design and modelling of the pipeline infrastructure.
- Data Acquisitions & warehousing.
- Data processing with Anomaly Forensics.
- AI & ML Capabilities with Auto learning.
- Real-time analytics and Actionable insights.

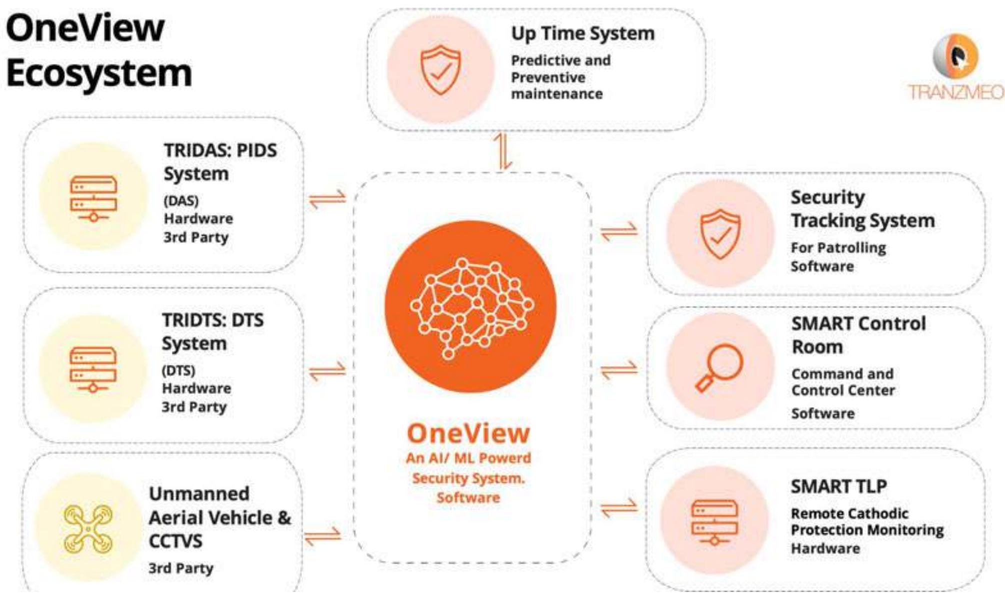
When we are talking about digitisation & pipeline 4.0 and leveraging Artificial intelligence and machine learning capabilities, and utilizing the power of Big data, 100's of individual components have to be worked seamlessly and in sync with the echo system.

To achieve this kind of power and capability, team tranzmeo has developed a complete comprehensive pipeline integrity ecosystem called T-Connect OneView. Our product will give a complete comprehensive pipeline integrity solution for our customers which helps them to protect and monitor their entire pipeline infrastructure. Along with that, it provides preventive maintenance, anomaly detection, leakage detection, intrusion detection, real-time analytics and comprehensive inspection.

T-Connect OneView will act as a command and control centre for the pipelines in terms of a pipeline integrity ecosystem. Our Solution, OneView is India's first non-intrusive solution, that can monitor and protect complete pipeline infrastructure 24x7. It can help you to identify many activities which are happening in a remote pipeline with an accuracy of less than 1 meter. Using our advanced photonics, fibre sensing technologies, Artificial intelligence and machine learning algorithms we help organizations to eliminate threats and save millions of dollars every year. Our system will be able to identify every meter of pipeline heartbeats in every millisecond.

With the real-time monitoring of every breath of pipelines, critical pipeline systems including SCADA, LDS, PIDS, Telecom, and much more OneView brings light to predictive and preventive maintenance to identify downtime and detection of abnormalities before causing issues. Like any good system, OneView is an Artificial intelligence system, which can learn and evolve over time.

The System will act as a SMART Control room for the pipeline, which provides a detailed understanding of Pipeline chainage information, fiber information, Right of use area landmark information such as warning boards, TLPS, Turning points, weld joints etc. The system also provides a comprehensive view of alarms and events generated in the respective systems. Currently, our system is protecting more than 4,000 KM of oil & gas pipelines in India.




***About Tranzmeo***

*Tranzmeo is a young vibrant Deep tech startup invested by Hindustan petroleum corporation (HPCL), focusing on Big Data, Machine learning, Artificial Intelligence, Distributed Fiber sensing Technology.*

# Learnings from Chinese Gas Markets

**Rajesh K Mediratta**
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**Indian Gas Exchange (IGX)**

Globally, gas exchanges have played a key role in establishing pricing, allowing producers and consumers greater freedom to sell and purchase this gaseous fuel, and transition towards becoming a gas-based economy. It is imperative for India to look at the leading gas markets across the globe, take away key learnings and adopt these to help circumnavigate its own roadmap.

In the first of series of articles, here we will briefly take the Chinese market - which is currently the largest in Asia and largest importer of LNG in the world and what can be take-aways from its development for India. Apart from building strong market penetration and a competitive pricing environment of their gas markets, China have also gone through significant regulatory and policy changes to facilitate their thriving gas markets.

**A glance at Asia's biggest gas market:**

By far, the biggest gas market in Asia is China. According to the Statistics of 2021, the consumption of natural gas in China stood at ~ 910 MMSCMD. About 58 % of the country's gas demand was satiated through the domestic gas production of ~ 530 MMSCMD while the remainder of 42 % was met by the import of LNG to the tune of ~ 380 MMSCMD. Of the entire energy market of China, natural gas contributed an 8.2 % share. China grew to become the world's largest importer of LNG in the month of June '21, relegating Japan to second place. China has a total of 22 LNG regasification terminals with a combined capacity of 76.8 MMTPA.

The country's gas transmission network consists of more than 80,000 km of pipelines. The country has also underground gas storage facility of ~ 24 BCM ( 7% of Country's Gas Demand). With a market of such a large size, the Chinese natural gas sector has high leverage in global markets.

A major chunk of the overall Chinese natural gas infrastructure is owned and operated by CNPC, SINOPEC and CNOOC, all of which are national oil companies. The regulatory framework for the Chinese natural gas market is drafted by the National Development and Reform Commission (NDRC), along with the National Energy Administration (NEA).

**Takeaways for India from the Chinese Gas Market:**

India and China are both going through similar timelines with regard to development. However, China has put some robust regulatory reforms into place and this needs to be done in some areas for the Indian gas markets as well to accelerate the country towards a gas-based economy and achieve the vision of increasing the contribution of gas to 15% in the overall energy mix by 2030.

This article outlines learnings from one step ahead Chinese gas market and specific gas market reforms, largely categorized in 4 categories as mentioned below:

1. Pricing of domestic gas
2. Operator for Country's Gas Infrastructure
3. Favorable policy frameworks to increase usage of gas replacing the other polluting fuels
4. Role of Gas Exchange in country's transition to a gas-rich economy

**1. Pricing of domestic gas**

***Story of Natural Gas Pricing reforms in China***
***Cost-plus Approach - Pre 2013 Era*** : Self-sufficient in natural gas supply, China's pricing structure was entirely based upon a cost-plus approach until 2010. These prices were determined by NDRC based on proposals from gas producers, pipeline operator and local distribution operators. Producers and buyers were able negotiate up to a 10% price increase or decrease based on the ex-plant prices set by NDRC.

The old pricing regime was established when natural gas was supplied domestically, which was based on the cost of domestic production. Under this regime, the ex-plant pricing approach applied for both domestic and imported gas. After 2010, with the substantial increase of LNG imports, in many situations the city gate prices set by the old pricing approach were much lower than the international contract prices for imported natural gas. Natural gas importers incurred significant losses, which discouraged natural gas imports.

As a result, many cities experienced severe shortages of natural gas. This necessitates the government to alter the pricing mechanism to prevent the NOC's huge lose in LNG import business. In 2012 PetroChina earned about 40 billion yuan on the sales of natural gas and pipeline operations. At the same time, they paid about 42 billion yuan for the imported gas from Central Asia. As a result, the company lost 2 billion yuan in 2012.

***Two Tier Pricing – 2013*** : Purpose was to not to discourage the buyers and at the same time to make the seller's business profitable. For this purpose, China introduced 2 tier pricing mechanism. Tier 1 Volumes : An existing volume, defined as the amount of natural gas consumption in 2012 & Tier 2 volumes : An incremental volume, the amount of volume added in 2013, 2014, and 2015 beyond that in 2012. Tier 1 Volume priced accordingly old regime; Tier 2 volume linked to FO & LPG. The primary rationale for the new pricing is that the value of natural gas can be largely represented by the value of its two substitutes in terms of providing energy services – fuel oil used in the industrial sector and liquefied petroleum gas (LPG) used in the residential sector.

This resulted in increase in NOC's profitability. In 2013, PetroChina paid a similar amount for imported gas as that of 2012, after the introduction of the new pricing system in 2013 PetroChina earned about 71 billion yuan from the sales of natural gas and pipeline operations. As a result, PetroChina earned 31 billion yuan more in 2013, after this pricing reform.

***Single gas price – 2015*** : Gov. through various directives increased/decreased the prices of both the tire volume. This regime lasted till March 31, 2015. From 2015, the prices of both tired volumes reached the same level, ending 2 tier pricing. Gov. started benchmarking the prices of all gas instead of fixing the ceiling price. Buyer/seller were given flexibility to negotiate price up to 120% of benchmark price. 1st Gas Exchange established - Shanghai Petroleum and Natural Gas Exchange – SHPGX.

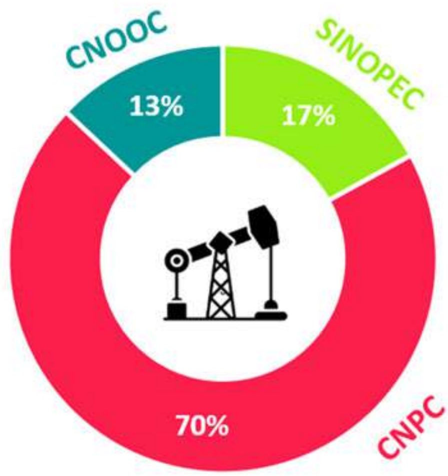
***Liberalization – 2016*** : From 2016 onwards, gas used for almost all direct users were fully liberalized and subject to direct negotiation between buyer & seller. NDRC sets the benchmark prices of non-residential gas instead of the ceiling, and the actual price shouldn't exceed 120% of the benchmark price. Govt encouraged buyer/sellers to use newly formed gas exchange – SHPGX.

**Takeaway for Indian Gas Market**
In a bid to improve the profitability of domestic gas producers, the pricing for India's entire domestic gas should be de-linked with the four international hub prices and moved to exchange for price discovery. The market should have complete freedom, however, if govt is wary of market power, then, can fix ceiling price linked to alternate fuels in appropriate proportions. Either complete freedom of marketing in terms of buyers or alternatively, only priority sectors may be allowed to participate in the special domestic gas trading sessions on the exchange. If govt is keen to keep APM gas for priority sector, then, same set of buyers will be allowed to bid for such gas. Gas Exchange will help setup indigenous price benchmarks in India. In India, we have taken the first step by authorizing domestic contractors to sell up to 500 million standard cubic meter or 10% of annual production from contract area, whichever is higher, per year through gas exchanges.

**2. Operator for the Country's gas infrastructure**

***China's LNG terminals and gas infrastructure – ownership and operation - An oligopoly Market***

As stated earlier, the majority of country's natural gas infrastructure is owned and operated by its 3 national oil company ("NOC") which are CNPC, SINOPEC & CNOOC.




(Share of domestic gas production, Source : IHS Markit)


(Share of Natural gas pipeline infrastructure, Source : IHS Markit)

Out of country's total 22 operational LNG regasification terminals, these three NOC companies own and operate 17 terminals and remaining 5 terminals are owned and operated by non-NOC companies. Apart from these, NOC companies together own and operate over 90% of China's gas storage business.

These NOC's import portfolio includes some expensive long-term contracts, which probably ranks among the most expensive LNG ever contracted. The companies routinely lose money on these imports because the price it pays is often higher than the state-set prices at which it can sell the gas in China. Owing to these losses, NOCs are reluctant to grant third party access to their pipelines and LNG import terminals with cheaper supplies, such as LNG purchased on the spot market in periods when Asian spot prices are well below China's prices, to avoid making it more difficult to sell its expensive imported gas.

They are also reluctant to forge interconnections between pipelines and LNG terminals that they operate with those operated by their domestic peers for the same reason. This resulted into another hurdle of the construction of "repeat" infrastructure that wasted financial and land resources. They built duplicate pipeline networks to avoid sharing infrastructure and thus customers and revenue with other operators.

