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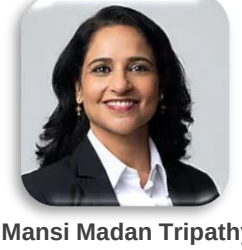

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From the Desk of the

Director General

Greetings from Federation of Indian Petroleum Industry (FIPI)!

As we begin a new financial year, I am honoured to take a moment to reflect on the successes and challenges we have faced together over the past year. It has been a year of growth and transformation, and I am proud of the way we have navigated these changes together. Amidst an uncertain and challenging global macroeconomic environment, the Indian economy presented a picture of confidence, positivity and optimism. After clocking real GDP growth of 7.2% in 2022-23, real GDP is expected to grow by 7.6% during 2023-24 according to the latest release by the National Statistical Office (NSO). With strong domestic demand conditions, India remains the fastest growing major economy and is now the fifth largest economy in the world. Buoyed by its growth, according to the IMF, India is expected to become the third-largest economy in the world by 2027 on the back of continued reforms.

The resilience of India's growth process was deliberated in the Union Budget delivered by the Hon'ble Finance Minister, Smt. Nirmala Sitharaman on 1st February, 2024. The Interim Budget contained several announcements which focused on infrastructure development, consolidation of the fiscal deficit, green energy growth, financial inclusion, and social justice.

An increase in economic growth was reflected in the robust demand for petroleum products in FY 2023-24. Consumption of petroleum products rose by ~ 5% reaching a record high of 233.28 MMT from consumption as in last FY at 223 MMT. While sale of petrol rose 6.4% year-on-year by 3.32 million tonnes in FY 2023-24, diesel consumption climbed 4.4% year-on-year by 8.04 million tonnes and sale of LPG rose year on year 4% by 2.61 million tonnes.

In the green energy space, the Interim Budget has doubled down on its efforts on alternate energy sources and green growth by announcing financial assistance in the form of Viability Gap Funding (VGF) to support the growth of wind and biomass energy sources. To strengthen the EV ecosystem, the government has made additional allocation of Rs. 2500 crore under the FAME policy and an allocation of Rs. 3500 crore under the PLI scheme to ensure that the EV manufacturing and charging infrastructure are in place. Measures have been undertaken to increase the availability of solar energy through rooftop solarization with 1 crore households being mandated to obtain up to 300 units of free electricity every month. In the field of CBG, a budget allocation of Rs. 150 crore has been announced towards collection of raw material such that blending of CBG in CNG and PNG can take place. This push from the government for blending CBG with natural gas and promoting its adoption as a fuel, particularly in the transportation segment are the positive developments taking place to promote growth of the gas sector in India.

In continuation of its aggressive acceleration of E&P activities and adhering to the prescribed timelines, the government has launched OALP Bid Round-IX for International Competitive Bidding on 3rd January 2024. In this bid round, 28 blocks are on offer for bidding which are spread across 8 Sedimentary Basins and include 9 onland blocks, 8 shallow water blocks and 11 Ultra-Deep-water blocks.

Further, to rationalise the open access charges, new rules have been prescribed with methodologies for determining various open access charges like wheeling charges, state transmission charges and additional surcharges. In order to ensure ease of doing business, a person/company setting up a

captive generating plant or an Energy Storage System shall not be required to obtain a licence for establishing, operating, or maintaining a dedicated transmission line to connect to the grid if such company or person complies with the regulations and technical standards issued under the provisions of the Act.

To give a further push to clean mobility in the country, the Ministry of Heavy Industries announced an increase in the scheme outlay of FAME India scheme Phase II -from ₹10,000 crore to ₹11,500 crore. This initiative focuses on aiming to broaden the landscape for electric vehicles in the Indian market and reflects the government's commitment to fostering a cleaner and greener future.

Further, the government has announced a series of guidelines for pilot projects on the use of green hydrogen in the transport sector, steel sector and shipping sector. While the use of green hydrogen in the transport sector will lead to development of necessary infrastructure including refueling facilities and distribution infrastructure, use of hydrogen in the steel sector will be beneficial in the Direct Reduced Ironmaking process; Blast Furnace; and further, substitution of fossil fuels with green hydrogen in the shipping sector would be beneficial in development of necessary infrastructure including refueling stations, storage, and distribution networks.

In addition, the finalization of the structure for operationalizing the scheme for Viability Gap Funding (VGF) for development of Battery Energy Storage Systems (BESS) with capacity of 4,000 MWh is a welcome step towards energy transition. This initiative will encourage the setting up of BESS capacity to meet the fast-growing needs of power demand as well as ensure environmental sustainability.

Various Events organized by FIPI during the quarter

India Energy Week (IEW), India's flagship energy event, is held under the patronage of the Ministry of Petroleum & Natural Gas (MoP&NG), and is organized by FIPI. Building on the success of the 2023 IEW edition, the Hon'ble Prime Minister Shri Narendra Modi inaugurated the India Energy Week (IEW) 2024 as well at IPSHEM, Goa, on 6th February 2024, under the theme of Growth, Collaboration, Transition. IEW highlighted India's leadership in the battle against climate change while allowing stakeholders across the energy spectrum to freely exchange ideas and explore opportunities under one roof. The event witnessed over 35,000 attendees, 350 exhibitors, 400 speakers spread across 80 conference sessions and 4,000 delegates from over 120 countries.

Further, several ministerial, leadership, technical sessions and roundtables were held that explored varied themes like energy transition of the global south, building a future ready energy stack, chartering the roadmap of alternate fuels for energy optionality and the impact of localization, regionalization and globalization on energy-related industrialization and manufacturing processes.

To further enhance the event, FIPI exhibited a stall at IEW 2024. The stall displayed infographics related to its core competencies and major advocacy areas, publications such as the Annual Report and quarterly & monthly publications, member organizations, various studies carried out etc.

Further, as part of the FIPI student chapters initiative, FIPI extended sponsorship support towards participation of two students from each of 11 FIPI student chapters in IEW 2024 to give them first -hand exposure to the latest technological developments in the hydrocarbon industry besides an opportunity to network.

The IEW 2024 also featured the Energy Startup Challenge, awarding Iron Technologies the first prize, followed by Vasitara Private Limited in second place and Aloe Ecell in the third place. Honourable mentions went to Biofuels Junction and VDT Pipeline Integrity Solutions, showcasing the innovation and entrepreneurial spirit within the Indian energy sector.

During the quarter, FIPI participated in various knowledge sharing events and webinars.

On 2nd February, 2024, FIPI organized its flagship post - budget analysis session. The session was organized with EY, as the knowledge partner. The objective of the session was to analyse the recently presented Interim Budget and weigh the impact of the Budget on the Economy and India's oil and gas industry. A panel discussion was conducted to discuss the main features of the Budget. The session was attended by CFOs of leading public & private sector companies among other industry

leaders and participants. The Budget session was attended by nearly 100 delegates (virtually) and was appreciated in terms of content by everyone.

FIPI in association with EY organized a webinar on 'Biofuels in India' on 21st March 2024. The webinar was conducted to shed light on the approaches that have been adopted by companies globally with respect to mature biogas/biofuel pathways, along with key opportunities and challenges in developing a robust ecosystem for biofuels in India. The webinar witnessed an overwhelming response with the participation of more than 300 professionals working across the oil and gas value chain.

Ongoing FIPI Studies

FIPI, on behalf of its members, is carrying out a study on "Role of CCUS in India's Energy Sector" in knowledge partnership with EY with the objective to assess the role & importance of CCUS, in India's energy sector. Eight industry members, namely, IOCL, BPCL, HPCL, GAIL, HMEL, ONGC, OIL and Nayara Energy have agreed to partner this study. The knowledge partner has submitted the draft report in February 2024 and the final report is under preparation which is expected in April 2024.

Another major work initiated by FIPI is carrying out a study with BCG for developing the Global Biofuel Alliance (GBA) under India's G20 Presidency. The objective of the study is to analyse and support alignment and broader adoption of GBA. The report is expected to be submitted this month.

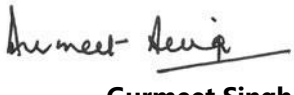
Lastly, FIPI, through its committee meetings, regularly interacts and discusses the pertinent issues with its member companies and tries to resolve the same with the relevant regulatory authorities.

Conclusion

Amid a growing focus on net-zero, the energy transition compels the oil and gas industry to undergo significant innovation and adaptation to newer, cleaner, and more sustainable technologies. The oil and gas industry will need to adjust its supply and investment strategies to cope with more variable demand and prices, as well as to diversify its energy portfolio and revenue streams. In this journey, we are excited to embark on this new financial year with our member organisations and look forward to collaborating on innovative and impactful strategies in the field of energy sector.

We thank you for your trust and support, and here is to a successful and prosperous financial year ahead.

Wishing everyone all the best!



Gurmeet Singh

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

Follow us on:

A Strategic Shift to Petrochemicals

Papia Mandal
General Manager

Engineers India Limited

Background

India's remarkable progress hitherto has distinguished this decade as a momentous era. While transitioning towards renewable energy sources, the government of India has placed huge emphasis on indigenisation, self-reliance and sustainability. Import reduction of fossil fuel is one of the foremost important aspects in this endeavour.

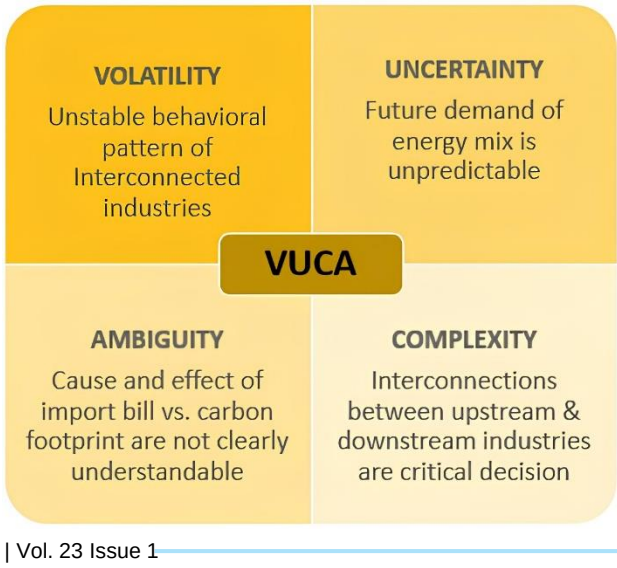
With the economic growth of the Nation, demand of energy is increasing exponentially. To cater to this gigantic demand increase, various alternate energy sources are being explored. Environmental sustainability is another important factor posing challenge which demands cleaner, greener and sustainable energy. In view of this, renewable energy sources and production methods are a fervent subject of debate and discussion. Our Nation being deprived of sufficient natural fossil resources, such as crude oil and natural gas, the need is primarily fulfilled through import of the same, incurring massive foreign exchange outgo. At the same time, the need for petrochemicals and its derivatives are emerging as an equally important and indispensable part of the development journey.

Reduction of fossil fuel and its usage as transportation fuel and energy, has incentivised the carbon footprint control, which is need of the hour to ensure sustainability, alongside curtailment and a check on the import bills. The fossil fuel that is apparently getting displaced from energy generation could be manifested in several ways either to fill the energy gaps with respect to rising demand of energy or become instrumental in bringing tremendous prosperity in the connected petrochemical industry. Channelizing fossil fuel strategically towards petrochemical has the potential for economic growth as well as sustainability for the Nation.

Dynamics of Hydrocarbon Industry

Hydrocarbon industries are very much CAPEX sensitive. Not only that, but also, geo-political situation is a primary driver behind arranging feedstock for effective utilisation of the refining capacity having been set up in the country. In this era of Volatility, Uncertainty, Complexity, and Ambiguity (VUCA), when along with up-soaring demand, its usage pattern is also changing continuously. Keeping in view of the tectonic shift in energy paradigm and rising demand of petrochemical derivatives in textile, automobile and other household and utilities items, more flexibility is needed in this sector.

Fig. 1: Volatility, Uncertainty, Complexity, and Ambiguity (VUCA)



In 1901, the first refinery was set up in Digboi. Ever since, 23 refineries have mushroomed in the country in the northern belt, western and eastern coastlines; some of the new refineries are upcoming. The present cumulative refining capacity is 253.9 million Metric Tonne per Annum (MMPTA). This refining capacity could potentially increase by about 56 MMTPA by the year 2028, with upcoming new refineries as well as capacity enhancement of existing refineries.

Presently, the country has already established itself as a refining hub, there are a few more steps to traverse to become a petrochemical hub too.

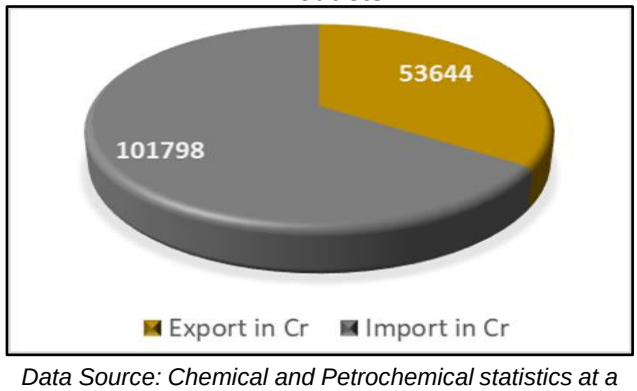
Petrochemical Scenario in India

The country has surging petrochemical demand, out of which substantial amounts of petrochemical along with its derivatives are primarily imported, necessitating a substantial financial outgo.