***Establishment of new national pipeline company - A New Player in China's Oil and Gas Industry***

At last, the Chinese government taken important step to segregate pipeline ownership and spur competition through the proposed establishment of the national pipeline company. On December 9, 2019, China legally established a new player in China's oil and natural gas industry, the China Oil & Gas Piping Network Corporation (PipeChina). The company is formed through the transfer of assets and personnel from China's three major national oil companies (NOCs).

It marks a significant step towards improved third party access, better network integration and lower transmission tariffs. The reform may increase market competition, stimulate investment across the natural gas value chain and reduce the cost of gas to end users. It will probably take several years for the company to be fully operational.

In October 2020, they launched centralized booking platform and TPA to its infrastructure (https://www.pipechina.com.cn/gpkf/tzgg.html). PipeChina has a mandate to develop the infrastructure required to improve the allocation of natural gas resources nationwide. This endeavor entails building some of the pipelines, LNG import terminals, and natural gas storage facilities that have constrained China's ability to meet demand during peak periods. It also entails forging connections between infrastructure previously operated by the NOCs and provincial governments. In addition, this move is also intended to eradicate the development of "repeat pipelines" and the resulting waste of capital and land.

PipeChina has consolidated most of the long-distance gas pipelines as well as regasification terminals and underground storage sites that were previously controlled by China's three state owned energy majors (PetroChina, Sinopec and CNOOC) and providing fair and open third-party access to all as per the guidelines set out by NDRC.

**Takeaway for Indian Gas Market**

In China, the government has separated the ownership of the pipelines and has brought in competition into the segment by virtue of the sole government owned pipeline company that is set to acquire most of the infrastructure from the three National Owned Companies. Similarly, India too should form a single entity that will take control and operate the nation's entire gas grid or at least that owned by Central and State PSUs. Transparent access must be provided by this company to all interested players to boost competition in the market. This will also simplify pipeline tariffs since number of operators will be lower. In India, we have allowed multiple pipeline operators and bundled services by few integrated operators. It is high time, as step one, we mandate all contracts may be unbundled. Invoicing should have separate elements of transport and commodity transactions. Further, govt is in process of setting up of a common Transport System Operator (TSO) which will be tasked with transporting gas from the producers to the final distribution network through existing pipelines. However, best solution for competition is – legal unbundling of transport and marketing with clear guidelines to ensure neutrality. TSO may be authorized to monitor non-discriminate processes and operations by transporters.

**3. Favorable policy frameworks to switch to cleanest fossil fuel:**

In China, because of the growing political imperative to reduce air pollution by switching to gas, a boom has been seen in the demand for natural gas in the country in the last decade. In fact, in the second half of 2020, China had announced is net-zero emissions target that is to be achieved by 2060, which will be a catalyst to future growth of mid-term gas demand. Overall, the rate of China's transition from other fuels to gas is nearly double as that of the global average. This is testament to the fact that the government's policies of incentivizing a shift to cleaner fuels is driving up the country's medium-term demand for natural gas. Various Central government policies to promote natural gas as a fuel includes coal to gas switching in almost all the industries to make "China's skies blue again". On transportation sector, various state government has introduced subsidy on CNG, LNG fuel cost and subsidy on CNG, LNG vehicle purchase cost, etc. In residential sector also, government has rolled out stricter policy to convert room heating system powered by coal to clean fuels like gas or electricity.

In India, conducive policies are needed to reduce the production of electricity through the burning of coal and transition to gas instead. One way of achieving this would be to impose carbon tax or create cap-and-trade mechanisms to deter use of dirty fuels and provide incentives and subsidies for gas-based power plants while penalties should be applied to powerplants that utilize coal for the generation of electricity. This will increase the share of gas in India's overall energy basket, while simultaneously discouraging the usage of coal in the country.

Natural gas as cleanest fossil fuel should be promoted and mandated for use in public transport, to start with. Schemes aimed at promoting usage of natural gas, specifically mandatory conversion of public transport in Tier II & Tier III cities to CNG, where authorized CGD is active and where key pollution level indicators, like AQI are above certain threshold (say, AQI > 200) should be implemented. Single nodal agency responsible for obtaining faster governmental clearances for executing gas pipeline and related infrastructure projects may be appointed.

**4. Role of Gas Exchange in country's transition to a gas-rich economy**

***Evolution of Shanghai Petroleum and Natural Gas Exchange (SHPGX) in China***

China established SHPGX in late 2016 which is largest natural gas spot trading center in the Asia-Pacific region. It is purely a physical delivery-based Exchange which provides centralized trading platform for the products like Pipeline Natural Gas (PNG),Liquefied Natural Gas (LNG),Liquefied Petroleum Gas (LPG),Refined Oil, etc. With the huge support from China Government, SHPGX is trading the volume of approximately 25 % of country gas consumption with the participation from more than 3000 domestic members and around 60 international trading members. Over the years, SHPGX has developed a great platform through the support of local government and has provided innovative offerings to the Chinese gas market including but not limited as mentioned below.

- ***Trading of Piped Natural Gas (PNG):***
"SHPGX is currently trading 25 % of China's gas consumption which includes domestically produced gas as well. This has been through the continuous government support and favourable policies. Here, the price of natural gas traded on exchange are deregulated and formed by the market only which includes domestically produced gas as well."

- ***Index release of "China's imported spot LNG price" and Index release of "China's LNG Comprehensive Import Index"***
"Previously, China's imports were primarily linked to foreign international indexes which is purely on assessment basis, and which was not truly reflecting country's gas demand – supply conditions. But now the state-backed exchange – SHPGX has started publishing China-based spot LNG pricing daily. SHPGX in collaboration and support from department of Chinese Customs (where customs department provides price data of LNG coming to the Chinese ports) is releasing gas price index for its own country's buyers and sellers which reflects true market conditions and pricing. As per the data available, China-based spot price had the support of top state majors like PetroChina , Sinopec Corp and China National Offshore Oil Corp, as well as that of non-major importers."

- ***Trading of Liquified Natural Gas (LNG) for downstream buyers***
- ***International LNG tender service for upstream buyers***

- ***"E-GAS" system (Gas Information platform to educate the market)***
"E-Gas system is a joint project created by China Economic Information Service and Shanghai Petroleum and Natural Gas Exchange with the aim to play an important role in information dissemination and industry research help in Chinese natural gas sector development. It provides all the relevant information required by the upstream and downstream industries of Chinese natural gas market like (not limited to) domestic natural gas industry map, LNG international trade map, Realtime statistics of international trade, Natural gas industry information, various international and national gas price index, important regulatory orders, industry news etc. all at one place"

- ***Trading of petroleum products***

IGX as neutral platform, can also provide similar services like
1. Auction of LNG for mid-term say month-year
2. Auction for fertilizer (Urea ) plants
3. Price Reporting of RLNG/LNG etc. for each zone capturing OTC and Exchange prices
4. E-Gas like platform
5. Trading of SSLNG and other Petroleum Products

**Takeaway for Indian Gas Market**

The country's first digital trading platform – Indian Gas Exchange (IGX), went live recently and allows buyers and sellers of natural gas to trade in the forward and spot markets for imported natural gas.

In China, the price of natural gas traded on Gas Exchange are deregulated and formed by the market only (including domestically produced gas). In India, the recent amendment of policies that allows for the sale of domestically produced gas (with Marketing & Pricing Freedom) through the exchange will improve the market liquidity and allow for price discovery based on the market. Additionally, in a bid to improve the profitability of domestic gas producers and to increase domestic gas production of the country and reduce dependence on imported RLNG, the pricing for India's domestic gas (APM Gas) should be de-linked with the four international hub prices and moved to exchange for price discovery as mentioned in earlier section of this article.

Secondly, India's gas buyers / sellers are currently relying on international gas price benchmarks which are purely on assessment basis, and which does not reflect country's gas demand – supply conditions. As like SHPGX, India's own gas exchange, IGX is best and trustable platform which can work with India's Custom department for releasing India's true Import Gas Pricing index for its buyers and sellers instead of relying on assessed basis markers.

The launch of India's first Gas Exchange is a significant development and ushers in a new era in the country's gas journey towards the promoting and sustaining of a robust and efficient gas market. IGX is committed to lead India's transition towards a gas-based economy by architecting next generation solutions for natural gas trading and access. IGX is actively working on new products and innovative offerings to Indian gas market to increase its market offerings.

Through the driving of sustainability, facilitation of competition in the sector, efficient usage of infrastructure, promoting the resurgence of gas-based power-generation, and growth of investments across the value chain, the Gas Exchanges will satiate the demand for transparency in the trading of gas in India and transform the country's gas market. Learnings from global gas markets & exchanges will definitely help India create well-functioning, liquid and vibrant markets with conducive regulatory framework, facilitation of market development.

# Addressing Climate Change Through Carbon Pricing

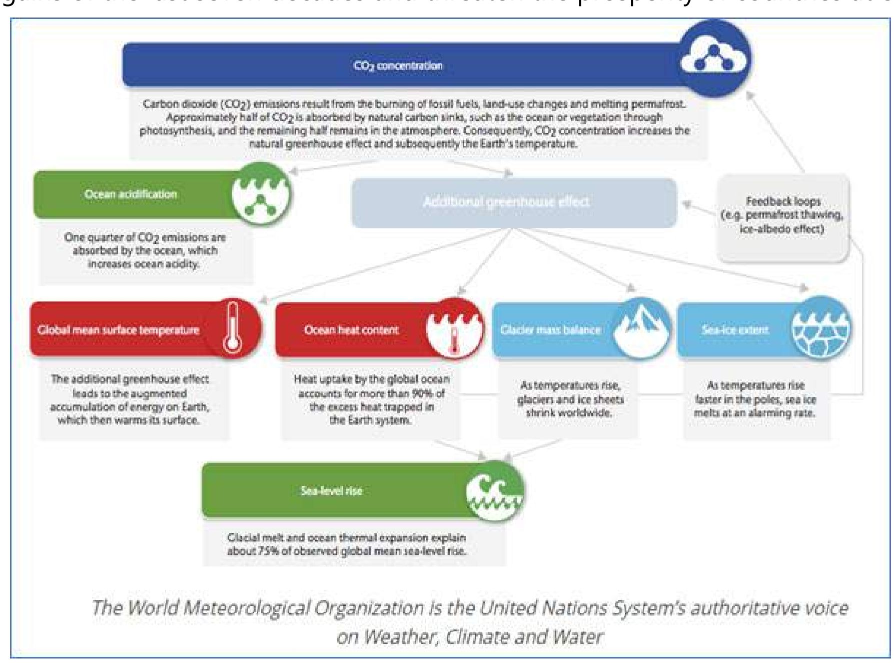
**Pankhuri Goyal**
Senior Assistant Director (Economic Research)

**Federation of Indian Petroleum Industry (FIPI)**

## Climate Change in Sustainable development

Climate change is one of the greatest global challenges of our time. It threatens to roll back decades of development progress and puts lives, livelihoods, and economic growth at risk. Today, the science is unequivocal: Humans have been driving global warming through the extensive burning of fossil fuels. Fourteen of the 15 hottest years since record keeping began over 130 years ago have been since the turn of this century. The intensity of extreme weather-related events has also increased.

Recent reports from the **Intergovernmental Panel on Climate Change (IPCC)** and the **"Turn Down the Heat Reports"**, prepared for the Word Bank by the Potsdam Institute for Climate Impact Research warn of dangerous effects on agriculture, water resources, ecosystems, and human health if countries do not take action. If the world warms by just 2°C (3.6°F in next 20 to 30 years, the world could see widespread food shortages, unprecedented heat-waves, and more intense storms. Sea level rise, storm surges, and salinization may ruin land used for agriculture or other purposes. Carbon emissions would also lead to ocean acidification, which would affect marine ecosystems. Unmanaged climate change could, over the next century, reverse the development gains of the last seven decades and threaten the prosperity of countries at every income level.




*Source: - World Meteorological Organisation*

At COP21 in Paris, in December 2015, nearly 200 countries agreed to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C." Limiting global average temperature increase to 1.5 degrees is estimated to require a global emissions decline of around 45% from 2010 levels by 2030, reaching net zero around 2050. These temperature targets require a large-scale transformation in the structure of economic activity including a major change in energy systems- power generation; industrial processes; space heating and cooling systems; transport and public transportation systems; urban forms; land use (including forests, grasslands, and agricultural land); and the behaviours of households.

Climate change is considered a market failure by economists, because it imposes huge costs and risks on future generations who will suffer the consequences of climate change. To overcome this market failure, there is need to 'internalise' the costs of future environmental damage by putting a price on the carbon that causes GHG emissions. Further, to stay below 2°C, the IPCC says the world will need to get to zero net emissions before the end of this century.

Carbon pricing has therefore, become one of the strongest policy instruments available for tackling climate change. It has the potential to decarbonize the world's economic activity by changing the behaviour of consumers, businesses, and investors while unleashing technological innovation and generating revenues that can be put to productive use. In short, well-designed carbon prices offer several benefits: they protect the environment, drive investments into clean technologies, and raise revenue.

## Role of Carbon Pricing on the path to Net Zero

### *What is Carbon Pricing?*

Carbon pricing puts a price on carbon and act as a means of bringing down emissions and drive investment into cleaner options. Its broad goal is to discourage the use of carbon dioxide–emitting fossil fuels in order to protect the environment, address the causes of climate change, and meet national and international climate agreements.

According to the Paris Commission, the explicit carbon-price level that is consistent with achieving the Paris temperature target is at least US$40–80/tCO2 by 2020 and US$50–100/tCO2 by 2030. There are several paths' governments can take to price carbon, all leading to the same result. They tap the external costs of carbon emissions – costs that the public pays for in other ways, such as damage to crops and health care costs from heat waves and droughts or to property from flooding and sea level rise – and tie them to their sources through a price on carbon.

Putting a price on carbon can likewise create financial incentives for polluters to reduce emissions. In this way, the overall environmental goal is achieved in the most flexible and least-cost way to society. The carbon price is generally normalized to the amount of GHG that would lead to the same equivalent warming as a ton of CO2 over a specific period, and is specified as a price per ton of CO2 e (or CO2 equivalent).

## Carbon Pricing Options

There are two main types of carbon pricing: ***emissions trading systems (ETS) and carbon taxes.***

1. An emission trading system (ETS) referred to as a cap-and-trade system – Here, government sets a cap on the maximum level of allowable emissions (quota) and creates permits, or allowances, for each unit of emissions allowed under the cap i.e., allows those industries with low emissions to sell their extra allowances to larger emitters. This approach allows polluters to meet emissions reductions targets flexibly and at the lowest cost. It provides certainty about emissions reductions, but not the price for emitting, which fluctuates with the market. The European Union's Emissions Trading System (ETS) is the most widely known example of a cap-and-trade system.

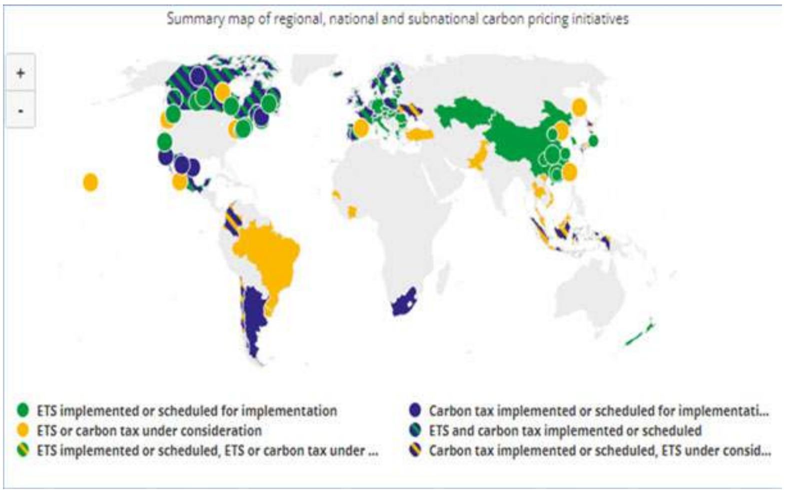
### Mechanism under ETS

- Under a baseline-and-credit system, baselines are set for regulated emitters. Emitters with emissions above their designated baseline need to surrender credits to make up for these emissions. Emitters that have reduced their emissions below their baseline receive credits for these emission reductions, which they can sell to other emitters.
- For a given permit price, some firms will find it easier, or cheaper, to reduce emissions than others and will sell permits. If there are too many such firms in the market, the price of permits, will decline, inducing some firms to reduce their emissions reduction efforts.
- Only when the price of permits is just right will the number of permits offered for sale by firms that can reduce emissions at low cost be equal to the number of permits demanded by firms for which emissions reductions are costly.

• This process of trading ensures there is a unique price for all firms coordinating their activities and drives down emissions to the level allowed under the cap cost-effectively.

2. A carbon tax directly sets a price on carbon by defining a tax rate on greenhouse gas emissions or on the carbon content of fossil fuels. It thus creates a financial incentive to lower emissions by switching to more efficient processes or cleaner fuels. This approach provides certainty about price because the price per ton of pollution is fixed. A prominent example is Sweden, which currently has the highest carbon price in the world at US$ 137.

The figure below shows countries where Carbon pricing initiatives have been implemented.




**Opportunities for carbon pricing to support a sustainable recovery**

• A carbon tax can be levied at any point in the energy supply chain. The simplest approach, is to levy the tax "upstream," (for instance, suppliers of coal, natural gas processing facilities). Alternatively, the tax could be levied "midstream" (electric utilities) or downstream (energy-using industries, households, or vehicles).

• Economic theory suggests a carbon tax should be set equal to the social cost of carbon, which is the present value of estimated environmental damages over time caused by an additional ton of CO2 emitted today. The tax rate should also rise over time to reflect the growing damage expected from climate change. An increasing price over time also provides a signal to emitters that their investments in more aggressive technologies will be economically justified.

• Without provisions protecting local production, a carbon price could put domestic energy-intensive, trade-exposed industries (EITEs), such as chemicals, cement/concrete, and steel, at a competitive disadvantage against international competitors that do not face an equivalent price. A shift in demand to those countries could result in "emissions leakage" from one country to another—reducing the climate benefit of a carbon price. There is growing interest in a carbon border adjustment as a preferred approach to address emissions leakage and incentivize emission reductions.

• A carbon price can encourage investments in and mobilize revenue toward low-carbon, net-zero, and net-negative technologies, fuelling new, low-carbon drivers of economic growth.

• A carbon tax can raise significant revenue. It could be reinvested towards government revenue to support additional stimulus and investment programs.

• Carbon pricing helps support sustainable industries and the competitiveness of low-carbon products, which can generate additional jobs. Global estimates indicate the employment impacts of the energy efficiency and renewable energy sectors can be substantial, generating three times as many full-time jobs as equivalent government spending in fossil fuels.

• A given carbon price (translated to local currency based on market exchange rates) will also be equivalent to a higher local price in poorer countries, since the Purchasing Power Parity (PPP) exchange rates are usually higher than the market exchange rates The Deep Decarbonization Pathways Project (DDPP)shows that pathways compatible with the objectives of the Paris Agreement usually show lower carbon prices for lower-income countries. However, higher capital costs in developing countries act in the opposite direction.

• Emission reductions may seem more profitable when considering their co-benefits, such as reduced air pollution and improved human health. The benefits and co-benefits of climate action may be aggregated into a Social Value of Mitigation Action.

The choice of the instrument will depend on national and economic circumstances. There are also more indirect ways of more accurately pricing carbon, such as through fuel excise taxes, removal of fossil fuel subsidies, and regulations that may incorporate a “social cost of carbon.”

**Current Global Landscape: Carbon Pricing**

• 40 countries and more than 20 cities, states and provinces already use carbon pricing mechanisms, with more planning to implement them in the future.

• In 2021, 21.5% of global GHG emissions are covered by carbon pricing instruments in operation, representing a significant increase on 2020, when only 15.1% of global emissions were covered. This increase is largely due to the launch of China’s national ETS.

• A majority of carbon prices still remain far below the USD 40–80/tCO2e range needed in 2020 to meet the 2° C temperature goal of the Paris Agreement — only 3.76% of global emissions are covered by a carbon price at and above this range.

• France is the only G20 member whose carbon price is above the USD 40/tCO2e threshold by 2020 recommended by the High-Level Commission on Carbon Prices. A few G20 members (Canada, Germany, Italy, South Korea, the UK and the EU) have a carbon price that is defined as “low” (USD 11-39/tCO2e), while carbon prices in the rest of the G20 remain below the USD 10/tCO2e threshold.

• China’s national ETS launched in February 2021, becoming the world’s largest carbon market. Initially covering around 2,225 entities in the power generation industry, the plan regulates annual emissions of around 4,000 MtCO2. Regulated entities will need to surrender allowances to cover their 2019 and 2020 emissions in 2021. The national carbon market will be a tool to promote China’s commitment to peak carbon before 2030 and achieve carbon neutrality before 2060.

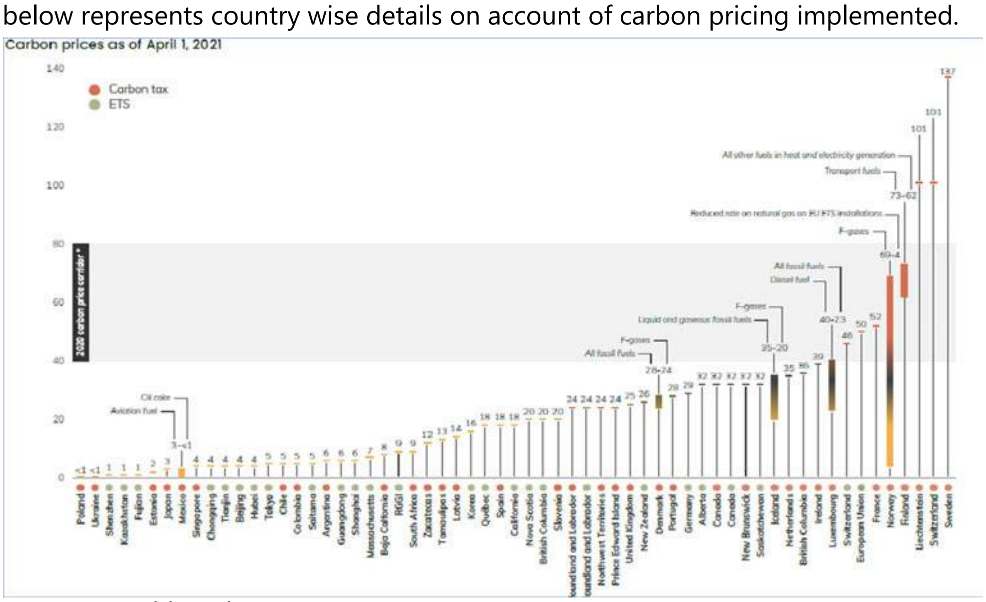
• The announcement of the European Green Deal recovery package and new 2030 mitigation targets has triggered wide-ranging changes for the European Union ETS. It includes a proposal for the European Climate Law legislating a 2050 climate neutrality objective and a 2030 Climate Target Plan to reduce net emissions by at least 55% by 2030.

• National carbon pricing instruments were also launched in several European countries. Following its departure from the EU, the United Kingdom stopped participating in the EU ETS on January 1, 2021. On the same day, the U.K. ETS came into operation. Covering the power, industry, and domestic aviation sector, the cap will reduce emissions by 4.2 Mt annually and will be revised in 2024 in line with the country’s 2050 net-zero trajectory. Germany’s national fuel ETS also came into operation, covering all fuel emissions not regulated under the EU ETS — around 40% of national GHG emissions.

• On the subnational level, two carbon taxes came into effect in Mexico. The Baja California carbon tax entered into force on May 1, 2020, for the sale of gasoline, diesel, natural gas, and LPG. In July 2020, the Mexican state of Tamaulipas passed legislation enacting a carbon tax starting in 2021, equivalent to about MXN 250 (USD 12.23)/tCO2e to fixed sources and facilities that emit more than 25 tCO2e of GHG monthly.

• In 2020, carbon pricing instruments generated USD 53 billion in revenue globally. This is an increase of around USD 8 billion compared to 2019, largely due to the increase in the EU allowance price

The figure below represents country wise details on account of carbon pricing implemented.