In the FY 2021-22, total export of petrochemical products was Rs 53,644 Crores approx., whereas import of petrochemical products was double of the import value, that is Rs 1,01,798 Crores approx. (Refer Exhibit-1)

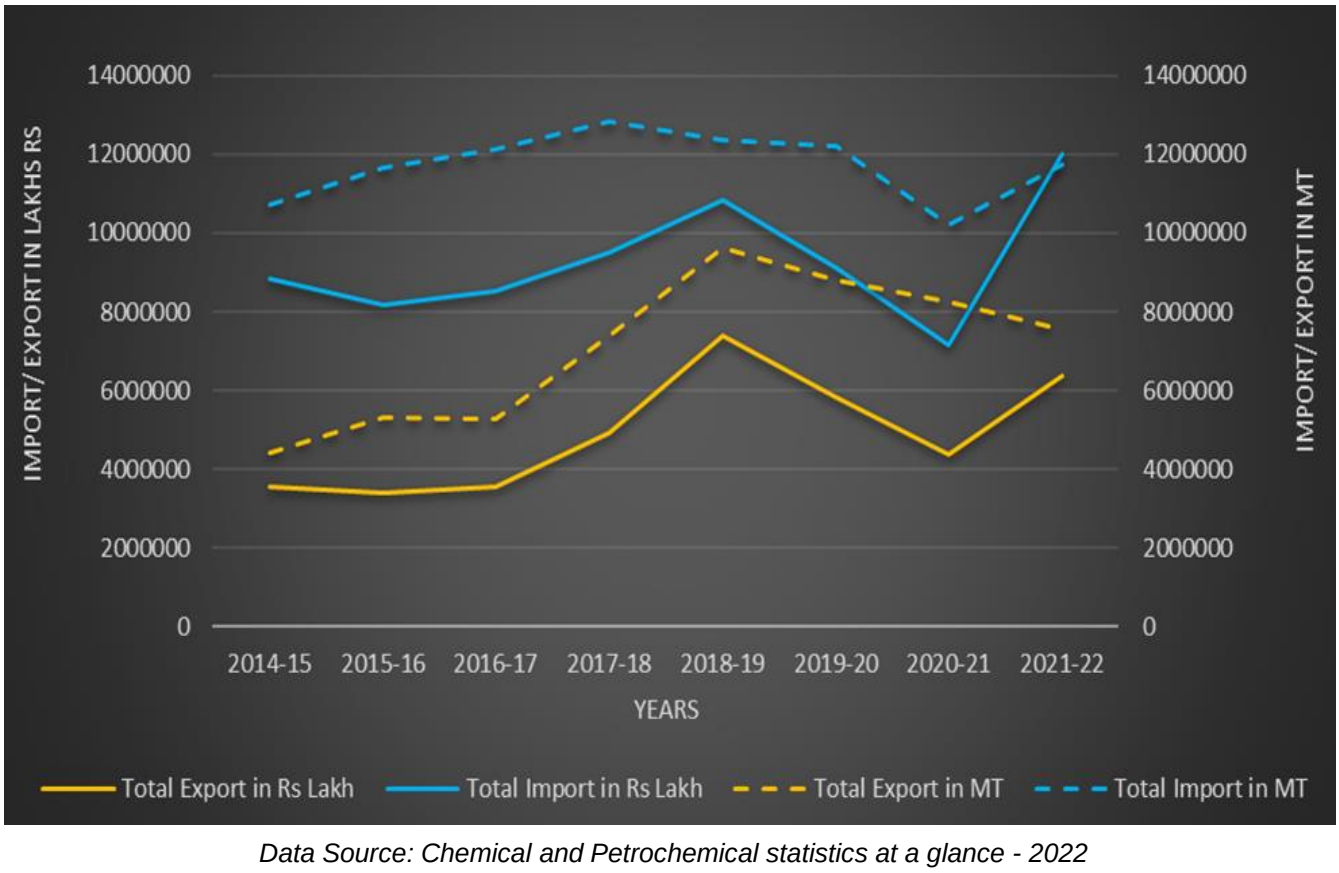
Over the past decade, import of major petrochemical products and its derivatives has increased at a CAGR of 1% and export of the same has increased at a CAGR of 7%. In the financial year 2014-15 total import was 1,07,04,840 MT worth Rs 88,44,609 Lakhs and in the financial year 2021-22 total import was 1,17,31,702 MT worth Rs 1,20,09,342 Lakhs. Similarly, in the financial year 2014-15 total export of petrochemicals and its derivatives was 44,11,994 MT worth Rs 35,37,460 Lakhs and in 2021-22 total export was 75,34,583 MT worth Rs 63,63,886 Lakhs (Refer Exhibit-2)

Exhibit-1: Export and Import of Petrochemical Products



Data Source: Chemical and Petrochemical statistics at a glance - 2022

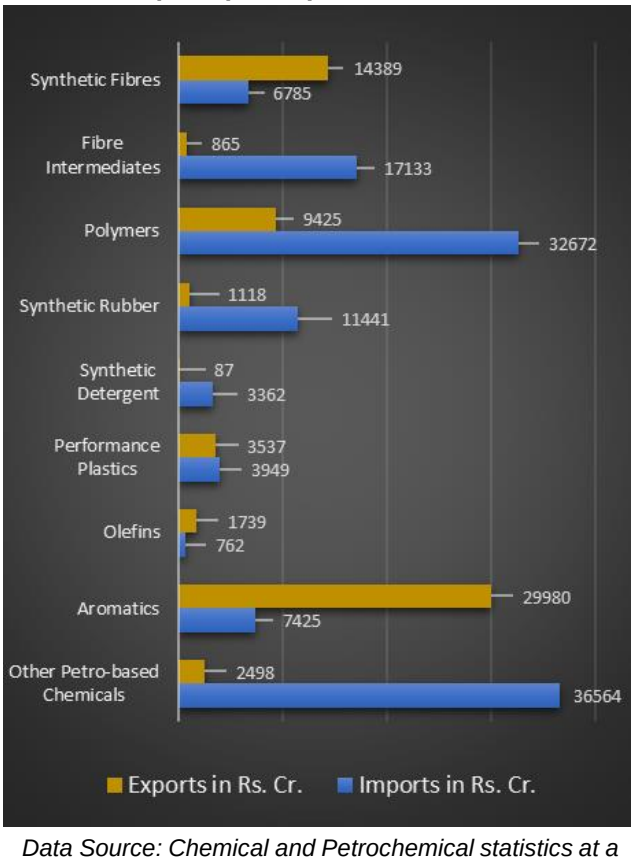
Exhibit-2: Export and Import of Major Petrochemical Products from FY 2014-15 to FY 2021-22



Data Source: Chemical and Petrochemical statistics at a glance - 2022

Export of petrochemicals belonging to Synthetic Fibres, Aromatics and Olefins groups are more than import of petrochemicals of these groups. On the other hand, import of petrochemicals of the group Fibre Intermediates, Polymers, Synthetic Rubber, Synthetic Detergent and other Petro-based chemicals is more than export of petrochemicals of these groups. For Performance plastics export and import was of the same order. Petrochemical group-wise export and imports are furnished in Exhibit-3. Net import/ export of various petrochemical groups is given in Exhibit-4.

Exhibit-3: Export and Import of Petrochemicals (Group-wise) in FY 2021-22



Data Source: Chemical and Petrochemical statistics at a glance - 2022

In F2021-22, amongst various petrochemicals and its derivatives that were exported, value contributed more than thousand crores were by Benzene, Para-xylene, Polyester Filament Yarn, Polyester Staple Fibre, Polyester Chips/ Pet Chips, Ortho-Xylene, Poly Tetra Fluoro Ethylene.

On the flip side, various petrochemicals and its derivatives that contributed more than thousand crores to the import bill were by Purified Terephthalic Acid, Styrene, Polypropylene (Inc. Co-Polymer), High Density Polythene, Poly Vinyl Chloride, Polycarbonate, Mono Ethylene Glycol, Ethyl Vinyl Acetate, Ethylene Dichloride, Polyol, Linear Alkyl Benzene, Toluene, Acrylonitrile, Low Density Polythene, Styrene Butadiene Rubber, Vinyl Acetate Monomer, ABS Resin, Linear Low-Density Polythene, Poly Butadiene Rubber, Butyl Rubber, Propylene Glycol, Poly Styrene, Epichlorohydrin, Isopropanol, Ethyl Propylene Dimers. Net Export/ Import value of each is indicated in Exhibit-5.

Exhibit-4: Petrochemical Group-wise Net Import/ Export in FY 2021-22

Petrochemicals Groups	Net Exports in Rs. Cr.	Net Imports in Rs. Cr.
Synthetic Fibres	7604	
Fibre Intermediates		16267
Polymers		23247
Synthetic Rubber		10323
Synthetic Detergent		3275
Performance Plastics		412
Olefins	977	
Aromatics	22555	
Other Petro-based Chemicals		34066

Data Source: Chemical and Petrochemical statistics at a glance - 2022

Exhibit-5: Major Petrochemical Net Import/ Export in FY 2021-22

Petrochemicals & its Derivatives	Net Exports in Rs. Cr.	Net Imports in Rs. Cr.
Benzene	13882	
Para-xylene	10348	
Polyester Filament Yarn	6237	
Polyester Staple Fibre	3297	
Polyester Chips/ Pet Chips	2218	
Ortho-Xylene	1482	
Poly Tetra Fluoro Ethylene	1219	
Purified Terephthalic Acid		8474
Styrene		7999
Polypropylene (Inc. Co-Polymer)		7438
High Density Polythene		6703
Poly Vinyl Chloride		5081
Polycarbonate		4760
Mono Ethylene Glycol		4718
Ethyl Vinyl Acetate		3839
Ethylene Dichloride		3797
Polyol		3520
Linear Alkyl Benzene		3333

Data Source: Chemical and Petrochemical statistics at a glance - 2022

Exhibit-5: Major Petrochemical Net Import/ Export in FY 2021-22. Contd.

Petrochemicals & its Derivatives	Net Exports	Net Imports
	in Rs. Cr.	
Toluene		3153
Acrylonitrile		2982
Low Density Polythene		2688
Styrene Butadiene Rubber		2565
Vinyl Acetate Monomer		2529
ABS Resin		2101
Linear Low-Density Polythene		2080
Poly Butadiene Rubber		1672
Butyl Rubber		1561
Propylene Glycol		1298
Poly Styrene		1215
Epichlorohydrin		1189
Isopropanol		1125
Ethyl Propylene Dimers		1017

Data Source: Chemical and Petrochemical statistics at a glance - 2022

Hydrocarbon Industry - Perspectives

Balancing Priorities:
India being the fastest growing economy in the world, its energy demand is soaring in various forms including transportation fuels such as gasoline, diesel, ATF. This demands not only continual operation of the refineries, rather expansion of refinery capacities as well. Besides that, along with the economic growth and improved lifestyles, petrochemical products are requiring at an increased volume, demanding more polymers and obviously more feedstocks for the petrochemical units. Striking a balance between the two priorities must be thought of strategically.

Feedstock Availability:
Choice between expanding or setting up new refinery and petrochemical plants depend largely on the feedstock availability and its cost effectiveness. Petrochemicals are mostly planned with the feedstock availability from the throughputs of the domestic refineries as well as from the gas that one could source domestically or through import. With the emphasis of including various nascent technologies and alternate energy sources in the energy basket, like generation of green hydrogen, wind energy, solar energy etc., the displaced Naphtha and other feedstocks from the refineries can be thought to be channelised towards petrochemicals production as a more economically viable choice.

Global Market Dynamics:
Considerations for global market dynamics, including demand of finished refinery products, polymers and niche petrochemicals is another important perspective to be investigated. As far as economics is concerned, petrochemicals attract better economics and therefore trade-off between feedstock diet for petrochemicals and production of distillates is always critical for review.

Environmental and Regulatory Factors:
In view of the global thrust towards sustainable practices, both refinery and petrochemicals need to align with more cleaner technologies, not only to meet environmental regulations but also for a more holistic social cause.

Path ahead

The Indian Hydrocarbon map has to be carefully analysed to examine as to how some of the refinery products could be utilised more usefully to enhance the production of petrochemicals. For instance, Green Hydrogen Integration to Refineries would not only reduce the carbon footprint intensity in the refineries, but also, enable vast quantities of naphtha to be displaced from the refineries, and could be utilised for more value addition through petrochemicals. Since Scale of the Petrochemical plants is always an issue the displaced naphtha from a couple of refinery clusters could be collated at one place to set up world scale petrochemical complexes.

Enabling Green Ammonia production could help release equivalent gas from the fertiliser segment and thereby assist in integrating with refineries to facilitate releasing naphtha and other liquid feedstocks to support the feedstock diet to petrochemicals. This could be a game changer as both the carbon footprint reduction and environmental friendliness could be achieved besides enabling large scale petrochemical production. For a country like India where the fossil fuel are scarce, such efficient energy integration studies and measures can be a transformative innovation.

To compound the growth further, e-Furnace technologies could be integrated in the Refineries and petrochemicals to displace a hefty fuel firing in the systems. This way a terrific balance between the hydrocarbon chain could be put in place where the Refineries become more efficient, Petrochemical produce is enhanced, Fertilisers becomes greener and Green ammonia begins to step in. Above all, India's burgeoning problem of continued Fossil fuel import could be rationalised sufficiently, as India begins to set the equilibrium between Energy-Economy-Atma-nirbharta to enable the country make giant strides towards growth and prosperity in alignment with the larger vision of emerging as a developed Nation!

Effect of Methyl ethyl ketone and Mineral turpentine oil on the viscosity of heavy crude oil: An experimental investigation

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Abstract

The high viscosity of heavy crude oil is a major hindrance in the smooth flow of crude oil through pipelines. Different aromatic solvents such as xylene, toluene in combination with chemical additives are commonly used to enhance the rheological properties of heavy crude oil. The work has been carried out to investigate the effect of methyl ethyl ketone and mineral turpentine oil as flow improvers for heavy and viscous crude oil. The studies are carried out on one crude oil sample of Lanwa field of Western onshore. Crude oil sample is heavy is having API gravity of 13.72ºAPI as well as highly viscous in nature with viscosity of 44050 cP at 25ºC. Lanwa#AB crude oil contains high amount of resins which give it a sticky appearance and low fluidity. Studies reveal that methyl ethyl ketone, mineral turpentine oil and their blend have reduced the viscosity of the crude oil by 20-35% at lower doses of less than 1%. However, greater viscosity reductions have been achieved on increasing the concentration of these solvents.

1. Introduction

Heavy crude oil reservoirs contain significant amount of large structural hydrocarbons that are relatively challenging to produce and lift to the surface due to low mobility of these heavy crude oils. Even after producing these heavy oils, transportation problems arise due to their high viscosity (Sherif Facker et al., 2018). Viscosity of the crude oil is the key variable responsible for the fluidity of the oil throughout the production process (Farid Souas et al., 2021). High viscosity of heavy crude oil is attributed to its significant resin content, asphaltenes and network amongst them. The crude oil viscosity increases with increasing resin content (Malkin et al., 2016). Branthaver et al., 1992, pointed out that the acid and basic components in resin are the main factors responsible for the oil viscosity increase, while the neutral component reduces the viscosity. The upstream oil industry faces a great challenge to transport these heavy oils as almost always additional energy is required to make them flowable and manageable.

Thermal method for oil recovery is one of the most commonly used mechanisms which include steam flooding, high temperature oxidation, steam assisted gravity drainage, etc. Another commonly used method to reduce viscosity of heavy crude oil is to treat with light crude oil. However, such dilution and blending method usually requires a considerable volume of light oil, which must have a convenient source. Chemical method has acquired a preponderant role in the oil industry as a cost-effective emergent technology. All chemical additives have a strong selectivity for crude oil depending on its structural composition. Many chemical additives have been developed as flow improvers for heavy crude oils which are generally termed as wax dispersant, pour point depressant or asphaltene dispersant depending on its composition. These chemical additives are used in combination with xylene or toluene as flow improvers.

The mechanism of heavy crude oil viscosity reduction by chemicals is related to non-covalent interactions such as π-π stacking, hydrogen bonding, acid-base interactions and van der Waals forces which take place between chemical additive molecules and the heavy components of crude oil (Shaohua Chenet. et al., 2023). Different chemical additives/copolymers form strong hydrogen bonds or π-π interactions with the asphaltene molecules in heavy oil and make the stacking structure more dispersed (Lv et al., 2019; Mao et al., 2018; Quan and Xing et al., 2019) which ultimately lead to reduction in viscosity of crude oil.

This research investigates the effect of methyl ethyl ketone and mineral turpentine oil as solvent on the rheology of viscous crude oil sample of Lanwa#AB.

2. Experimental Details

2.1 Materials and Equipment

One crude oil sample from the well Lanwa#AB from the Lanwa field of western onshore is taken up for the study. Mineral Turpentine oil (MTO) and methyl ethyl ketone (MEK) of LR grade have been selected for study. Ethylene Glycol Monobutyl Ether (EGMBE) of LR grade has been used as an additive. All rheological measurements are done have been carried out using Rheometer-301.

2.2 Sample preparation

A measured quantity of crude oil and previously weighed chemical additive of the required dose are mixed carefully in a flat/round bottom flask and refluxed for one and half hour keeping the flask in a water bath at 70°C.

2.3 Viscosity measurement

Viscosity measurements of untreated crude oil and treated oil have been carried out at constant shear rate of $50s^{-1}$ and temperature ranges from 55°C to 25°C using Rheometer-301.

3. Results and Discussion

3.1 Physico-chemical properties of crude oil

Lanwa#AB crude oil is heavy in nature with an API gravity of 13.72ºAPI. Lanwa#AB crude oil have significant resin content of 22.9 wt%. The water content is 12% and pour point is less than 6°C. Physico-chemical parameters are given in Table-1.

Table-1: Physico-chemical characterization of crude oil of Lanwa#AB

Sl. No.	Property	Unit	Result
1	Water Content	%(V/V)	12
2	Density at 15ºC	g/cc	0.9737
3	Specific gravity at 15ºC	-	0.9744
4	API Gravity	ºAPI	13.72
5	Pour point	ºC	< 6ºC
6	Asphaltenes	Wt%	2.1
7	Resins	Wt%	22.9
8	Wax	Wt%	1.39

3.2 Sara Analysis of crude oil

Lanwa#AB crude oil contain both the saturates (36.53%) and aromatics (33.17%) in comparable concentrations. Resin and asphaltene content of crude oil of Lanwa#AB are 2.1 wt% and 22.9 wt%. Results are given in Table-2.

Table-2: SARA analysis of crude oil of Lanwa#AB

Sl. No.	Components	Unit	Result
1	Saturates	Wt%	36.53
2	Aromatics	Wt%	33.17
3	Asphaltenes	Wt%	2.1
4	Resins	Wt%	22.9

3.3 Colloidal instability index (CII)

Colloidal instability index (CII) is one of the methods to analyse crude oil system with asphaltene deposit problems (Yen et al., 2001; Choiri et al., 2010). CII value of Lanwa#AB shows that it is of moderate stability in terms of asphaltene deposition.

$$CII = \frac{\text{Saturates + Asphaltene}}{\text{Aromatics + Resin}} = 0.69$$

3.4 Viscosity study of neat crude oil

The viscosity of untreated crude oil of Lanwa#AB at 55°C is 2550 cP and it increases to 44050 cP at 25°C (Table-3). The viscosity of crude oil is sensitive to temperature and has shown rapid increase at temperatures 40°C-25°C.

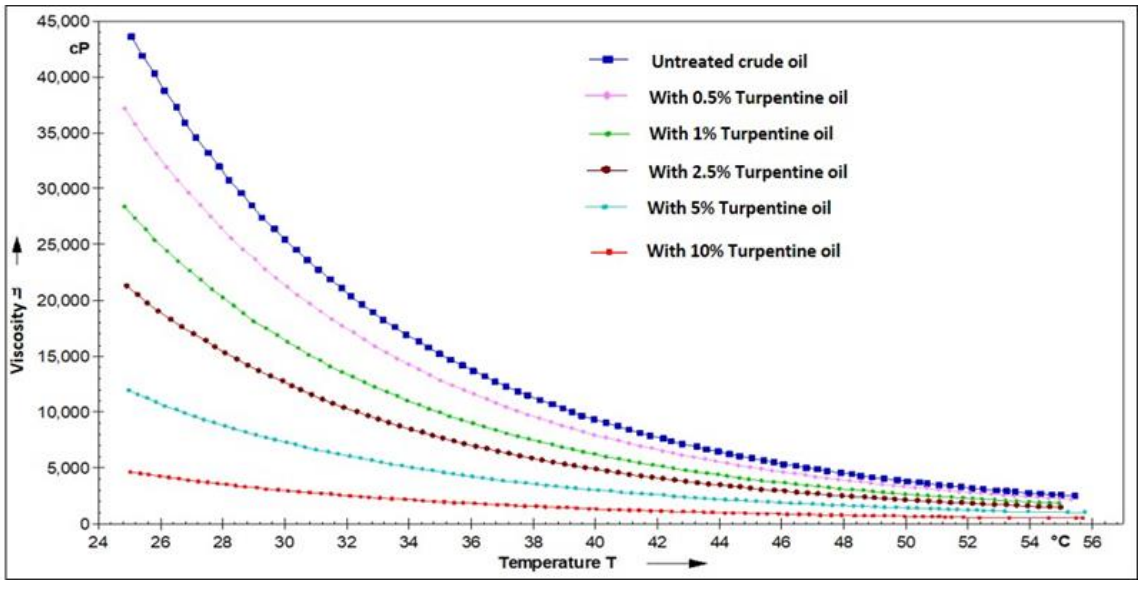
3.5 Effect of different concentration of Mineral Turpentine oil (MTO) on the viscosity of crude oil

Mineral turpentine oil resulted in 15.7% reduction in viscosity at 30°C and that of 17.1% at 25°C at 0.5% concentration. Whereas, 1% MTO reduced viscosity by 35% at 30°C and 36.4% at 25°C. 2.5% MTO showed viscosity reduction by 49.6% at 30°C and 52% at 25°C. When crude oil was treated with 5% MTO, it reduced viscosity of crude oil by 71.1% at 30°C and 72.9% at 25°C. 10% MTO resulted in 88.2% of reduction in viscosity at 30°C and that of 89.3% at 25°C. Viscosity of untreated crude oil and with different concentrations of MTO at temperature ranges from 55°C-25°C are given in Table-3 and Figure.1.

Table-3: Effect of different concentration of Mineral Turpentine oil on the viscosity of Lanwa#AB crude oil at different temperatures

Sl. No.	Chemical Dosing	Viscosity (cP) at $50s^{-1}$ shear rate						
		55°C	50°C	45°C	40°C	35°C	30°C	25°C
1	Untreated crude oil	2550	3847	5880	9340	15200	25400	44050
2	0.5% Turpentine oil	2245	3325	5090	7980	12900	21400	36500
3	1% Turpentine oil	1808	2650	3968	6210	9950	16500	28033
4	2.5% Turpentine oil	1480	2140	3180	4870	7747	12800	21500
5	5% Turpentine oil	1070	1428	2040	3020	4663	7345	11900
7	10% Turpentine oil	533	691	945	1340	1987	2990	4685

Fig.1: Effect of different concentration of Mineral Turpentine oil on the viscosity of Lanwa#AB crude oil at different temperatures



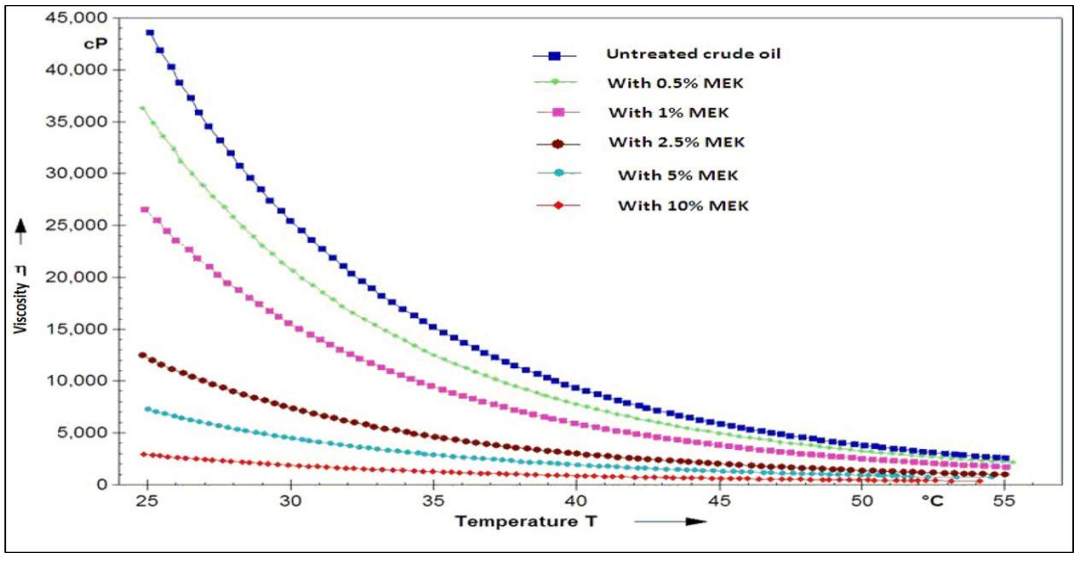
3.6 Effect of different concentration of Methyl ethyl ketone (MEK) on the viscosity of crude oil

The viscosity of the doses at the temperature ranges from 55°C - 25°C are shown in Table-3. Treatment of neat crude oil with 0.5% MEK reduced the viscosity of crude oil by 18.1% at 30°C and 19.4% at 25°C. 1% MEK resulted in 39.2% reduction in viscosity at 30°C and that of 40.4% at 25°C. 2.5% MEK reduced the viscosity by 71% at 30°C and 72.3% at 25°C and on increasing the concentration of MEK to 5% MEK, viscosity reduction was achieved by 82.2% at 30°C and 83.5% at 25°C. 10% of MEK resulted in viscosity reduction by 92.6% at 30°C and 93.4% at 25°C (Table-4, Fig.2). Viscosity of untreated crude oil and with different concentrations of MEK at temperature ranges from 55°C-25°C are given in Table-4 and depicted in Figure.2.