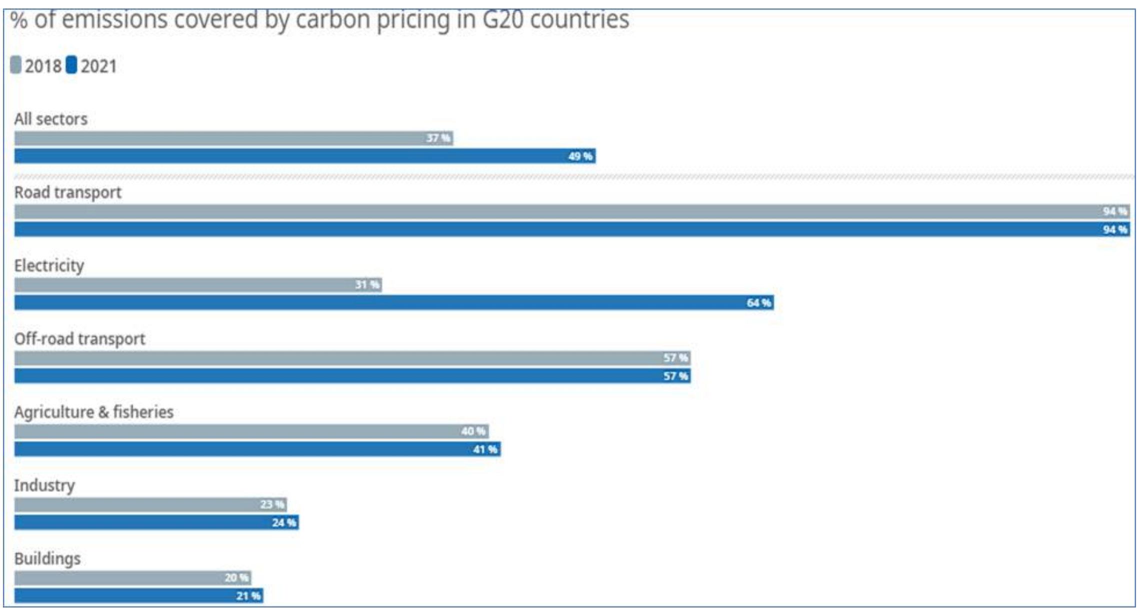

*Source- World Bank*

Several countries have increased their carbon tax rates and adopted more ambitious trajectories. As of April 1, 2021 has seen several rates increases in line with previously agreed trajectories.

| Jurisdiction | Carbon Pricing Instrument | 2020 Price | Price Increase |
|---|---|---|---|
| Latvia | Carbon tax | EUR 9<br>(USD 10.57) | EUR 12/tCO2e (USD 14.1/tCO2e |
| Canada | Federal backstop (output-based pricing<br>system and carbon tax) | CAD 30/tCO2e<br>(USD 23.88) | • CAD 40/tCO2e (USD 31.83/tCO2e) |
| Ireland | Carbon tax | EUR 26/tCO2<br>(USD 30.54/tCO2e) | • Tax rate for petrol and diesel to EUR 33.5/tCO2 (USD 39.35/tCO2e), the same increase applies to other fuels from May 1, 2021<br>• Target rate for 2030 increased from EUR 80/ tCO2 to EUR 100/tCO2 (USD 93.97 to USD 117.46 / tCO2e) |
| Germany | National fuel ETS | - | Rises to EUR 55 (USD 64.60) by 2025 |

*Source- World Bank*

**Carbon Pricing progress by sector in G20 countries**




*Source OECD (2021)*

• Carbon pricing in G20 economies – in the form of ETS, carbon taxes or fuel excise duties – applies to 49% of all energy-related emissions in 2021, up from 37% in 2018.
• More carbon pricing in the electricity sector – up to 64% from 31% in the same period, driven by the introduction of the Chinese national ETS for the power sector and an expansion of carbon pricing in Canada.
• Other sectors saw little change, with the lowest overall coverage in buildings, at 21%.
• Effective carbon rates continue to be highest in road transport and lowest in the industry and electricity sectors. The average effective carbon rate across G20 countries in road transport is EUR 88 per tonne of CO2 (due to relatively high rates of existing excise taxes), compared to EUR 3.77 for industry and EUR 6.36 for electricity.

**Carbon pricing in India**

India does not have an explicit carbon price or a market-based mechanism such as cap-and-trade. It does, however, have an array of schemes and mechanisms that put an implicit price on carbon.

**1. Perform, Achieve and Trade (PAT) Scheme:** Under this scheme, energy intensive units from industrial sectors with high emissions are assigned specific energy reduction targets. The units are required to meet these targets by implementing energy-efficient technologies. Those that exceed the targets are awarded Energy Saving Certificates (ESCerts), each equal to one metric tonne of oil (MTOe). On the other hand, those unable to meet their assigned targets are required to purchase ESCerts (from the units that have exceeded their targets) through a centralised online trading mechanism hosted by the Indian Energy Exchange (IEX). The achievements from the first two cycles of the PAT scheme are given Table 1.

**Table: Achievements of the PAT Scheme**

| | Implementation Period | Energy Savings Target (Mn Tonne of Oil equivalent) | Actual Energy Savings (Mn Tonne of Oil equivalent) | Actual Emission Reduction (MN Tonnes of $CO_2$) |
|---|---|---|---|---|
| PAT Cycle-I | 2012–15 | 6.6 | 8.67 | 31 |
| PAT Cycle-II | 2016–17 to 2018–19 | 8.869 | 13.28 | 61 |

*Source: Bureau of Energy Efficiency*

Since 2017, the PAT scheme is being implemented annually on a rolling cycle basis. The most recent cycle, PAT Cycle-VI, commenced on 1 April 2020.

**2. Internal Carbon Pricing (ICP)**

ICP is emerging as a popular tool that companies can voluntarily deploy to reduce emissions; channel investments towards innovative, clean, and energy-efficient technologies; enhance competitiveness; and deliver corporate sustainability goals. Some of the leading Indian companies that have adopted an internal carbon price are listed below:-

**Table: Internal Carbon Prices of Companies in 2019**

| Company | Price in INR | Price in USD ($) | Type of price used |
|---|---|---|---|
| ACC | 2541 | 33.94 | Implicit price; Shadow Price |
| Ambuja Cements | 2163.9 | 30.74 | Implicit Price |
| Dalmia Bharat Ltd | 773.34 | 11 | Shadow Price |
| Dr Reddy's Laboratories | 937 | 13.32 | Implicit Price |
| Godrej Consumer Products Limited | 750 | 10 | Shadow Price |
| Godrej Industries | 740 | 10 | Shadow Price |
| Hero Motocorp Ltd | private | private | private |
| Hindustan Zinc | 1118.46 | 15.9 | Implicit Price |
| Infosys Ltd | 1001.82 | 14.25 | Implicit Price |
| JSW Cement Ltd | 1566 | 21 | Shadow Price |
| JSW Steel Ltd | 1400 | 20 | Shadow Price |
| Mahindra & Mahindra | 982.42 | 13.97 | internal fee |
| Mindtree Ltd | private | private | private |
| Shree Cement | private | private | private |
| Tata Chemicals | 1406.07 | 20 | Shadow Price |
| Tata Consultancy Services | 1131 | 16.08 | Implicit price; Shadow Price |
| Tata Consumer Products Ltd | 315 | 4.48 | Offsets |
| Tata Motors | 980 | 14 | Shadow Price |
| Tata Steel | 2720-975 | 38.68-15 | Implicit price; Shadow Price |
| Tech Mahindra | 703.03 | 10 | Implicit price; Internal fee |
| Ultratech Cement | 750 | 10.66 | Shadow Price |
| Wipro | 3622.91 | 50.11 | Shadow Price |

*Source: Carbon Disclosure Project, India Report 2020*

**3. Coal Cess:** In 2010, the government of India introduced a tax on coal, to be levied as excise duty The cess was implemented at a rate of INR 50 per tonne, and subsequently increased to INR 400 IN 2016. Revenue collected through the cess was transferred to the National Clean Energy Fund (NCEF), which sought to finance clean-energy initiatives and research in this area. This setup, while promising in theory, failed to achieve the desired outcomes. First, a significant portion of the revenue collected through the coal cess remained unutilised. From 2010–11 to 2017–18, the coal cess collection amounts to about INR 86,440.21 crores. Of this, only INR 29,654.29 crores have been transferred to the NCEF and a mere INR 15,911 crores utilised. Second, in 2017, the coal cess was abolished and replaced by the GST Compensation Cess. The proceeds from this tax are used for compensating states for revenue losses in the wake of shifting to the new indirect tax regime.

**4. Renewable Purchase Obligations (RPO)**

To provide a fillip to India's growing renewable energy sector, all electricity distribution licensees are required to purchase or produce a minimum specified quantity of their requirements from renewable energy sources. The RPO for each state is fixed and regulated by the respective State Electricity Regulatory Commission.

**Way Forward: Green spending in focus**

Despite the global pandemic, the momentum toward adopting net-zero targets has not stopped but accelerated. As of April 2021, 29 countries have enshrined net-zero targets in laws or policy documents or have proposed legislation to do so. The majority of targets aim for achieving net zero by 2050, though China and Ukraine are aiming for 2060 and 2070, respectively.

Carbon pricing can promote cost-effective abatement, deliver powerful innovation incentives, and ameliorate fiscal problems by adding to the government revenue. Countries such as Sweden have been able to effectively thread the needle between carbon pricing and economic growth: Sweden's economy grew by 60 percent since the introduction of the Swedish carbon tax in 1991, while its carbon emissions decreased by 25 percent.

The policy pathways for a sustainable future are as follows: -

- To reach net zero emissions by mid-century and prevent emissions surging to a new record, investments of USD 1tn per year from 2021-23 are needed across the power, industry, transport and building sectors, where only 35% of these investment needs are currently being met.
- Developing countries need support from developed G20 members to mobilise additional finance to encourage investment in green sectors.
- Investments in climate-adjacent technologies, such as carbon capture and storage and offshore wind development can play to strengths to many developed nations.
- G20 members must eliminate continued subsidies as well as domestic and international public finance for fossil fuels. The subsidies should be redirected towards sector transformation and investments in renewable energy and other green sectors.
- Between 2030 and 2040, all the regions of the world need to phase out coal-fired power generation. By 2040, the share of renewable energy in electricity generation needs to be increased to at least 75%, and the share of unabated coal reduced to zero.
- The implementation record of low-cost, high-impact carbon taxes in a large number of jurisdictions indicates that they are a viable regulatory mechanism to meet this critically urgent need to reduce emissions. Increasing the regional and sectoral reach of international trading systems will go a long way to remedy carbon leakage and drive-up prices.

However, climate policies, if well designed and implemented, are consistent with growth, development, and poverty reduction. Strategically deploying the revenues from carbon pricing will make climate policy more inclusive and effective. To succeed, that is, to deliver efficiently and fully realize the potential benefits of climate policies, careful policy design is essential.

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# Oil & Gas in Media

## Hon'ble Union Minister for MoP&NG launches IndianOil Surya Nutan Solar Cooktop, releases IndianOil R&D Golden Jubilee Commemorative Postal Stamp at Vigyan Bhawan

In a momentous occasion, marking the grand finale of Golden Jubilee celebrations of IndianOil R&D; the Hon'ble Union Minister of Petroleum & Natural Gas and Housing & Urban Affairs, Mr Hardeep Singh Puri, launched an innovative solar cooktop – IndianOil Surya Nutan and released a commemorative customised postal stamp of IndianOil R&D, in a function held in Vigyan Bhavan on 22nd March 2022.

Hon'ble Union Minister of State for Petroleum & Natural Gas and Labour & Employment, Mr. Rameshwar Teli; Padma Vibhushan Dr. R.A. Mashelkar; Padma Vibhushan Dr Anil Kakodkar; Mr Pankaj Jain, Secretary, MoPNG; Mr S M Vaidya, Chairman (IndianOil); Dr SSV Ramakumar, Director (R&D)-IndianOil; Ms Manju Kumar, Chief Postmaster General – Delhi Circle, India Post; were present on the occasion.

On this occasion, a special citation of 1501 patents of IndianOil R&D, was presented to the Hon'ble Minister by IndianOil's Chairman and Director (R&D) as a symbol of intellectual wealth created by the institution over the last 50 years. Addressing the gathering, Mr. Puri said that IndianOil Surya Nutan solar cooktop could be a path-breaking innovation for the average Indian consumer.

Urging IndianOil to expand it reach and usage on a large scale in a reasonable period of time, he said that this could empower millions of households, especially the women. Mr Hardeep Singh Puri also interacted with the customers of IndianOil Surya Nutan solar cooktop regarding their experiences of the new product.