Table-4: Effect of different concentration of Methyl ethyl ketone on the viscosity of Lanwa#AB crude oil at different temperatures

Sl. No.	Chemical Dosing	Viscosity (cP) at $50s^{-1}$ shear rate						
		55°C	50°C	45°C	40°C	35°C	30°C	25°C
1	Untreated crude oil	2550	3847	5880	9340	15200	25400	44050
2	0.5% Methyl ethyl ketone	2210	3260	4960	7760	12500	20800	35500
3	1% Methyl ethyl ketone	1720	2540	3800	5900	9430	15450	26250
4	2.5% Methyl ethyl ketone	1480	2140	1988	4870	4648	7407	12200
5	5% Methyl ethyl ketone	713	933	1300	1905	2880	4523	7260
6	10% Methyl ethyl ketone	382	468	626	881	1280	1873	2913

Fig.2: Effect of different concentration of Methyl ethyl ketone on the viscosity of Lanwa#AB crude oil at different temperatures



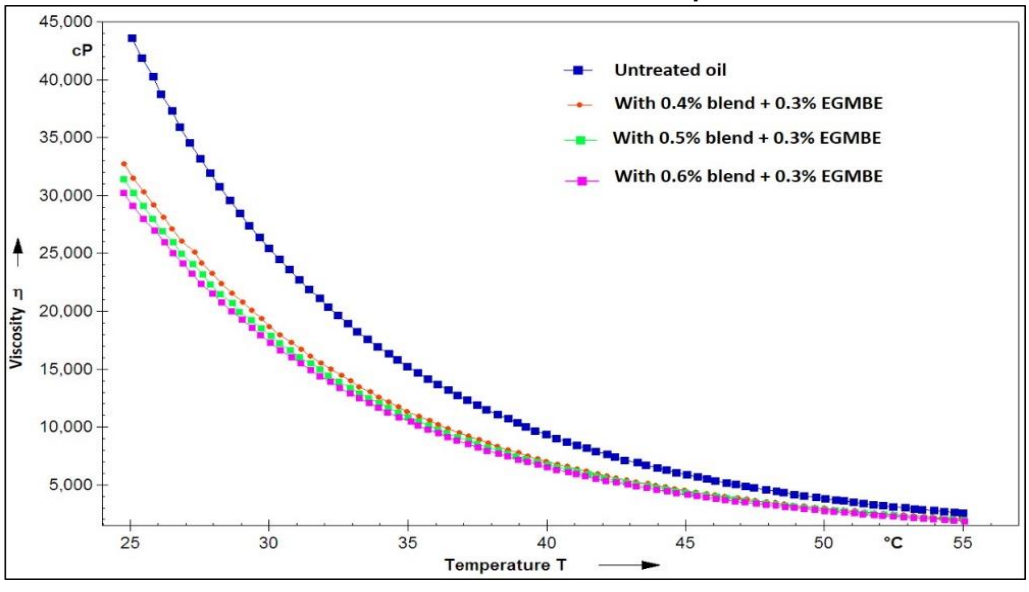
3.7 Effect of blend of MEK and MTO with EGMBE at lower concentrations on the viscosity of crude oil:

Blend of MEK and MTO was prepared at 1:1 ratio and used at concentrations of 0.4-0.6% with EGMBE (0.2-0.3%) to observe their effect on viscosity of Lanwa#AB crude oil. 0.4% blend with 0.2% EGMBE reduced the viscosity by 22.4% at 30°C and 24.2% at 25°C. 0.4% blend with increased concentration of EGMBE of 0.3% resulted in viscosity reduction of 26.8% at 25°C. Further, 0.5% blend with 0.2% of EGMBE decreased the viscosity by 29.3% at 25°C and that of by 33.1% at 25°C with 0.3% EGMBE. 0.6% blend with 0.2% of EGMBE reduced the viscosity by 29.8% at 25°C and by increasing the concentration of EGMBE to 0.3% the viscosity was reduced by 33.1% at 25°C. Viscosity of untreated crude oil and with different concentrations of blend & EGMBE at temperature ranges 55°C-25°C are given in Table-5. Effect of 0.4%-0.6% blend with 0.3% EGMBE on the viscosity of Lanwa#AB crude oil is represented in Figure.3.

Table-5: Effect of blend of MEK and MTO with EGMBE on the viscosity of Lanwa#AB crude oil at different temperatures

Sl. No.	Chemical Dosing	Viscosity (cP) at $50s^{-1}$ shear rate						
		55°C	50°C	45°C	40°C	35°C	30°C	25°C
1	Neat oil	2550	3847	5880	9340	15200	25400	44050
2	0.4% Blend+ 0.2% EGMBE	2100	3100	4680	7350	11900	19700	33400
3	0.4% Blend+ 0.3% EGMBE	2010	2960	4490	7020	11300	18600	32700
4	0.5% Blend+ 0.2% EGMBE	1967	2900	4397	6845	11000	18200	31100
5	0.5% Blend+ 0.3% EGMBE	1950	2870	4340	6760	10800	18050	30600
6	0.6% Blend+ 0.2% EGMBE	1960	2880	4350	6800	10900	18175	30900
7	0.6% Blend+ 0.3% EGMBE	1893	2760	4210	6530	10575	17300	29467

Fig.3: Effect of different concentration of blend of MEK and MTO on the viscosity of Lanwa#AB crude oil at different temperatures



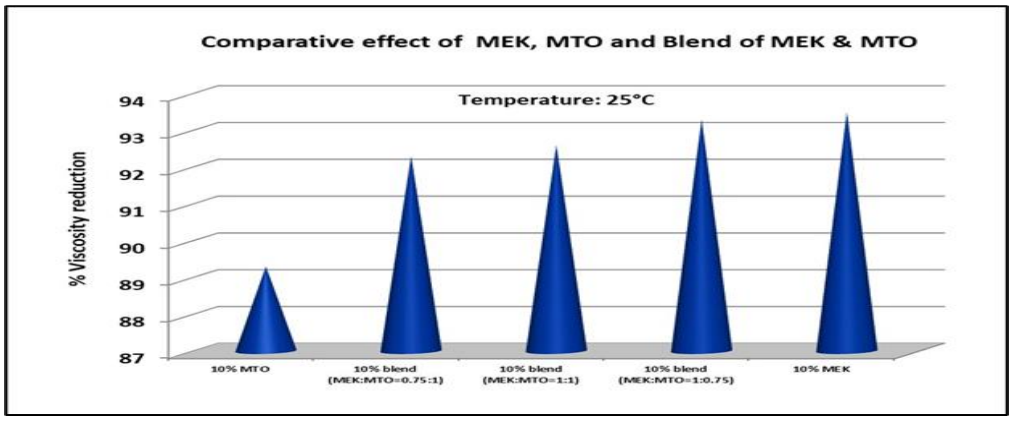
3.8 Comparative effect of MEK, MTO and Blend of MEK & MTO on viscosity reduction of crude oil at 25°C

MEK, MTO and their blend at different ratios are evaluated at 10% concentration to see their comparative effect on the viscosity of Lanwa#AB crude oil at 25°C. 10% MTO reduce viscosity of the crude oil by 89.3% at 25°C. 10% concentration of blend at 1:1 ratio of MEK and MTO has shown 92.6% viscosity reduction. 10% blend at 0.75:1 ratio of MEK & MTO reduces viscosity by 92.3% and that of by 93.3% when MEK & MTO is used at 1:0.75 ratio. 10% MEK has resulted in 93.4% reduction in viscosity at 25°C. The results indicate that viscosity reduction percentage increases with increase in MEK concentration which can be attributed to its polar nature. Viscosity measurement results are given in Table-6 and illustrated by Fig.4.

Table-6: Effect of MEK, MTO and Blend of MEK & MTO on viscosity of crude oil of Lanwa#AB at 25°C

Sl. No.	Chemical Dosing	Viscosity (cP) at $50s^{-1}$ shear rate
		25°C
1	Untreated crude oil	44050
2	10% MTO	4685
3	10% Blend (MEK:MTO=0.75:1)	3380
4	10% Blend (MEK:MTO=1:1)	3230
5	10% Blend (MEK:MTO=1:0.75)	2993
6	10% MEK	2913

Fig.4: Comparative effect of MEK, MTO and Blend of MEK & MTO on viscosity reduction of crude oil of Lanwa#AB at 25°C



4. Conclusions

Crude oil of Lanwa#AB is heavy in nature with an API gravity of 13.72°API. It is highly viscous having viscosity of 44050 cP at 25°C. Its high viscosity and poor fluidity is mainly because of its high resin content (22.9 wt%) which gives it a sticky appearance. MEK, MTO and their blend give promising result in reducing the viscosity of heavy crude oil. It is obvious that greater viscosity reduction is achieved with increasing concentration of the solvents. Effect of MEK is found to be better than MTO at similar concentrations in reducing the viscosity of resinous heavy crude oil. Similarly, higher percentage of viscosity reduction is achieved with blend of MEK & MTO when ratio of MEK is on higher side. Polarity of MEK and its ability to form hydrogen bonding with asphaltene/resin molecules play essential role of breaking down the heavy molecule agglomerates and achieve greater viscosity reduction.

Acknowledgement

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Abundance-Biomass Comparison: A Simple Diagnostic Tool Used to Assess Marine Health of Arabian Sea around the Western Offshore Installations of ONGC in the year 2023

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The ONGC Institute of Petroleum Safety, Health and Environment Management (IPSHEM)

Abstract

Health of the marine ecosystem can be effectively monitored by studying the benthic fauna. They play a very important role in energy transfer from primary producers to higher trophic levels in the food chain, and are extremely sensitive to even slight disturbances in their habitat. Applying the evolutionary theory of r & k- selected species, this paper studies their Biomass & Abundance and compares the two (ABC Analysis), for regions around ONGC's western offshore installations, for the year 2023, in order to gauge the marine health and plausible effects of ONGC's E&P operations on the same.

Results indicate an overall healthy marine ecosystem, reinstating ONGC's commitment to sustainable growth and environmental preservation. This paper is aimed to generate a valuable data bank, which can open doors to further modelling and environmental co-relation as well as temporal studies in the Western Offshore Region.

Keywords: ABC curve, Macro benthos, W-statistic, marine ecosystem

Introduction

Abundance Biomass Comparison (ABC) is a graphical approach to compare, as the name suggest, the abundance and biomass of macro-benthic organisms in order to predict the environmental stress level of the marine ecosystem.

The concept behind this approach can be understood through the classic evolutionary r & k- selection theory. k-selected species are slow growing, large and late maturing whereas the r-selection species are fast growing, small and opportunistic. When the marine ecosystem is healthy, i.e. undisturbed, k-selected species dominate. Thus the biomass curve lies above the abundance curve, and hence the difference between the two (or the area between the two), given by W-statistic, is positive. As the environmental stress increases, the healthy state of the marine ecosystem is disturbed, and the slow growing k-species cannot keep up. The opportunistic r-species hijack and dominate the ecosystem, resulting in the abundance curve overtaking the biomass curve. As a result the W statistic becomes negative.

The ABC method also accounts for the number of species being analysed. Hence this method requires solely the correct data set for a particular area, at a particular time, to generate the W-statistic and diagnose the marine health, eliminating the need for any spatial or temporal control for comparison.