Mr. Puri also said, "Fifty years of pioneering research to make energy secure and accessible in India is truly an enormous achievement. As the apex organization for research and innovation in the sector, IndianOil R&D has transcended to the gold standard for industry innovation. However, we need to be doing much more to achieve our national and global targets. I believe that cutting-edge R&D—which aims to produce equitable, sustainable and large-scale innovations—will be at the forefront of change in the coming years, particularly in dynamic areas such as the energy sector".

Calling IndianOil R&D 'Young at 50", MoS, MoP&NG said that the institution has worked to make India Aatamnirbhar, by developing low-cost, environmentally-benign and customer-friendly solutions and products. He called upon IndianOil to continue playing a meaningful role in achieving the Prime Minister's vision of $5 trillion economy in shortest possible time.

Secretary, MOPNG, Mr. Pankaj Jain complimented IndianOil R&D on the scale & speed of research work and said, "Even before the ink had dried on the 1501 patent citation, the milestone had been crossed and the figure was outdated. He said that the research at IndianOil R&D is not only cutting-edge but also has direct customer connect.

Chairman, IndianOil, Mr S M Vaidya said that over the last 50 years, IndianOil R&D has worked to enhance the self-sufficiency index of the country and had contributed to 'Urja Aatmanirbharta'. A healthy figure of patents and the rate of commercialization is testimony to the commercial focus of research happening at IndianOil", he added.

Dr. R.A. Mashelkar said that IndianOil R&D has a remarkable contribution to Aatmanirbhar Bharat and is leading from the forefront with its flagship lubricants and cutting-edge technologies. Dr. Anil Kakodkar said that IndianOil R&D is expeditiously meeting the clean energy needs of the consumers in net-zero scenarios.

Earlier, welcoming the gathering, Dr Ramakumar spoke about the golden journey of IndianOil R&D that has been full of challenges, setting benchmarks, creating brands, and making them iconic. He shared that all along R&D has been committed to powering self-reliance in the downstream petroleum sector and today it has emerged as an apex energy research institute of the nation. He also added, "IndianOil R&D has the largest patent portfolio among the oil & gas PSU companies and our 56 indigenously developed technologies are fully proven and commercialized and also licensable globally".

On the occasion, the Hon'ble Minister gave also away cash prizes to the 12 winners of IndianOil R&D Golden Jubilee National Essay Competition in which over 1500 entries were received.

The high-profile grand event was also graced by IndianOil's Directors - Mr Ranjan Kumar Mohapatra, Director (HR); Mr Sandeep Sharma, Director (Finance); Mr V Satish Kumar, Director (Marketing); Mr D S Nanaware, Director (Pipelines); Ms Sukla Mistry, Director (Refineries); Mr Sujoy Choudhary, Director (P&BD) and Mr Anant Kumar Singh, CVO IndianOil. The captains of Indian industry, senior officials from IndianOil, academia, oil & gas industry were present on the occasion.

## HPCL expands its footprint in Non-Fuel retailing

Hindustan Petroleum Corporation Ltd., giving a further push to its ambitions in non-fuel retailing announced opening of two more Convenience Stores under its brand name 'HaPpyShop'. The new HaPpyShop stores have been opened at Company's Auto Care Centre, Bandra West in Mumbai and Millennium Retail Outlet in Visakhapatnam. The first Retail Store under brand name HaPpyShop was opened at the Company's Retail Outlet at Nepean Sea Road in Mumbai in September, 2021 and the Store has been a huge hit amongst the residents of the locality. In addition to above, the Online Store at Madurai was also inaugurated marking the entry of HaPpyShop in purely online format also.

The Company has decided to set up its own chain of multi-channel Retail Stores under the brand name HaPpyShop for making available the products of daily need to its customers. The product range in each of the new Store has been meticulously planned to suit the tastes and preferences of the local neighbourhoods. The Stores' refreshing appearance and layout is well appreciated by the customers. The Stores are equipped with advanced technology to provide a seamless shopping experience to customers in the nearby areas. Along with the experience of physical Store, they have the option of Online shopping with door delivery model.

Customers will be able to browse & shop the merchandise on HPCL's 'HP Pay App' (available on App Store & Play Store), and have goods delivered to their homes.

Speaking on the occasion, C&MD HPCL Shri Surana said, "At HPCL, we are focused on giving a differentiated experience to the customers. HaPpyShops will provide a range of quality products to the customers at a great value." HPCL has also started marketing branded packaged drinking water under the name 'Paani@Club HP' at its Retail Outlets across the Country adding another offering in the customer convenience. The offering has been well accepted by the customers and is creating its own space.

## GAIL starts India's maiden project of blending hydrogen into CGD network

Gas Authority of India Limited has commenced India's first-of-it's-kind project of mixing hydrogen into natural gas system at Indore, Madhya Pradesh. The hydrogen blended natural gas will be supplied to Avantika Gas Limited, one of GAIL's Joint Venture (JV) Company with HPCL, operating in Indore.

In line with the National Hydrogen Mission, GAIL has started hydrogen blending as a pilot project to establish the techno-commercial feasibility of blending hydrogen in City Gas Distribution (CGD) network. This project marks the stepping stone of India's journey towards hydrogen based and carbon neutral future.

GAIL started injection of grey hydrogen at City Gate Station (CGS), Indore. This grey hydrogen would subsequently be replaced by green hydrogen. GAIL has already obtained necessary regulatory permissions to commence the project. GAIL has also engaged domain experts to carry out the impact assessment of blending of hydrogen in natural gas.

GAIL has always been committed to the growth of a gas-based economy in India and to India's vision of a greener and cleaner environment. As our country is moving forward with ambitious goal of achieving a carbon-neutral and self-reliant future, this project is a significant step in that direction.

It is expected that this pilot project would help in creation of a robust standard and regulatory framework in India to cover the aspects of injecting hydrogen into natural gas. This will pave the path for carrying out more similar projects in India.

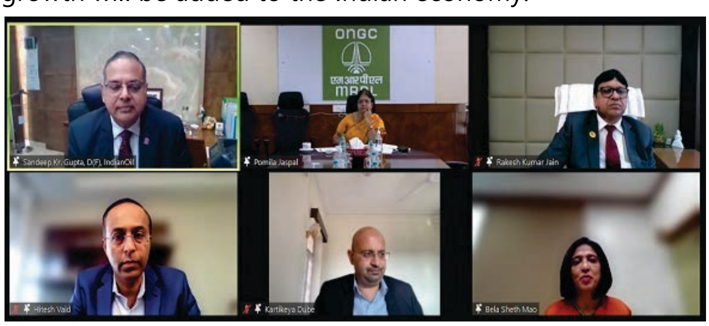
# Events

## FIPI Post Budget Analysis 2022

The Union Budget for the Year 2022-23 was announced by the Hon'ble Finance Minister of India Smt. Nirmala Sitharaman on 1 February, 2022. Keeping up with FIPI's long tradition, FIPI organized its flagship FIPI Post Budget Analysis 2022 session on 2nd February with Deloitte India as the knowledge partner. The Budget session was attended by nearly 300 delegates (virtually) and was appreciated in terms of content by one and all. The objective of the session was to analyze the recently presented Union Budget 2022-23 and weigh the impact of the Budget on the Economy and India's oil and gas industry. The session was attended by many senior dignitaries from across the industry.


In his opening remarks, Mr. Gurmeet Singh, Director General, FIPI, welcomed all the panelists during the budget analysis session organized by FIPI. He said that the Budget has come against the backdrop of gradual recovery taking place in the Indian economy hit by the COVID-19 pandemic and spoke about some of the key announcements highlighted in the Economic Survey and Union Budget 2022-23. He mentioned that India is on a growth trajectory as India's GDP is projected to grow in real terms by 9.2% in 2021-22 and 8.0-8.5% in 2022-23 as highlighted in the economic survey. He highlighted that the growth of the economy will be supported by widespread vaccine coverage, gains from supply-side reforms and easing of regulations, robust export growth, availability of fiscal space to ramp up capital spending, and pick up in private sector investment. He said that the budget was growth oriented with increased focus on Inclusive development, productivity enhancement, Energy transition & climate action, and financing investments.

Setting the context for the session, while Mr. Debasish Mishra, Partner, Deloitte India, made presentation on the key takeaways of the Economic Survey, the insights on Direct tax & Indirect tax were presented by Mr. Jimit Devani, Subject Matter Expert and Mr. Anoop Kalavath, Partner, Deloitte respectively. Mr. Debasish Mishra welcomed Govt's decision to increase capex to Rs. 7.50 cr as it will provide a multiplier effect on the growth of Indian economy. He further said that with fiscal deficit targeted at 6.9% in FY 22, the increase in government investment will have a positive impact in terms of demand generation and employment opportunities in core sectors such as cement, steel and other ancillary sectors and with introduction of PLI scheme, an additional 2% growth will be added to the Indian economy.




The main highlight of the session was the 'Panel Discussion on Union Budget 2022-23, focusing on the outcome for oil and gas companies in the new budget. The panel comprised of Mr. Sandeep Kumar Gupta, Director - Finance, Indian Oil Corp Ltd, Mr. Rakesh Kumar Jain, Director – Finance, GAIL (India) Ltd, Ms. Pomila Jaspal, Director – Finance, MRPL, Mr. Hitesh Vaid, Deputy Chief Financial Officer, Cairn Oil & Gas, Vedanta Ltd and Mr. Kartikeya Dube, Chief Financial Officer – Reliance BP Mobility Ltd. The panel discussion was moderated by Ms. Bela Sheth Mao, Tax Partner, Deloitte.


Delivering the closing remarks at the session, Mr. Vivekanand, Director (Finance, taxation and Legal), FIPI, thanked all the panelists and the subject matter experts for providing their insights on the Union Budget 2022-23 and its implications on the oil & gas industry and the economy as a whole. He said that the budget was in the right policy direction for the Government to achieve its CoP 21 and CoP 26 commitments and the energy transition. He further highlighted that with Govt spending of Rs. 7.5 lakh crores and assistance provided to State Governments, Indian economy can achieve its targeted growth of 8-8.5% by 2023.

In his concluding comments, he said that for achieving a gas-based economy, it is crucial for gas to be included under the ambit of GST and subsequently the other petroleum products and assured the industry members that FIPI will continuously strive to pursue this issue at relevant forums in the future as well.

# Events

## 11th Annual Convention of FIPI Student Chapters

The 11th Annual Convention of FIPI Student Chapters was held on 31st March 2022 in the premises of Dibrugarh University. The convention provides a platform to the students to interact, compete and share knowledge with each other and also an opportunity to listen to the industry experts, academicians etc. This year the theme given to the Student Chapters was "Enhancing the Energy Value Chain through Innovation and Digital Ecosystem".

A total of 43 participants (36 Students and 7 Faculty members) from 8 FIPI Students Chapters participated in the convention. In addition to the above, students and faculty members from various departments of Dibrugarh University were also present during the convention. FIPI had invited Dr. L K Nath, Vice Chancellor, Dibrugarh University to deliver the Keynote Address and senior officials from Indian Oil & Gas Industry viz. Shri Prasanta Borkakoty, Resident Chief Executive, Oil India; Shri Rajesh Kumar Sharma, ED-Asset Manager, ONGC Assam Asset and Shri G Ramesh, ED-Head, AOD State Office, IOCL were invited to address the gathering during the Inaugural Session and also as the esteemed Jury member to adjudge the presentations during the day. Shri Gurmeet Singh, Director General and Shri T K Sengupta, Director (E&P) FIPI were present during the event.

From the Indian Oil & Gas Industry OIL, ONGC and IOCL were the main sponsors of the event.

The event commenced in a traditional way by welcoming all the dignitaries with flower bouquet and Gamosa. The University Anthem was played and after that all the present guests formally inaugurated the event by lighting of lamp.

Shri T K Sengupta, Director (E&P), Federation of Indian Petroleum Industry (FIPI), delivered the Welcome Address and thanked the management of Dibrugarh University for giving an opportunity to FIPI to organize the Convention in their premises. While emphasizing the theme of the presentation i.e. "Enhancing the Energy Value Chain through Innovation & Digital Eco System, he mentioned the enhancement of three 'Es' i.e. Energy, Efficiency & Environment to be achieved through two "Ds" i.e. Decarbonization & Digitalization. Shri Gurmeet Singh, Director General FIPI delivered the Keynote Address and apprised the participants about national & international events conducted by FIPI, initiatives for Academia and future planning. Dr L K Nath appreciated the initiatives of FIPI w.r.t. various academic activities and events. The senior executives present from OIL, ONGC and IOCL delivered the address and shared their experience, Knowledge & latest happenings in the field of oil & gas with the students and the faculties present during the event.

*Inaugural Session : (L toR) Shri L. K. Nath, Vice Chancellor, Dibrugarh University; Shri Gurmeet Singh, Director General, FIPI; Shri T. K. Sengupta, Director (E&P), FIPI; Shri Prasanta Borkakoty, RCE, Oil India; Shri R. K. Sharma, ED-Head, ONGC Assam Asset; Shri G. Ramesh, ED-Head, AOD-SO, IOCL;*

At the end of the Inaugural Session Shri Gurmeet Singh felicitated Dr L K Nath with a bouquet, Gamosa and a memento on behalf of FIPI.

After the Inaugural session the event was divided into two competition segments. In the first part, the Student Chapters made a 10 minutes presentation on the activities covering the technical events, quiz contests, article/paper/poster presentations, webinar/lecture series, activities related to CSR and social awareness events organized during the previous year.

In the second part, a theme presentation on "Enhancing the Energy Value Chain through Innovation and Digital Ecosystem" was also made by the Student Chapters of FIPI. Each Chapter was given 15 minutes for the presentation and 5 minutes were kept for the question & answers by the Jury members w.r.t their presentation. The Jury members viz. Shri T K Sengupta from FIPI, Shri Prasanta Borkakoty from Oil India; Shri Rajesh Kumar Sharma from ONGC Assam Asset and Shri G Ramesh from AOD-SO, IOCL adjudged the presentations as per the evaluation criteria covering no. of the technical events, quizzes, webinars/lecture series/paper and poster presentation relevant to the Indian Oil & gas industry organized by the Chapters during previous year and introduction, contents, summing up, oratory, time management etc. for theme presentation.

After the detailed discussions by the Jury member the result was announced as below:

| | |
|---|---|
| • Winner of 'Best Chapter Award 2021' | University of Petroleum and Energy Studies (UPES), Dehradun |
| • Runner Up of 'Best Chapter Award 2021' | Pandit Deendayal Energy University, Gandhi Nagar |
| • Winner 'Best Presentation Award 2021' | University of Petroleum and Energy Studies (UPES), Dehradun |
| • Runner Up of 'Best Presentation Award 2021' | IIT (ISM) Dhanbad |


*Winner of Best Chapter Award 2021-UPES*

*Runner Up for Best Chapter Award 2021- PDEU*

*Winner of Best Presentation Award 2021 - UPES*

*Runner-up Award for Best Presentation 2021-IIT (ISM)*

As the competition was very tough and almost all the chapters performed well in making both the presentations, the panel of judges recommended two 'Special Commendation Award' to those who competed very closely with the awardees. The Special Commendation Award for Chapter Activities was given to the following: -

| | |
|---|---|
| 1. Dibrugarh University | 2. IIT(ISM) Dhanbad |

*Special Commendation Award -Dibrugarh University*

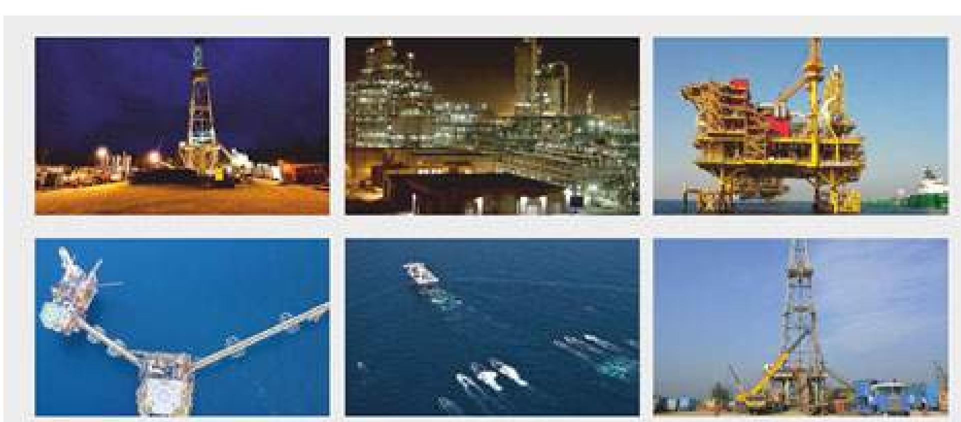
*Special Commendation Award -IIT (ISM) Dhanbad*

After the award ceremony the students from other Chapters were given a certificate of participation. Shri Gurmeet Singh, Director General FIPI presented mementos to the esteemed Jury Members and thanked them to spare their valuable time and making the Convention a success.

Dr Borkha Mech Das, Faculty Advisor, Dibrugarh University FIPI Student Chapter delivered the Vote of Thanks!

The 11th Convention of FIPI Student Chapter was a successful event.

*Group Photograph of Participants during the 11th Convention of FIPI Student Chapters*



# NEW APPOINTMENTS

## Ms. Sukla Mistry takes over as Director (Refineries) of IndianOil

**Sukla Mistry**

Ms. Sukla Mistry took over as the first woman functional director on the board of Indian Oil Corporation Ltd as its Director (Refineries) on 7th February 2022.

Ms. Sukla Mistry is a Metallurgical Engineer from Bengal Engineering College, Calcutta University and also holds an Advanced Diploma in Management from the ICFAI. She has more than 3 decades of rich experience in refining and petrochemicals operation, having worked at IndianOil's refineries at Haldia, Panipat, Digboi and Barauni as well as at the Refineries Headquarters.

Ms. Sukla has extensive experience in execution of various green-field and brown-field projects in the refineries. Before her elevation as Director (Refineries), she was heading the Barauni Refinery in Bihar where she was instrumental in successful rolling-out of BS-VI grade fuels and Ethanol blended MS.

Ms. Sukla is also a Nominee Director of IndianOil on the Board of Chennai Petroleum Corporation Limited; Ratnagiri Refinery & Petrochemicals Limited; and IHB Limited. Ms. Sukla has won many awards notably ET Prime Women Manufacturing & Operational Leadership Award (2021), SCOPE Award for Outstanding Woman Manager (2016-17), Petrotech Ojaswini Award (2016) and Petrofed Best Woman Executive Award (2009).

## Mr. Deepak Gupta assumes charge as Director (Projects), GAIL

**Deepak Gupta**

Mr. Deepak Gupta has assumed charge as Director (Projects) of GAIL (India) Limited. Mr. Gupta is a Mechanical Engineer, a Delhi College of Engineering alumnus, with more than 31 years of rich and diverse experience in Oil and Gas Sector encompassing Project Management, Construction Management and Business Development functions.

Mr. Gupta was working as Executive Director (Projects), Engineers India Limited (EIL), before assuming his new post on February 12, 2022.

He is a certified Project Management Professional (PMP) by the PMI, USA and has comprehensive and extensive experience in Project Management of Refinery, Petrochemical and Pipeline Projects from concept to commissioning and has led the execution of several successful projects in India in all modes of project implementation. He has successfully collaborated with multi-disciplinary and cross-functional teams across geographies for implementing the highly complex and challenging Oil and Gas Projects.

In EIL, he was on the forefront in leading the implementation of the multi-billion dollar 650 KBPSD Dangote Refinery and Petrochemical Project in Nigeria, the largest single train grass root Refinery in the world, which is also the largest Refinery Complex under implementation in the African continent. Besides this mammoth project, he has also led the implementation of the one of the largest Polymer facilities for HMEL at Bhatinda and the upcoming maiden Refinery Project in Mongolia. Besides the above, he has made significant contribution as part of team EIL that is credited with the successful implementation of the Petrochemical Expansion Project at Pata for GAIL and the PFCC Unit of MRPL Phase III Expansion Project at Mangalore.

# NEW APPOINTMENTS

## Mr. Sanjay Khanna takes over as Director Refineries, BPCL

Sanjay Khanna

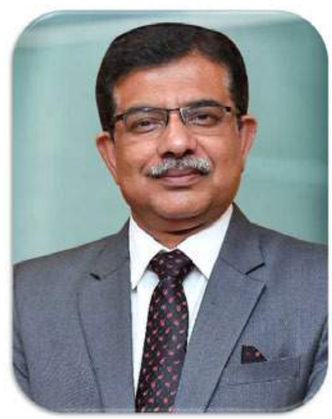
Mr. Sanjay Khanna took over as Director Refineries of BPCL on 22nd Feb 2022.

A Chemical Engineering graduate from NIT, Tiruchirapalli and Post Graduate in Finance Management from Mumbai University, he has more than 30 years of experience in Refinery Operations.

In his illustrious career, he has earlier held the positions of Chief General Manager In-charge (Mumbai Refineries), Executive Director (Kochi Refineries) and Executive Director In-charge of Refineries, where he headed the refineries operations in BPCL.

## Mr. Sujoy Choudhury takes over as Director (Planning & Business Development) of IndianOil

Mr. Sujoy Choudhury has taken charge as Director (Planning & Business Development), Indian Oil Corporation Limited on 23rd February 2022.



Sujoy Choudhury

A Mechanical Engineer and MBA (Finance) from Jadavpur University, Kolkata, Mr Choudhury brings with him a vast cross-functional experience spanning every facet of the Indian energy business. He has rich experience working in Eastern, Western and Northern regions of the country and across various oil industry functions, including Engineering, Retail Sales, and Petrochemicals functions of the Corporation. During his more than three decades of service, Mr Choudhury has held several leadership positions.

Before assuming the office of Director (Planning and Business Development), Mr Choudhury was heading IndianOil's Punjab State office wherein he was in-charge of all petroleum activities in the States of Punjab and Himachal Pradesh, and in the Union Territories of Jammu & Kashmir, Ladakh and Chandigarh. His major contributions include strengthening the Oil infrastructure of the State / UT's, introducing Winter Grade Diesel for high altitude areas, developing specialized lubricants for FMCG industry, and introducing geotextiles and steel concrete structures for construction in hilly terrains.

# STATISTICS

## INDIA: OIL & GAS

### DOMESTIC OIL PRODUCTION (MILLION MT)

| | | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 (P) | April - Dec. 2021 (P) | % of Total |
|---|---|---|---|---|---|---|---|---|---|
| **Onshore** | ONGC | 5.8 | 5.9 | 6.0 | 6.1 | 6.1 | 5.9 | 4.4 | 38.3 |
| | OIL | 3.2 | 3.3 | 3.4 | 3.3 | 3.1 | 2.9 | 2.2 | 19.6 |
| | Pvt./ JV (PSC) | 8.8 | 8.4 | 8.2 | 8.0 | 7.0 | 6.2 | 4.8 | 42.1 |
| | **Sub Total** | **17.8** | **17.6** | **17.5** | **17.3** | **16.2** | **15.1** | **11.4** | **100** |
| **Offshore** | ONGC | 16.5 | 16.3 | 16.2 | 15.0 | 14.5 | 14.2 | 10.2 | 93.4 |
| | OIL | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Pvt./ JV (PSC) | 2.5 | 2.1 | 1.9 | 1.9 | 1.5 | 1.1 | 0.7 | 6.6 |
| | **Sub Total** | **19.1** | **18.4** | **18.1** | **16.9** | **16.0** | **15.4** | **11.0** | **100.0** |
| **Total Domestic Production** | | 36.9 | 36.0 | 35.7 | 34.2 | 32.2 | 30.5 | 22.4 | 100.0 |
| | ONGC | 22.4 | 22.2 | 22.2 | 21.0 | 20.6 | 20.2 | 14.6 | 65.2 |
| | OIL | 3.2 | 3.3 | 3.4 | 3.3 | 3.1 | 2.9 | 2.2 | 10.0 |
| | Pvt./ JV (PSC) | 11.3 | 10.5 | 10.1 | 9.9 | 8.4 | 7.4 | 5.5 | 24.7 |
| **Total Domestic Production** | | **36.9** | **36.0** | **35.7** | **34.2** | **32.2** | **30.5** | **22.4** | **100.0** |