This paper aims to compare abundance and biomass data around the ONGC installations in the Arabian Sea in the year 2023

Study Area

The study area comprised of the below tabulated 21 installations of ONGC in the Western Offshore (Arabian Sea) region and is as given in the table below (**Table 1**)

Table 1: List of ONGC Installations around which sampling was done for the study

Sl. No.	Platform/Rig
1	R-12A (Ratnagiri)
2	HRA (Heera)
3	B-134A
4	NLM (Neelam)
5	B-173A
6	BPA Process Complex (BLQ-2)
7	BPA Process Complex (BLQ-1)
8	Panna Processing Facilities (PPF)
9	B-193
10	WO-16
11	NBP Field
12	B-192-5
13	ICP
14	SHP
15	BHS
16	SCA
17	NQ
18	NA
19	B-48
20	TPP-TCPP
21	B-127

Figure 1: Map showing ONGC Installations around which sampling was done for the study

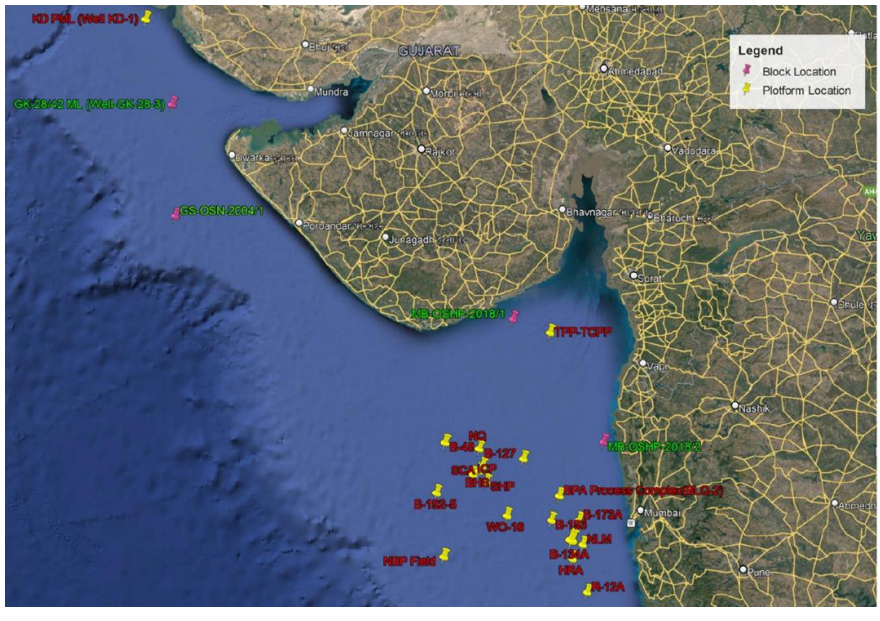
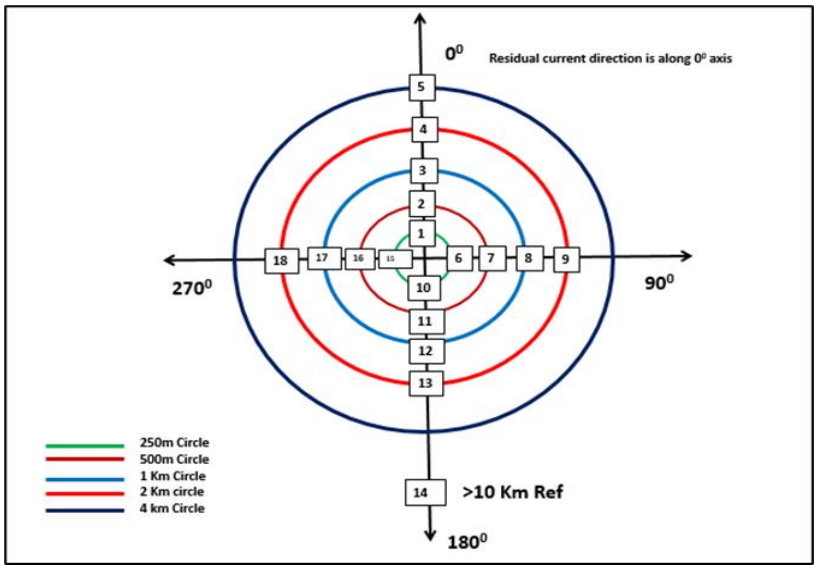


Figure 2: OSPAR Sampling Strategy



Sample Collection & Analysis

Sampling was carried out during the post monsoon season (26th March to 14th April 2023) using the sampling vessel *NP Enakshi*.

The macro-benthos sample around each installation was collected following the OSPAR sampling strategy i.e. samples were collected at stations scattered in circles of 250m, 500m, 1000m, 2000m and 4000m surrounding each installation. Reference samples were collected beyond 10 kms from the installations.

Sample collection was done using a Van Veen Grab (0.1 m^2). After taking samples for sediments and meiobenthic analysis from the grab, the rest was sieved through 0.5mm mesh. All the organisms retained were preserved in 5% neutralized formalin mixed with Rose Bengal Stain for subsequent identification. The Macro Benthic productivity was identified with the help of a trinocular dissecting microscope with a magnification of 20x & 40x; fitted with a camera to take photographs for reference.

The ABC was performed on the macro benthic fauna collected from the sampling sites. Seven species of Polychaetes namely, Nepthys sp., Phyllodace sp., Sigambra sp., Paraprionospio sp., Nereis sp., Diopatra sp. & Eunice sp., and three species of gastropods namely Ampelisca sp., Strombus sp. & Murex sp. were recorded during the study period (Some shown in **Figure 3**). Based on principal component analysis, Ampelisca sp., Strombus sp. and Murex sp. were identified as characteristic gastropod species that could be used to classify study sites in the rehabilitated and non-rehabilitated areas of this tropical offshore region in the post monsoon season.

Macro fauna were separated and segregated to major groups and quantified as number in an area of 1 m^2. Biomass (wet weight) was measured by blotting the sample on a blotting paper and weight was taken by direct weighing on balance. The biomass was calculated in g/m^2.

The mean density of different macro-benthic species around each installation (no/m^2) or abundance and total biomass (g/m^2) were tabulated and fed into Primer version 6, a software made for statistical analysis for ecological study. After running the software as "cumulative dominance curve", the ABC curve of the installation was generated with "cumulative dominance %" in y-axis and "species rank" in x-axis. The difference between the two curves is given by the W-statistic, which represents the area between them.

Figure 3: Microscopic Images of Macro Fauna in the Sediment Samples

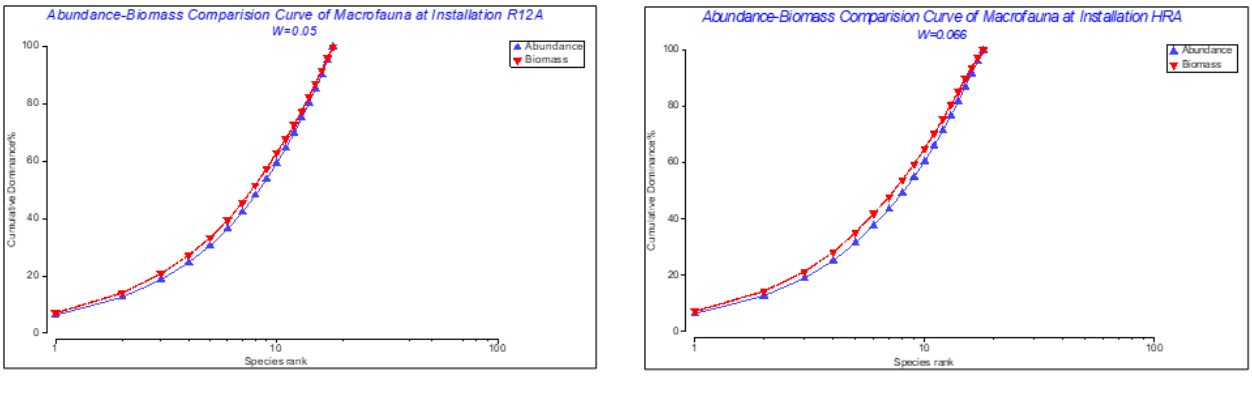
Results & Discussion

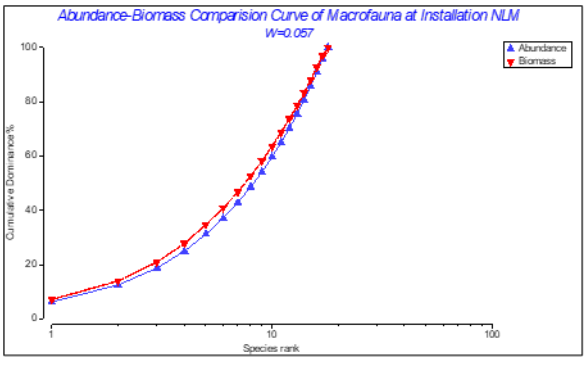
The ABC curves generated from the software is given below (Figure 4), for all the 21 installations taken up for the study.

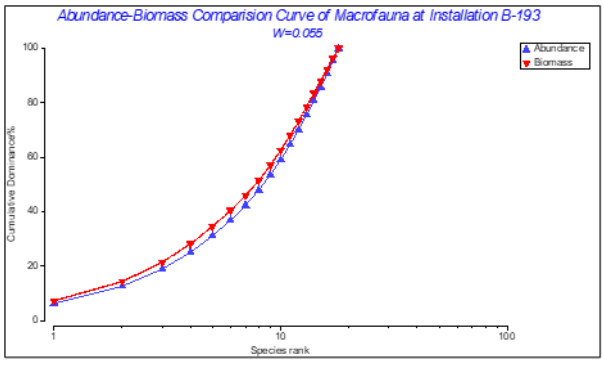
The W-statistic has been tabulated in **Table 2**.

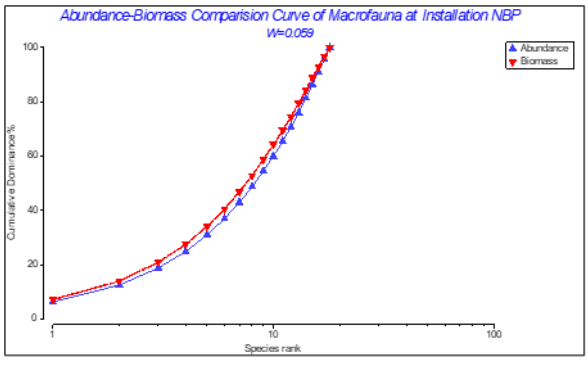
(*The data fed into the software (abundance and biomass) is available in Table 3, as supplementary Annexure*)

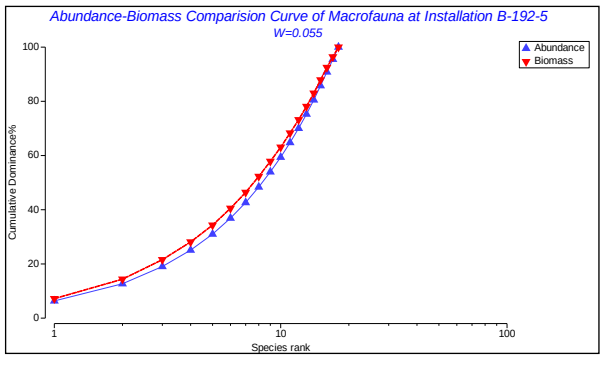
Figure 4: ABC Curves of the studied installations




Abundance-Biomass Comparision Curve of Macrofauna at Installation NLM
W=0.057
Abundance
Biomass
Cumulative Dominance%
Species rank


Abundance-Biomass Comparision Curve of Macrofauna at Installation B-193
W=0.055
Abundance
Biomass
Cumulative Dominance%
Species rank


Abundance-Biomass Comparision Curve of Macrofauna at Installation NBP
W=0.059
Abundance
Biomass
Cumulative Dominance%
Species rank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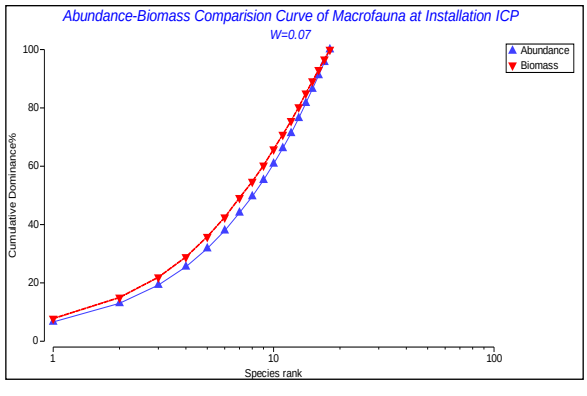
Abundance
Biomass
Cumulative Dominance%
Species rank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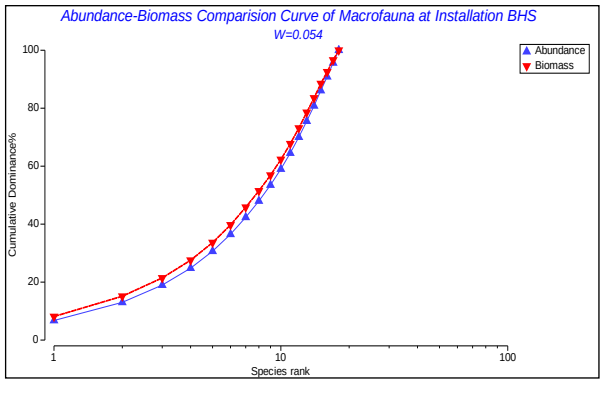
W=0.07
Abundance
Biomass
Cumulative Dominance%
Species rank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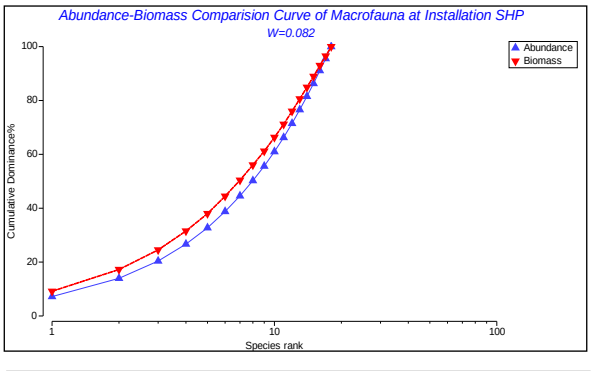
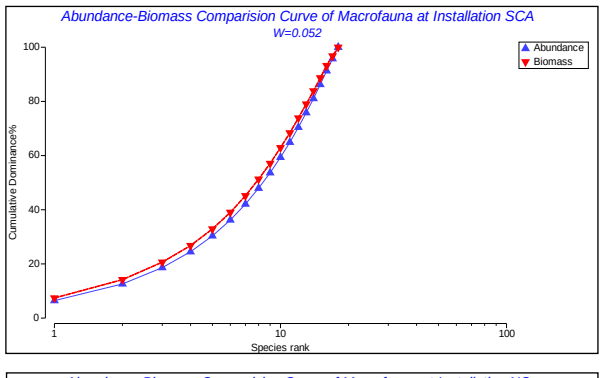
Abundance
Biomass
Cumulative Dominance%
Species rank