Source : PIB/PPAC

## REFINING

### Refining Capacity (Million MT on 1st January 2022)

| Indian Oil Corporation Ltd. | |
|---|---|
| Digboi | 0.65 |
| Guwahati | 1.00 |
| Koyali | 13.70 |
| Barauni | 6.00 |
| Haldia | 8.00 |
| Mathura | 8.00 |
| Panipat | 15.00 |
| Bongaigoan | 2.70 |
| Paradip | 15.00 |
| **Total** | **70.05** |

| Chennai Petroleum Corp. Ltd. | |
|---|---|
| Chennai | 10.50 |
| Narimanam | 0.00 |
| **Total** | **10.50** |

| 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** | **0.07** |
| **Total PSU Refineries Capacity** | **141.92** |

| 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 249.2 (5.00 million barrels per day)**
# Nayara Energy Limited (formerly Essar Oil Limited)
**Source : PPAC**

## CRUDE PROCESSING (MILLION MT)

| PSU Refineries | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 (P) | April - Dec 2021 (P) |
|---|---|---|---|---|---|---|---|
| IOCL | 58.01 | 65.19 | 69.00 | 71.81 | 69.42 | 62.35 | 49.40 |
| BPCL | 24.10 | 25.30 | 28.20 | 30.90 | 31.53 | 26.22 | 21.67 |
| HPCL | 17.20 | 17.80 | 18.20 | 18.44 | 17.18 | 16.42 | 9.28 |
| CPCL | 9.60 | 10.30 | 10.80 | 10.69 | 10.16 | 8.24 | 6.13 |
| MRPL | 15.53 | 15.97 | 16.13 | 16.23 | 13.95 | 11.47 | 10.53 |
| ONGC (Tatipaka) | 0.07 | 0.09 | 0.08 | 0.07 | 0.09 | 0.08 | 0.06 |
| NRL | 2.52 | 2.68 | 2.81 | 2.90 | 2.38 | 2.71 | 1.93 |
| **SUB TOTAL** | **127.03** | **137.33** | **145.22** | **151.04** | **144.71** | **127.50** | **99.00** |

| JV Refineries | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 (P) | April - Dec. 2021 (P) |
|---|---|---|---|---|---|---|---|
| HMEL | 10.71 | 10.52 | 8.83 | 12.47 | 12.24 | 10.07 | 9.82 |
| BORL | 6.40 | 6.36 | 6.71 | 5.71 | 7.91 | 6.19 | 5.39 |
| **SUB TOTAL** | **17.11** | **16.88** | **15.54** | **18.18** | **20.15** | **16.26** | **15.21** |

| Pvt. Refineries | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 (P) | April - Dec. 2021 (P) |
|---|---|---|---|---|---|---|---|
| NEL | 19.11 | 20.92 | 20.69 | 18.89 | 20.62 | 17.07 | 15.18 |
| RIL | 69.50 | 70.20 | 70.50 | 69.14 | 68.89 | 60.94 | 47.83 |
| **SUB TOTAL** | **88.61** | **91.12** | **91.19** | **88.03** | **89.51** | **78.01** | **63.00** |

| | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 (P) | April - Dec. 2021 (P) |
|---|---|---|---|---|---|---|---|
| **All India Crude Processing** | **232.90** | **245.40** | **251.90** | **257.25** | **254.38** | **221.77** | **177.21** |

Source : PIB Release/PPAC

## CRUDE CAPACITY VS. PROCESSING

| | Capacity On 01/01/2022 Million MT | % Share | Crude Processing April-Dec. 2021 (P) | % Share |
|---|---|---|---|---|
| PSU Ref | 141.9 | 56.9 | 99.00 | 55.9 |
| JV. Ref | 19.1 | 7.7 | 15.2 | 8.6 |
| Pvt. Ref | 88.2 | 35.4 | 63.0 | 35.6 |
| **Total** | **249.9** | **100** | **177.2** | **100** |

Source: PIB/PPAC

## POL PRODUCTION (Million MT)

| | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 (P) | April-Dec. 2021 (P) |
|---|---|---|---|---|---|---|---|
| From Refineries | 227.9 | 239.2 | 249.8 | 257.4 | 258.2 | 229.2 | 182.9 |
| From Fractionators | 3.4 | 3.5 | 4.6 | 4.9 | 4.8 | 4.2 | 3.1 |
| **Total** | **231.2** | **242.7** | **254.4** | **262.4** | **262.9** | **233.4** | **186.0** |

## DISTILLATE PRODUCTION (Million MT)

| | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 (P) | April-Dec. 2021 (P) |
|---|---|---|---|---|---|---|---|
| Light Distillates, MMT | 67.1 | 71.0 | 74.7 | 75.4 | 76.8 | 71.4 | 53.2 |
| Middle Distillates , MMT | 118.3 | 122.5 | 127.5 | 130.8 | 130.2 | 110.5 | 87.7 |
| Total Distillates, MMT | 188.8 | 196.9 | 206.8 | 211.1 | 211.7 | 186.2 | 144.0 |
| **% Distillates Production on Crude Processing** | **79.9** | **79.1** | **80.6** | **80.5** | **81.7** | **82.4** | **79.9** |

Source: PIB/PPAC

## PETROLEUM PRICING

## OIL IMPORT - VOLUME AND VALUE

| | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 (P) | 2020-21 (P) | April-Dec. 2021 (P) |
|---|---|---|---|---|---|---|---|
| Quantity, Million Mt | 202.9 | 213.9 | 220.4 | 226.5 | 227.0 | 198.1 | 156.6 |
| Value, INR ₹000 cr. | 416.6 | 470.2 | 565.5 | 783.2 | 717.0 | 463.0 | 614.6 |
| Value, USD Billion | 64.0 | 70.2 | 87.8 | 111.9 | 101.4 | 62.7 | 82.7 |
| Average conversion Rate, INR per USD (Calculated) | 65.1 | 67.0 | 64.4 | 70.0 | 70.7 | 73.8 | 74.3 |

## OIL IMPORT - PRICE USD / BARREL

| | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 (P) | 2020-21 (P) | April-Dec. 2021 (P) |
|---|---|---|---|---|---|---|---|
| Brent (Low Sulphur - LS-marker) (a) | 47.5 | 48.7 | 57.5 | 70.0 | 61.0 | 44.3 | 73.9 |
| Dubai (b) | 45.6 | 47.0 | 55.8 | 69.3 | 60.3 | 44.6 | 72.3 |
| Low sulphur-High sulphur differential (a-b) | 1.8 | 1.7 | 1.6 | 0.7 | 0.6 | -0.3 | 1.6 |
| Indian Crude Basket (ICB) | 46.17 | 47.56 | 56.43 | 69.88 | 60.47 | 44.82 | 72.76 |
| ICB High Sulphur share % | 72.28 | 71.03 | 72.38 | 74.77 | 75.50 | 75.62 | 75.62 |
| ICB Low Sulphur share % | 27.72 | 28.97 | 27.62 | 25.23 | 24.50 | 24.38 | 24.38 |

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

| | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 (P) | 2020-21 (P) | April-Dec. 2021 (P) |
|---|---|---|---|---|---|---|---|
| Gasoline | 61.7 | 58.1 | 67.8 | 75.3 | 67.0 | 47.5 | 82.5 |
| Naphtha | 48.5 | 47.1 | 56.3 | 65.4 | 55.1 | 43.9 | 74.1 |
| Kero / Jet | 58.2 | 58.4 | 69.2 | 83.9 | 70.4 | 45.8 | 79.0 |
| Gas Oil (0.05% S) | 57.6 | 58.9 | 69.8 | 84.1 | 74.1 | 50.0 | 81.2 |
| Dubai crude | 45.6 | 47.0 | 55.8 | 69.3 | 60.3 | 44.6 | 72.3 |
| Indian crude basket | 46.2 | 47.6 | 56.4 | 69.9 | 60.5 | 44.8 | 72.8 |

## CRACKS SPREADS ($/ BBL.)

| | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 (P) | 2020-21 (P) | April-Dec. 2021 (P) |
|---|---|---|---|---|---|---|---|
| **Gasoline crack** | | | | | | | |
| Dubai crude based | 16.1 | 11.1 | 12.0 | 5.9 | 6.7 | 2.9 | 10.2 |
| Indian crude basket | 15.6 | 10.6 | 11.4 | 5.4 | 6.5 | 2.6 | 9.8 |
| **Diesel crack** | | | | | | | |
| Dubai crude based | 12.0 | 12.0 | 13.9 | 14.8 | 13.8 | 5.5 | 8.9 |
| Indian crude basket | 11.5 | 11.4 | 13.4 | 14.2 | 13.6 | 5.2 | 8.5 |

## DOMESTIC GAS PRICE ($/MMBTU)

| Period | Domestic Gas Price (GCV Basis) | Price Cap for Deepwater, High temp High Pressure Areas |
|---|---|---|
| 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 |
| April 20 - September 20 | 2.39 | 5.61 |
| October 20 - March 21 | 1.79 | 4.06 |
| April 21 - September 21 | 1.79 | 3.62 |
| October 21 - March 22 | 2.90 | 6.13 |

Source: PIB/PPAC/OPEC

## GAS PRODUCTION

Qty in MMSCM

| | 2017-18 | 2018-19 | 2019-20 | 2020-21 (P) | April-Dec. 2021 (P) |
|---|---|---|---|---|---|
| ONGC | 23429 | 24667 | 23746 | 21872 | 15542 |
| Oil India | 2881 | 2722 | 2668 | 2480 | 2190 |
| Private/ Joint Ventures | 6338 | 5477 | 4770 | 4319 | 7942 |
| **Total** | **32648** | **32875** | **31184** | **28671** | **25674** |

| | | 2017-18 | 2018-19 | 2019-20 | 2020-21 (P) | April-Dec. 2021 (P) |
|---|---|---|---|---|---|---|
| Onshore | Natural Gas | 9904 | 10046 | 9893 | 9601 | 7923 |
| | CBM | 735 | 710 | 655 | 477 | 518 |
| | **Sub Total** | **10639** | **10756** | **10549** | **10078** | **8440** |
| Offshore | | 22011 | 22117 | 20635 | 18428 | 17234 |
| | **Sub Total** | **22011** | **22117** | **20635** | **18428** | **17234** |

| | | | | | |
|---|---|---|---|---|---|
| **Total** | **32649** | **32873** | **31184** | **28506** | **25674** |
| **(-) Flare loss** | 918 | 815 | 927 | 721 | 638 |
| **Net Production** | 31731 | 32058 | 30257 | 27785 | 25036 |

| | 2017-18 | 2018-19 | 2019-20 | 2020-21 (P) | April-Dec. 2021 (P) |
|---|---|---|---|---|---|
| Net Production | 31731 | 32058 | 30257 | 27785 | 25036 |
| Own Consumption | 5806 | 6019 | 6053 | 5736 | 4338 |
| Availabilty | 25925 | 26039 | 24204 | 22049 | 20698 |

## AVAILABILTY FOR SALE

| | 2017-18 | 2018-19 | 2019-20 | 2020-21(P) | April-Dec. 2021 (P) |
|---|---|---|---|---|---|
| ONGC | 18553 | 19597 | 18532 | 16972 | 12006 |
| Oil India | 2365 | 2207 | 2123 | 1930 | 1677 |
| Private/ Joint Ventures | 5007 | 4235 | 3549 | 3147 | 7015 |
| **Total** | **25925** | **26039** | **24204** | **22049** | **20698** |

## CONSUMPTION (EXCLUDING OWN CONSUMPTION

| | 2017-18 | 2018-19 | 2019-20 | 2020-21 (P) | April-Dec. 2021 (P) |
|---|---|---|---|---|---|
| Total Consumption | 53364 | 54779 | 58091 | 54910 | 45076 |
| Availabilty for sale | 25925 | 26039 | 24204 | 22049 | 20698 |
| LNG Import | 27439 | 28740 | 33887 | 32861 | 24378 |

## GAS - IMPORT DEPENDENCY

| | 2017-18 | 2018-19 | 2019-20 | 2020-21 (P) | April-Dec. 2021 (P) |
|---|---|---|---|---|---|
| Net Gas Production | 31731 | 32058 | 30257 | 27785 | 25036 |
| LNG Imports | 27439 | 28740 | 33887 | 32861 | 24378 |
| Import Dependency (%) | 46.4 | 47.3 | 52.8 | 54.2 | 49.3 |
| **Total Gas Consumption*** | **59170** | **60798** | **64144** | **60646** | **49414** |