Abundance-Biomass Comparision Curve of Macrofauna at Installation SHP
W=0.082
Abundance
Biomass
Cumulative Dominance%
Species rank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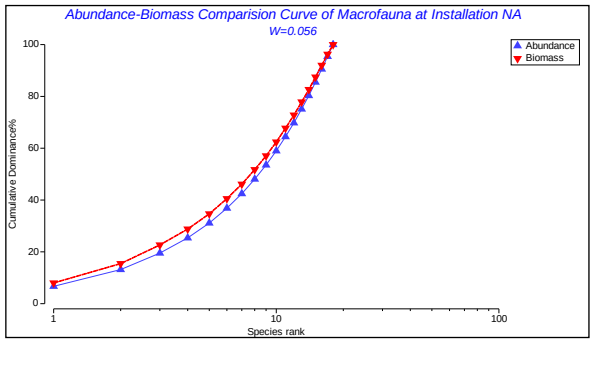
Abundance
Biomass
Cumulative Dominance%
Species rank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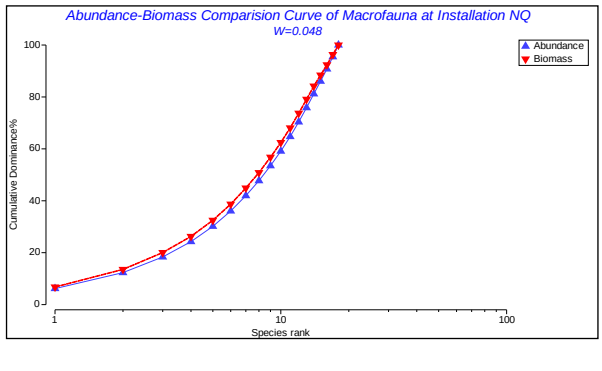
Abundance
Biomass
Cumulative Dominance%
Species rank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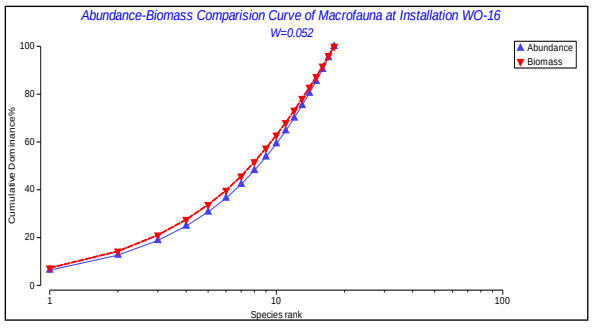
Abundance
Biomass
Cumulative Dominance%
Species rank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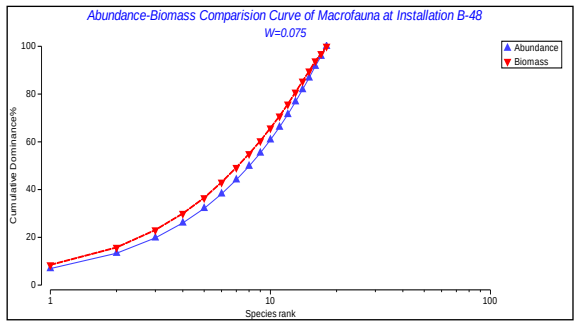
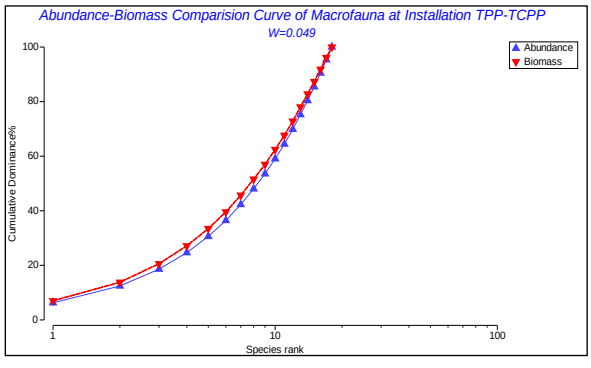
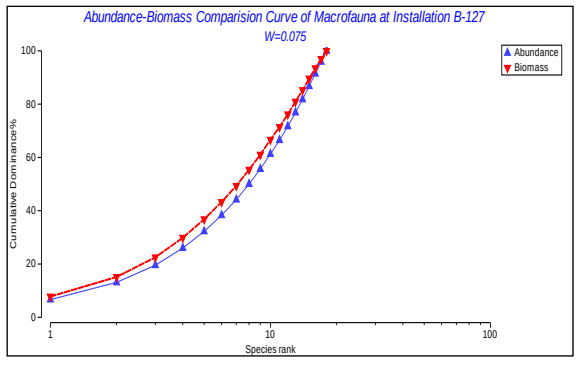
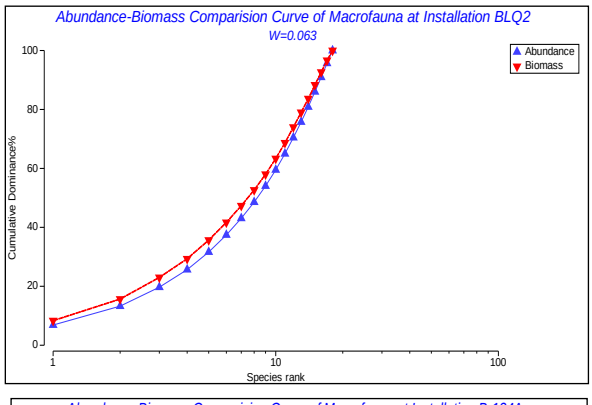
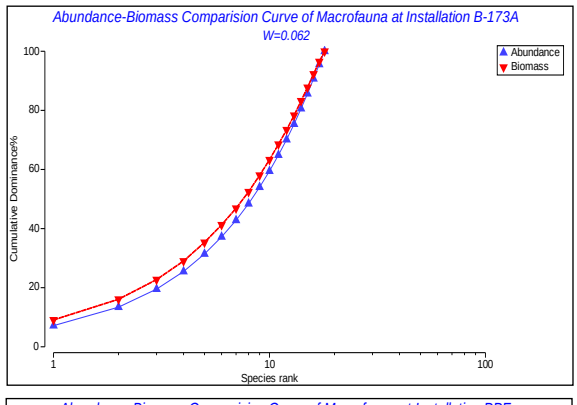
W=0.052
Abundance
Biomass
Cumulative Dominance%
Species rank

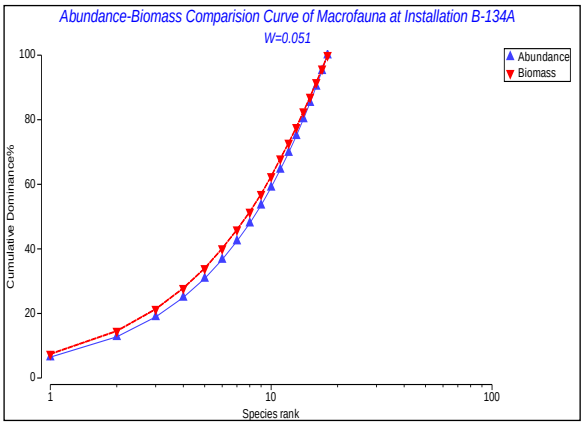

Abundance-Biomass Comparision Curve of Macrofauna at Installation B-48
W=0.075
Abundance
Biomass
Cumulative Dominance%
Species rank

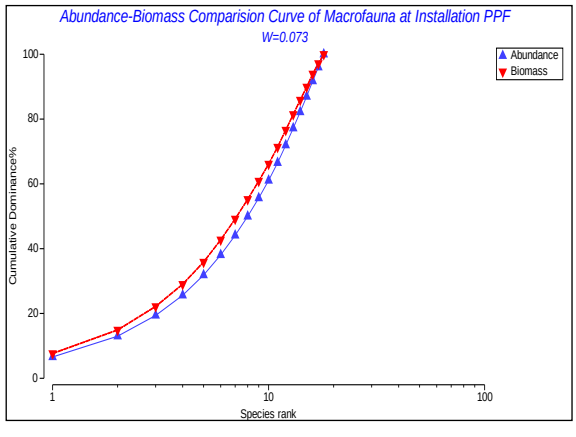

Abundance-Biomass Comparision Curve of Macrofauna at Installation TPP-TCPP
W=0.049
Abundance
Biomass
Cumulative Dominance%
Species rank


Abundance-Biomass Comparision Curve of Macrofauna at Installation B-127
W=0.075
Abundance
Biomass
Cumulative Dominance%
Species rank


Abundance-Biomass Comparision Curve of Macrofauna at Installation BLQ2
W=0.063
Abundance
Biomass
Cumulative Dominance%
Species rank


Abundance-Biomass Comparision Curve of Macrofauna at Installation B-173A
W=0.062
Abundance
Biomass
Cumulative Dominance%
Species rank


Abundance-Biomass Comparision Curve of Macrofauna at Installation B-134A
W=0.051
Abundance
Biomass
Cumulative Dominance%
Species rank


Abundance-Biomass Comparision Curve of Macrofauna at Installation PPF
W=0.073
Abundance
Biomass
Cumulative Dominance%
Species rank

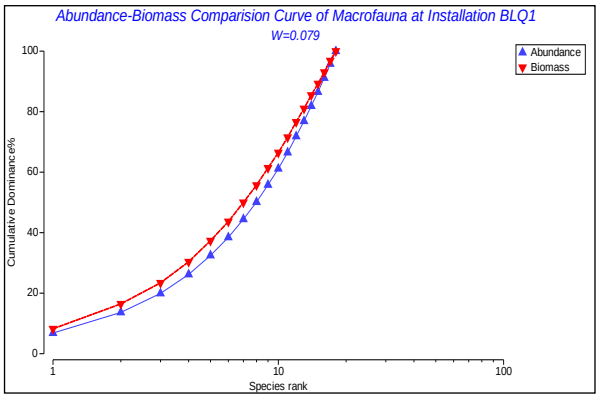

Abundance-Biomass Comparision Curve of Macrofauna at Installation BLQ1
W=0.079
Abundance
Biomass
Cumulative Dominance%
Species rank

Table 2: W-statistic data of the studied installations

Sr. No.	Platform	W-Statistic
1	R-12A (Ratnagiri)	0.050
2	HRA (Heera)	0.066
3	B-134A	0.051
4	NLM (Neelam)	0.057
5	B-173A	0.062
6	BPA Process Complex (BLQ-2)	0.063
7	BPA Process Complex (BLQ-1)	0.079
8	Panna Processing Facilities (PPF)	0.073
9	B-193	0.055
10	WO-16	0.052
11	NBP Field	0.059
12	B-192-5	0.055
13	ICP	0.070
14	SHP	0.082
15	BHS	0.054
16	SCA	0.052
17	NQ	0.048
18	NA	0.056
19	B-48	0.075
20	TPP-TCPP	0.049
21	B-127	0.075

Conclusion

The study period is post monsoon season (26th March to 14th April 2023)

The cumulative percentage dominance of biomass is located above the abundance throughout the period.

The W-statistic values are positive, indicating the predominance of k-selected species (slow growing large species). The W value in ABC curve analysis of macro benthic species ranges from 0.048 to 0.082. This reflects an overall healthy marine ecosystem in the study area.

The present study has aided to generate a valuable data bank, which can open doors to further modelling and environmental co-relation studies in the Western Offshore Region.

Acknowledgement

This research was a part of the ONGC project titled "***Environment Monitoring around ONGC Installations in Western Offshore Area of Mumbai High and Kutch-Saurashtra Region, 2022-23***" carried out by IPSHEM, ONGC and Vimta Labs Ltd., Hyderabad. Author is grateful to all members of Environment Team of IPSHEM and Vimta Labs Ltd., Hyderabad for successful and timely completion of the above mentioned research project. Author also acknowledges the encouragement provided by Shri Sanjeev Singhal, Head- IPSHEM for preparation of the manuscript.

Views expressed in the study are of the authors alone. Authors declare no conflict of interests.

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Table 3: Supplementary Data of Biomass and Abundance of Macro-Benthos around the Various Installations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
R-12-A	200	140	200	160	190	160	200	230	150	160	230	160	220	180	150	200	130	210
	4.71	3.94	4.71	4.22	4.59	4.22	4.71	5.06	4.08	4.22	5.06	4.22	4.94	4.47	4.08	4.71	3.80	4.83
HRA	240	200	220	150	300	260	240	310	310	170	230	300	290	120	220	300	260	200
	5.16	4.71	4.94	4.08	5.77	5.37	5.16	5.87	5.87	4.35	5.06	5.77	5.68	3.65	4.94	5.77	5.37	4.71
NLM	280	190	280	200	130	240	210	200	250	190	170	190	240	280	220	220	290	280
	4.18	3.45	4.18	3.54	2.85	3.87	3.62	3.54	3.95	3.45	3.26	3.45	3.87	4.18	3.71	3.71	4.26	4.18
B-193	170	180	220	130	240	150	170	180	180	180	180	230	160	120	230	190	210	140
	3.26	3.35	3.71	2.85	3.87	3.06	3.26	3.35	3.35	3.35	3.35	3.79	3.16	2.74	3.79	3.45	3.62	2.96
NBP Field	230	210	270	220	290	250	190	140	290	250	210	170	160	270	300	280	280	210
	3.79	3.62	4.11	3.71	4.26	3.95	3.45	2.96	4.26	3.95	3.62	3.26	3.16	4.11	4.33	4.18	4.18	3.62
B-192-5	140	220	120	160	220	160	220	150	180	150	110	200	150	180	190	170	190	150
	2.96	3.71	2.74	3.16	3.71	3.16	3.71	3.06	3.35	3.06	2.62	3.54	3.06	3.35	3.45	3.26	3.45	3.06
ICP	250	200	140	200	170	130	250	170	280	240	250	240	150	170	120	180	200	260
	3.95	3.54	2.96	3.54	3.26	2.85	3.95	3.26	4.18	3.87	3.95	3.87	3.06	3.26	2.74	3.35	3.54	4.03
BHS	150	250	360	180	180	270	220	240	240	240	310	240	270	270	280	220	240	270
	3.06	3.95	4.74	3.35	3.35	4.11	3.71	3.87	3.87	3.87	4.40	3.87	4.11	4.11	4.18	3.71	3.87	4.11
SHP	210	130	190	170	150	180	240	220	180	340	150	300	190	160	130	260	240	270
	3.62	2.85	3.45	3.26	3.06	3.35	3.87	3.71	3.35	4.61	3.06	4.33	3.45	3.16	2.85	4.03	3.87	4.11
SCA	180	190	170	110	200	230	100	190	150	190	190	210	160	150	180	190	140	170
	3.35	3.45	3.26	2.62	3.54	3.79	2.50	3.45	3.06	3.45	3.45	3.62	3.16	3.06	3.35	3.45	2.96	3.26
NA	180	230	190	200	220	180	280	300	200	200	190	220	160	210	270	170	210	140
	3.35	3.79	3.45	3.54	3.71	3.35	4.18	4.33	3.54	3.54	3.45	3.71	3.16	3.62	4.11	3.26	3.62	2.96
NQ	230	140	210	210	220	240	130	180	220	150	220	190	140	200	200	200	220	240
	3.79	2.96	3.62	3.62	3.71	3.87	2.85	3.35	3.71	3.06	3.71	3.45	2.96	3.54	3.54	3.54	3.71	3.87
PPF	130	130	160	180	80	110	70	120	180	100	100	170	170	140	190	130	150	170
	3.80	3.80	4.22	4.47	2.98	3.50	2.79	3.65	4.47	3.33	3.33	4.35	4.35	3.94	4.59	3.80	4.08	4.35
WO-16	190	230	170	180	220	280	200	200	260	270	250	210	150	170	240	170	230	230
	3.45	3.79	3.26	3.35	3.71	4.18	3.54	3.54	4.03	4.11	3.95	3.62	3.06	3.26	3.87	3.26	3.79	3.79
B-48	160	170	130	130	80	110	190	110	80	150	120	180	140	220	170	130	190	140
	4.22	4.35	3.80	3.80	2.98	3.50	4.59	3.50	2.98	4.08	3.65	4.47	3.94	4.94	4.35	3.80	4.59	3.94
TPP-TCPP	-	-	240	200	-	-	240	190	-	-	210	260	-	-	290	270	280	230
	-	-	3.87	3.54	-	-	3.87	3.45	-	-	3.62	4.03	-	-	4.26	4.11	4.18	3.79
B 127	110	110	130	70	140	160	90	110	130	100	140	80	180	170	100	150	170	170
	3.50	3.50	3.80	2.79	3.94	4.22	3.16	3.50	3.80	3.33	3.94	2.98	4.47	4.35	3.33	4.08	4.35	4.35
BPA (BLQ-2)	190	170	120	220	160	250	150	100	140	160	140	180	190	130	160	160	160	220
	4.59	4.35	3.65	4.94	4.22	5.27	4.08	3.33	3.94	4.22	3.94	4.47	4.59	3.80	4.22	4.22	4.22	4.94
BLQ-1	110	80	60	110	90	130	70	50	80	80	60	90	110	60	100	100	70	130
	3.50	2.98	2.58	3.50	3.16	3.80	2.79	2.36	2.98	2.98	2.58	3.16	3.50	2.58	3.33	3.33	2.79	3.80
B-173A	130	120	150	180	160	160	140	100	170	140	130	260	140	190	150	180	160	200
	3.80	3.65	4.08	4.47	4.22	4.22	3.94	3.33	4.35	3.94	3.80	5.37	3.94	4.59	4.08	4.47	4.22	4.71
B-134A	140	220	190	130	170	180	170	140	190	130	150	230	150	210	170	150	200	170
	3.94	4.94	4.59	3.80	4.35	4.47	4.35	3.94	4.59	3.80	4.08	5.06	4.08	4.83	4.35	4.08	4.71	4.35

Biomass (g/m^2) | Abundance (no/m^2)

Evolution of SCADA Systems for Safe & Secure Operation of Critical Cross-Country Pipeline Network

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Introduction

The use of hydrocarbons for meeting the energy requirements has revolutionized the industry. Hydrocarbons are very important for the modern economy and are responsible for more than 80% of global energy consumption. Although they are highly combustible and explosive, however if handled properly, they provide instantaneous high source of energy. During the initial days, the handling of hydrocarbons was a challenge, however with evolving technologies over time, they are used in a very safe and efficient manner.

Transportation of hydrocarbon is done through various modes i.e. by road, railways, ships etc. There is always a high chance of disruption in supply of hydrocarbons due to floods, strike, lockdowns etc. Also, transportation of hydrocarbons over large geographical distances involves time delays and high cost. To overcome the challenges of supply-chain, pipeline transmission of hydrocarbons is a very safe and efficient mode of transmission.

Considering the advantages of hydrocarbon transmission through pipelines, every country has invested heavily in creating pipeline infrastructure. Countries are in the process of creating a grid (international and national) of interconnected pipeline network for ensuring continuous energy supply, which is independent of natural calamities, war, strikes etc.

Since the pipeline networks are spreading across different geographical locations, it is essential to monitor the status of pipeline to maintain its integrity. Supervisory Control and Data Acquisition (SCADA) system is a software tool used by pipeline operators to have the real time status of the pipeline hydraulics. In the emergency situations, it is used to the control the pipelines by isolation of affected section or starting / stopping of compressors / pumps.

Evolution of SCADA systems

Traditionally the SCADA systems used to be standalone system within a plant or a localized geographical area. Data transmission was done over very low bandwidth of 1.2-9.6 kbps over copper cables. The systems had basic features of real time monitoring, control, alarming and trending. Standardization of communication was not available and proprietary protocols were used for data exchange.

The original approach in SCADA system was to have distributed architecture meaning heterogeneous SCADA systems in different pipeline networks as the pipelines in different geographical areas were laid in different time period. The advantage of such architecture was that the systems used to work independently and disruptions in one system did not affect other systems. However, consolidated data availability at central location, scalability and dedicated resources which could not be utilized in other pipeline networks were the key challenges.

With the technological advancements and spread of systems over widely spread geographical locations, the size of the SCADA system has grown. The approach of unified centralized system on top of regional SCADA components is now being adopted. Using this, data of entire pipeline is available everywhere based on authorizations. The centralized SCADA architecture is highly scalable, has a unified interface with other business applications and centralized administration resulting in efficient

pipeline operations. New SCADA systems have become very advanced with powerful Graphical User Interface (GUI), web connectivity, email and SMS alerts, alarm management, machine learning and big data analysis. Standard protocols have taken the place of proprietary ones which are no longer preferred.

Importance of SCADA system

The gas pipelines are used for transportation of natural gas over hundreds of kilometres. As the monitoring and control of pipelines manually is practically impossible, it is done through SCADA system. In the event of any pipeline leakage / rupture, the affected section is isolated through SCADA system to contain the spread of possible fire. Considering the criticality of the SCADA system for pipeline operations, it has been made mandatory by Governments to have SCADA system in all pipelines.

Controls during emergency situations

In the event of emergency situations in pipeline due to gas leakage, fire, sudden pressure drops etc, quick decision and action is to be taken to isolate the effected section and maintain the pipeline hydraulics. This is achieved through SCADA system which has the facility to operate valves, compressors remotely. Usually, the control based on logic is not implemented in SCADA system and decision is taken by the user based on pipeline hydraulics and pipeline integrity.

Pipeline integrity

The pipelines carry liquid and natural gas at very high pressure. Often these pipelines pass through densely populated areas where the risk to public increases in case of any leakage / rapture. To ensure pipeline safety, it is very important to maintain the pipeline integrity. For this, health of pipeline against corrosion and metal losses needs to monitored continuously. The gas transported through pipelines may contain H2S and moisture which corrode the pipeline internally over a significant time duration. Similarly, the pipeline may get corroded from outside due to coating loss, high voltage electrical lines and other factors. To mitigate these challenges to the pipeline integrity, gas quality at source and cathodic protection status is monitored through SCADA system. Any abnormality in the parameters is flagged to the pipeline operators through alarms for taking corrective action.

Fire System monitoring

Gas pipelines are buried at a certain depth for safety. However, part of pipeline is aboveground at maintenance and receiving terminals for routine maintenance and gas metering. To check for any leakage of gas into the surrounding area and atmosphere, gas detectors are used. Further, at such stations, firefighting systems are installed to prevent and control any fire. The health of these systems is also monitored through SCADA system at central control room to ensure proper functioning in case of any emergency.

Automated gas measurement and invoicing

The process of gas measurement and invoicing which was done manually a decade ago are now-a-days automated through SCADA system. The gas consumption for the day gets locked in SCADA system as per the contractual terms and passed on to the organization ERP systems for invoicing as per schedule. The transformation from manual to automated invoicing has led to time-bound invoicing, transparency and prevention against frauds.

Leak detection, forecasting and big data analysis

SCADA system in combination with application software is provides as software based leak detection tool to the pipeline operators. The profile of pressure, flow and temperature is created in the system and continuously checked with the actual field values at measured locations. Sudden changes in pressure or deviations crossing threshold values are triggered as probable leak alerts with leak size and leak location.

Huge volume of historical data of pipeline profile is available in SCADA system. With the advancement of machine learning and big data analysis, it is now a days possible to forecast the gas demand on daily or fortnightly basis. New SCADA systems are have in-built capacity for big data analysis or the historical data is also provided to analytical tools for processing and forecasting.

Management dashboards for decision making

The key performance indicators of the overall pipeline network is extended to the organization's management through SCADA over internet and mobile applications. Availability of real time data of gas at source, total gas available in pipeline network, gas price, status of compressors, and pumps and forecasted demand are very helpful to the management in taking business decisions.

IoT-based SCADA system

The future Internet is considered as another game-changing idea for traditional SCADA frameworks. The current SCADA frameworks use a combination of characteristics of traditional and modern SCADA features, due to which their security is in greater danger. Expansion of city gas distribution business has opened scope of IoT based SCADA system. In the CGD networks, the pipeline pass through densely populated areas. Considering the economic

viability, provision of dedicated space and communication infrastructure in CGD is not possible. In such scenarios, IoT based SCADA system is the new normal. The IoT devices communicate with the main SCADA servers over Internet / Wi-Fi using very less bandwidth. However, these types of SCADA systems are very prone to cyber security threats and considerations of cyber-security needs to be taken in the SCADA architecture since conceptualization.

Conclusion

SCADA systems have evolved from a standalone system into sophisticated, complex open systems based on advanced technology systems connected to the Internet. SCADA systems are composed of hardware as well as software components, i.e., RTUs, HMI, historian etc. These components communicate with each other using wired and wireless industrial communication protocols. The modern communication protocols enable remote monitoring and controlling over geographically distributed SCADA systems in a cost-effective manner. With the ever evolving threat landscape related to SCADA systems, all the stakeholders are needed to stay vigilant in ensuing safety of their systems.

Digital Transformation in Telecommunication Technologies for Efficient and Reliable Operation of gas pipeline infrastructure: A Journey

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Gas Pipeline infrastructure is an economical and safe mode of transporting the gas (Natural Gas or Liquified Petroleum Gas) by connecting gas sources to gas consuming markets where Natural Gas (NG) is used for fertilizer production, power generation, petrochemicals, transportation, as well as for other energy requirement; the Liquid Petroleum Gas (LPG) is mainly used for fuel requirements. Considering the criticality for the uninterrupted availability of gas at required consuming markets, its transportation through pipeline is also required to be highly efficient and reliable. At the same time, these gas pipelines carry highly inflammable gas through various types of terrains of the country; hence, the reliability in operation of the gas pipeline infrastructure also includes utmost safety in its entire operation. The pipelines being the cross-country pipelines, the operation and control of the pipeline infrastructure are required to be carried out remotely.