* Includes Own Consumption

Source:PIB/PPAC

## SECTOR WISE DEMAND AND COMSUMPTION OF NATURAL GAS

Qty in MMSCM

| | | 2019-20 | 2020-21 (P) | April-December 2021 (P) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
| Fertilizer | R-LNG | **9556** | **11336** | 877 | 893 | 964 | 1048 | 1084 | 1020 | 1128 | 1106 | 1148 | **9268** |
| | Domestic Gas | **6559** | **6331** | 539 | 521 | 538 | 568 | 541 | 415 | 435 | 464 | 492 | **4513** |
| Power | R-LNG | **3554** | **3630** | 286 | 263 | 281 | 343 | 329 | 285 | 338 | 127 | 129 | **2381** |
| | Domestic Gas | **7526** | **7289** | 560 | 584 | 554 | 489 | 527 | 551 | 552 | 527 | 494 | **4838** |
| City Gas | R-LNG | **5146** | **4169** | 431 | 409 | 351 | 415 | 396 | 444 | 422 | 469 | 509 | **3846** |
| | Domestic Gas | **5737** | **4899** | 455 | 404 | 517 | 575 | 592 | 620 | 643 | 614 | 652 | **5072** |
| Refinery Petrochemical Others | R-LNG | **13130** | **12505** | 1030 | 904 | 928 | 1007 | 785 | 784 | 798 | 721 | 732 | **7689** |
| | Domestic Gas | **5285** | **5920** | 682 | 797 | 845 | 906 | 807 | 954 | 968 | 926 | 939 | **7824** |

Source:PPAC

## CGD INFRASTRUCTURE

| | | As on 31st March 2018 | As on 31st March 2019 | As on 31st March 2020 | As on 31st March 2021 | As on 31st Jan 2022 (P) |
|---|---|---|---|---|---|---|
| PNG | Domestic | 42,80,054 | 50,43,188 | 60,68,415 | 78,20,387 | 88,98,132 |
| | Commercial | 26,131 | 28,046 | 30,622 | 32,339 | 34,316 |
| | Industrial | 7,601 | 8,823 | 10,258 | 11,803 | 13,016 |
| CNG | CNG Stations | 1,424 | 1,730 | 2,207 | 3,101 | 3,878 |
| | CNG Vehicles | 30.90 lakhs | 33.47 lakhs | 37.10 lakhs | 39.55 lakhs | 42.98 lakhs |

Source: PPAC/Vahan

## MAJOR NATURAL GAS PIPELINE NETWORK As on 30.09.2021

| Nature of Pipeline | | GAIL | GSPL | PIL | IOCL | AGCL | RGPL |
|---|---|---|---|---|---|---|---|
| Operational | Length | 8,918 | 2,700 | 1,459 | 143 | 107 | 304 |
| | Capacity | 171.5 | 43.0 | 85.0 | 20.0 | 2.4 | 3.5 |
| Partially commissioned# | Length | 4,543 | | | 166 | | |
| | Capacity | | | | | | |
| **Total operational length** | | **13,461** | **2,700** | **1,459** | **309** | **107** | **304** |
| Under construction | Length | 5,973 | 100 | | 1,265 | | |
| | Capacity | 23.2 | 3.0 | | | | |
| **Total length** | | **19,434** | **2,800** | **1,459** | **1,574** | **107** | **304** |

| Nature of pipeline | | GGL | DFPCL | ONGC | GIGL | GITL | Others* | Total |
|---|---|---|---|---|---|---|---|---|
| Operational | Length | 73 | 42 | 24 | | | | **13,770** |
| | Capacity | 5.1 | 0.7 | 6.0 | | | | **337.3** |
| Partially commissioned# | Length | | | | 441 | 365 | | **5,515** |
| | Capacity | | | | | | | **-** |
| **Total operational length** | | **73** | **42** | **24** | **441** | **365** | **0** | **19,285** |
| Under construction | Length | | | | 1,891 | 1,446 | 3,550 | **14,225** |
| | Capacity | | | | | | 153.5 | **-** |
| **Total length** | | **73** | **42** | **24** | **2,332** | **1,811** | **3,550** | **33,510** |

*Includes AGCL, DFPCL, ONGC and excludes CGD pipeline network

Source: PPAC/PNGRB

## EXISTING LNG TERMINALS

| Location | Companies | Capacity (MMTPA) As on 01st Mar. 22 | Capacity Utilisation (%) April- Jan 2022 |
|---|---|---|---|
| Dahej | Petronet LNG Ltd | 17.5 | 89.1 |
| Hazira | Shell Energy India Pvt Ltd | 5.2 | 52.6 |
| Dabhol* | Konkan LNG Ltd | 5 | 78.3 |
| Kochi | Petronet LNG Ltd | 5 | 22.1 |
| Ennore | Indian Oil LNG Pvt Ltd | 5 | 14.0 |
| Mundra | GSPC LNG Ltd | 5 | 19.6 |
| **Total Capacity** | | **42.7 MMTPA** | |

*To increase to 5 MMTPA with breakwater. Only HP stream of capacity of 2.9 MMTPA is commissioned

Source: PPAC

# Member Organizations

| S No | Organization | Name | Designation |
|---|---|---|---|
| 1 | Antelopus Energy Pvt Ltd | Mr. Suniti Bhat | Chief Executive Officer |
| 2 | Axens India (P) Ltd. | Mr. Philippe Bergault | Managing Director |
| 3 | Baker Hughes, A GE Company | Mr. Neeraj Sethi | Country Leader |
| 4 | Bharat Oman Refineries Ltd. | Mr. Abhairaj Singh Bhandari | Chief Executive Officer |
| 5 | Bharat Petroleum Corporation Ltd. | Mr. Arun Kumar Singh | Chairman & Managing Director |
| 6 | BP Group | Mr. Sashi Mukundan | President, bp India & Senior Vice President, bp group |
| 7 | Cairn Oil & Gas, Vedanta Limited | Mr. Sunil Duggal | Group CEO, Vedanta Ltd. |
| 8 | Chandigarh University | Mr. Satnam Singh Sandhu | Chancellor |
| 9 | Chennai Petroleum Corporation Ltd. | Mr. Arvind Kumar | Managing Director |
| 10 | Chi Energie Pvt. Ltd | Mr. Ajay Khandelwal | Director |
| 11 | CSIR-Indian Institute of Petroleum | Dr. Anjan Ray | Director |
| 12 | Decom North Sea | Mr. Will Rowley | Interim Managing Director |
| 13 | Deepwater Drilling & Industries Ltd. | Mr. Naresh Kumar | Chairman & Managing Director |
| 14 | Dynamic Drilling & Services Pvt. Ltd. | Mr. S. M. Malhotra | President |
| 15 | Engineers India Ltd. | Ms. Vartika Shukla | Chairman & Managing Director |
| 16 | Ernst & Young LLP | Mr. Rajiv Memani | Country Manager & Partner |
| 17 | ExxonMobil Gas (India) Pvt. Ltd. | Mr. Bill Davis | Chief Executive Officer |
| 18 | GAIL (India) Ltd. | Mr. Manoj Jain | Chairman & Managing Director |
| 19 | GSPC LNG Ltd. | Mr. Anil K. Joshi | President |
| 20 | h2e Power Systems Pvt. Ltd. | Mr. Siddharth R Mayur | Managing Director & CEO |
| 21 | Haldor Topsoe India Pvt. Ltd. | Mr. Alok Verma | Managing Director |
| 22 | Hindustan Petroleum Corp. Ltd. | Mr. M.K. Surana | Chairman & Managing Director |
| 23 | HPCL Mittal Energy Ltd. | Mr. Prabh Das | Managing Director & CEO |
| 24 | HPOIL Gas Private Ltd. | Mr. Arun Kumar Mishra | Chief Executive Officer |
| 25 | IHS Markit | Mr. James Burkhard | Managing Director |
| 26 | International Gas Union | Mr. Luis Bertran | Secretary General |
| 27 | IIT (ISM) Dhanbad | Prof. Rajiv Shekhar | Director |
| 28 | IMC Ltd. | Mr. A. Mallesh Rao | Managing Director |
| 29 | Indian Gas Exchange Ltd. | Mr. Rajesh Kumar Mediratta | Managing Director & CEO |
| 30 | Indian Oil Corporation Ltd. | Mr. S.M. Vaidya | Chairman |
| 31 | Indian Strategic Petroleum Reserves Ltd | Mr. H.P.S. Ahuja | Chief Executive Officer & MD |
| 32 | Indraprastha Gas Ltd. | Mr. A.K. Jana | Managing Director |
| 33 | Indian Oiltanking Ltd. | Mr. Rajesh Ganesh | Managing Director |
| 34 | IPIECA | Mr. Brian Sullivan | Executive Director |

| S No | Organization | Name | Designation |
|---|---|---|---|
| 35 | Invenire Petrodyne Ltd. | Mr. Mannish Maheshwari | Chairman & Managing Director |
| 36 | IRM Energy Pvt. Ltd. | Mr. Karan Kaushal | Chief Executive Officer |
| 37 | Jindal Drilling & Industries Pvt. Ltd. | Mr. Raghav Jindal | Managing Director |
| 38 | LanzaTech | Dr. Jennifer Holmgren | Chief Executive Officer |
| 39 | Larsen & Toubro Ltd | Mr. S.N. Subrahmanyan | CEO & Managing Director |
| 40 | Maharashtra Institute of Technology (MIT) Pune | Dr. L.K. Kshirsagar | Principal |
| 41 | Mangalore Refinery & Petrochemicals Ltd. | Mr. M. Venkatesh | Managing Director |
| 42 | Megha Engineering & Infrastructures Ltd. | Mr. P. Doraiah | Director |
| 43 | Nayara Energy Ltd. | Mr. Tony Fountain | Chairman |
| 44 | Numaligarh Refinery Ltd. | Mr. Bhaskar Jyoti Phukan | Director (Tech.) & MD (I/c) |
| 45 | Oil and Natural Gas Corporation Ltd | Dr. Alka Mittal | CMD (Addl. Charge) & Director (HR) |
| 46 | Oil India Ltd. | Mr. Sushil Chandra Mishra | Chairman & Managing Director |
| 47 | Petrofac International Ltd. | Mr. Paolo Bonucci | Head of Business Development & Senior Vice President |
| 48 | Petronet LNG Ltd. | Mr. Akshay Kumar Singh | Managing Director & CEO |
| 49 | Pipeline Infrastructure Ltd. | Mr. Akhil Mehrotra | Chief Executive Officer |
| 50 | Rajiv Gandhi Institute of Petroleum Technology | Prof. A.S.K Sinha | Director |
| 51 | Reliance BP Mobility Ltd. | Mr. Harish C. Mehta | Chief Executive Officer |
| 52 | Reliance Industries Ltd., | Mr. Mukesh Ambani | Chairman & Managing Director |
| 53 | SAS Institute (India) Pvt Ltd. | Mr. Noshin Kagalwalla | CEO & Managing Director-India |
| 54 | Schlumberger Asia Services Ltd | Mr. Vinay Malhotra | Managing Director |
| 55 | Scottish Development International | Mr. Kevin Liu | Head of Energy Trade, Asia Pacific |
| 56 | Secure Meters Ltd. | Mr. Sunil Singhvi | CEO - Energy |
| 57 | Shell Companies in India | Mr. Nitin Prasad | Country Chair |
| 58 | Siemens Limited | Mr. Gerd Deusser | CEO (Siemens Energy - India) |
| 59 | SNF Flopam India Pvt. Ltd | Mr. Shital Khot | Managing Director |
| 60 | South Asia Gas Enterprise Pvt. Ltd. | Mr. Subodh Kumar Jain | Director |
| 61 | Tecnimont Private Limited | Mr. Sathiamoorthy Gopalsamy | Managing Director |
| 62 | THINK Gas Distribution Pvt. Ltd. | Mr. Hardip Singh Rai | Chief Executive Officer |
| 63 | TotalEnergies Gas & Power Projects India Pvt. Ltd. | Mr. Jose Ignacio Sanz Saiz | Chairman & Managing Director India - Country Chair |
| 64 | University of Petroleum & Energy Studies | Dr. S.J. Chopra | Chancellor |
| 65 | UOP India Pvt. Ltd. | Mr. Mike Banach | Managing Director |
| 66 | VCS Quality Services Private Ltd. | Mr. Shaker Vayuvegula | Director |
| 67 | World LPG Association | Mr. James Rockall | CEO and Managing Director |

# 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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