The operation of gas pipeline infrastructure started in India during 1986-87. For the efficient and reliable remote operation of the gas pipeline infrastructure, a few systems were deployed along-with the pipeline infrastructure in the beginning:

- SCADA (Supervisory Control And Data Acquisition) system for real-time pipeline data acquisition and pipeline infrastructure control;
- Voice Communication system for communication with handful personnel deployed sparsely for the maintenance of the pipeline infrastructure.

The SCADA system of any gas pipeline mainly comprises of field unit like RTUs (Remote Terminal Units) and various Servers like FEP, Client Server, Remote Work Stations etc. The pipeline infrastructure communicates with SCADA through the RTUs (Remote Terminal Units) placed at pipeline stations; the RTUs are interfaced with pipeline instruments and the RTUs communicate with SCADA servers over telecom network along the gas pipeline.

Telecom services in gas pipeline network can be basically divided into two major segments: (a) telephones, wireline & wireless, and (b) Internet services. In addition, it also comprises of other smaller segments including radio paging services, VSATs, PMRTS and Global Mobile Personal Communication by Satellite (GMPCS).

For the data/voice transmissions for SCADA/Voice Communication, Telecom systems were deployed as per the available technologies at that time. Later on, various other systems/facilities, like: CCTV, PIDS, ERP/SAP, Video Conferencing etc, are also introduced to make the operation of the gas pipeline infrastructure more efficient, reliable and safe.

Telecommunication network in gas pipeline network has transformed from very low bandwidth communication media i.e. wired line, VHF, UHF, Microwave and Satellite Communication (SCPC /MCPC & VSAT) using PDH/ TDM/PAMA & DAMA multiplexing technology to very high communication bandwidth based on OFC (Optical Fibre Cable) using SDH/MPLS-TP/DWDM/OTN/G-PON technologies.

PDH based UHF/Microwave Systems were used initially for backbone and SCPC & MCPC Satellite communications were as back up links. Initially, field data of operations were fed to backbone links through RTU using Omniplexers. With the introduction of OFC, more advanced PDH systems deployed enabling high speed data up to 32MBPS enabling monitoring & control operations like

ON/OFF CCVT, Valve OPEN/CLOSE, gas flow regulation, etc. These technologies have enabled many applications such as WAN (Wide Area Network), Internet, Email, Intranet, CCTV surveillance, Video Conferencing, Voice & SCADA for safety & reliable operation of industry assets.

As of now Gas pipeline network is using state of art NMS/OSS to manage its telecommunication network and Optical fibre network for centralised SCADA, SAP, CCTV System, EPABXs where transformation in communication services is seen starting from use of VHF Walkie-Talkie, Low bandwidth dial-up internet, e-mail servers, Video Conference, CCTV surveillance, ERP/SAP services, Microsoft Teams applications, real time monitoring, SCADA, PIDS. EPABXs has been transformed from analog to Digital/IP. Mainly, OFC is the backbone for SDH/DWDM/MPLS-TP Telecommunication Technology for Voice and Data application i.e. hotline communication, IT applications, CCTV Surveillance and remote monitoring. However, the underlying telecom technologies witnessed various transformation to the latest platform.

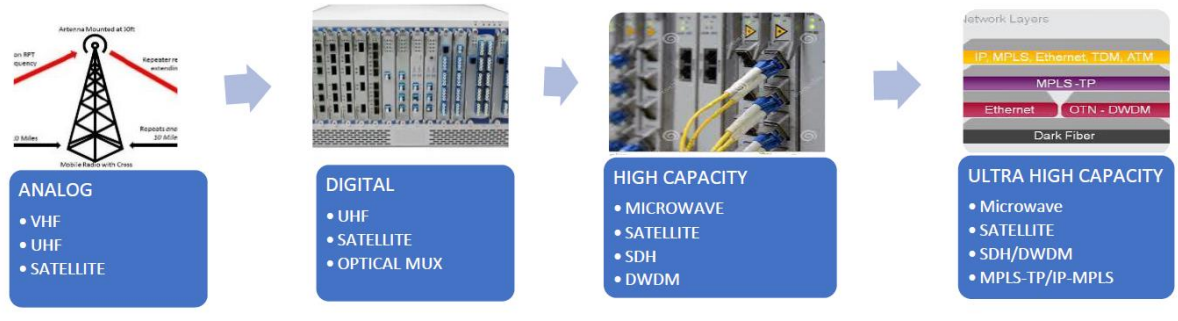

Fig. *Transition of Telecommunication Technologies in Oil & Gas Sector*

Digital transformation in Telecommunication technologies has enabled many applications for safe, secure & reliable operation of gas pipeline network as given below:

- Drone based aerial patrolling of pipelines which was earlier being done by Helicopters.
- RoU monitoring through real time Satellite imaging for immediate detection of encroachments/ exposures for safe & reliable operations.
- Integration of PIDS & Drone technology to immediately get the image/video of effected site.
- GPS monitored foot patrolling of pipelines.
- SAP based preventive maintenance modules.
- AI integrated CCTV systems to monitor remote sites for safety compliances.

As we look towards the future, we see a continued convergence of technologies and applications where Telecommunication network plays a major role. Here, with the recent evolution of 5G standards, the industry, in future, will have many significant opportunities to explore new initiatives in the industry's efforts to reduce CAPEX, OPEX and increase efficiency by deploying Long-Term Evolution (LTE) and 5G networks. Also, as more high-speed, reliable telecommunications are deployed, it will allow for increased remote monitoring and control as well as (with the IoT-generated information) to optimize equipment and assure worker safety to save the industry on maintenance expenses and obtain granular insight into their equipment and processes.

Abbreviations Used:

AI Artificial intelligence
BSS Business Support Systems
CCTV Closed Circuit Television
CCVT Closed Cycle Vapour Turbine
DAMA Demand Assigned Multiple Access
DWDM Dense wavelength division multiplexing
EPABX Electronic Private Automatic Branch Exchange
GMPCS Global Mobile Personal Communication by Satellite
G-PON Gigabit Passive Optical Network
GPS Global Positioning System
IP Internet Protocol
IP-MPLS Internet Protocol Multi-Protocol Label Switching
IoT Internet of Things
MCPC Multiple Channel Per Carrier
MPLS-TP Multiprotocol Label Switching-Transport Profile
NMS Network Management System
OSS Operations Support Systems
PAMA Permanently Assigned Multiple Access
PDH Plesiochronous Digital Hierarchy
PIDS Pipeline Intrusion Detection System
PMRTS Public Mobile Radio Trunking Service
SCADA Supervisory Control and Data Acquisition
SCPC Single Channel Per Carrier
SDH Synchronous Digital Hierarchy
VHF Very High Frequency
VSAT Very Small Aperture Terminal
UHF Ultra High Frequency

Interim Budget 2024 – An overview

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A. Backdrop

With the General Elections in the background, the Interim Budget 2024 (Finance Bill, 2024) was presented by the Hon'ble Finance Minister (FM) on 01 February 2024. The said Bill was enacted by the Parliament of India and received the President's assent on February 15, 2024. The full-fledged Budget is expected in June or July 2024 post the Government is elected for the next term.

The Hon'ble Indian Prime Minister Narendra Modi has quoted that the Interim Budget 2024 would offer a broad direction on the vision and policies of the Government.

The Interim Budget gave a brief outline of the Indian economy which has demonstrated resilience and maintained healthy macro-economic fundamentals, despite global economic challenges. The Interim Budget establishes a healthy balance of pursuing fiscal consolidation while not compromising on growth.

It was mentioned that next generation reforms will be guided by the principles of "Reform, Perform, and Transform" with the adoption of economic policies that foster and sustain growth, facilitate inclusive and sustainable development, improve productivity, create opportunities for all.

With the focus on strengthening the four pillars of 'Viksit Bharat' i.e. Women, Youth, Farmers and the Poor, policy measures have also been announced to promote research, innovation and green energy considering India's commitment to achieving 'net-zero' by 2070.

B. Key policy announcements for the Oil and Gas sector

In the Budget speech, the Hon'ble Finance Minister stated that the Government would work towards energy security in terms of availability, accessibility and affordability. Continuing with the objective to achieve net zero target by 2070 and the roadmap to energy transition and security laid down in the Budget 2023, the Hon'ble Finance Minister has provided following measures to achieve the aforesaid target:

- ***Mandatory blending of Compressed Bio Gas (CBG)***
  In line with National Policy on Biofuels, 2018, the Ministry of Petroleum and Natural Gas had launched Sustainable Alternative Towards Affordable Transportation (SATAT) initiative with the aim to establish an ecosystem for the production of CBG. In order to promote the production and consumption of CBG in the country, the Interim Budget proposed to mandate phase wise blending of CBG in compressed natural gas for transport and piped natural gas for domestic purposes.

- ***Procurement of biomass aggregation machinery***
  The Interim Budget proposes for financial assistance for procurement of biomass aggregation machinery to support collection of biomass. Post this announcement, the Government approved a Scheme[1] for providing financial assistance to CBG producers for procurement of biomass aggregation machinery to support collection of biomass with a total financial outlay of INR 564.75 crore for the period of FY 2023-24 to FY 2026-27.

- ***Coal gasification and liquefaction***
  In order to reduce the import of natural gas, methanol and ammonia, the Interim Budget provides for set up of coal gasification and liquefaction capacities of 100 MT by 2030. To promote setting up of gasification projects, the Government has approved the Scheme[2] with an outlay of INR 8,500 crores to incentivize potential investors, both domestic and overseas, to set up large scale coal gasification facilities with emphasis on maximum value addition and quality output and achieving pre-committed capacity level within a pre-defined time period along with development of indigenous coal gasification technology.

- ***Bio-manufacturing and Bio-foundry***
  The Interim Budget provides for a new scheme of bio-manufacturing and bio-foundry to be launched to promote green growth and provide environment friendly alternatives such as biodegradable polymers, bio-plastics, bio-pharmaceuticals and bio-agri-inputs.

C. Other key policy announcements

- To enable multimodal connectivity for improving logistics efficiency and reduction of cost, the Interim Budget provides for implementation of 3 major economic railway corridor:
  - energy, mineral and cement corridor;
  - port connectivity corridor; and
  - high traffic density corridor.

- The Interim Budget provides an impetus to research and innovation by establishing a corpus of INR 1,00,000 crore with 50-year interest free loan. This will provide long-term financing options for the private sector to scale up research and innovation significantly in sunrise domains.

- The e-vehicle ecosystem to be expanded and strengthened by supporting manufacturing and charging infrastructure. Greater adoption of e-buses for public transport networks to be encouraged through payment security mechanism.

  The FDI inflow during 2014-2023 was USD 596 billion. To attract sustained foreign investments, the Government is negotiating bilateral investment treaties with other foreign partners. The India-Middle East-Europe Economic Corridor is expected to be an economic game changer for India. Immediately after the budget, India and UAE signed bilateral investment treaty.

- On the agriculture sector the Government aims to promote private and public investment in post-harvest activities including aggregation, modern storage, efficient supply chains, primary and secondary processing and marketing and branding.

- To support the State Governments to enable Viksit Bharat reforms, the Interim Budget provides for INR 75,000 crore as 50-year interest free loans.

D. Key tax announcements

In the interim budget, no substantial amendments are made in tax laws including no change in the income-tax rates as well as import duties. Key amendments made in the interim budget are as under:

- Extension of sunset date by a year

Section	Applicable to	Exemption/ deduction	Sunset clause
80-IAC	Eligible start-ups	100% deduction of profits and gains derived from eligible business	The deadline for incorporation has been extended to 31 March 2025
10(4F)	Non-residents leasing aircraft/ ship to IFSC unit	Royalty and interest income on leasing of aircraft/ ship by an IFSC unit	The sunset clause for commencement of operations has been extended to 31 March 2025

Foot note
1. Scheme on guideline for providing financial assistance to CBG producers dated 02 February 2024
2. Guidelines for Scheme for promotion of Coal/Lignite Gasification Projects dated 07 February 2024

Section	Applicable to	Exemption/ deduction	Sunset clause
80LA	Aircraft/ ship leasing companies in IFSC	Income arising from transfer of a leased aircraft/ ship by an IFSC unit	The sunset clause for commencement of operations of such aircraft/ ship leasing IFSC units has been extended to 31 March 2025
10(4D)	Investment division of non-resident IFSC Banking Unit (IBU)	Income from foreign securities, capital gains from Indian securities (other than equity shares), capital gains from securities listed on IFSC exchanges, business income from securitisation trust	The sunset clause for commencement of investment operations by such IBUs has been extended to 31 March 2025
10(23FE)	Abu Dhabi Investment Authority, Sovereign Wealth Funds, Pension Funds (satisfying prescribed conditions)	Dividend, interest, income from units of a business trust, long-term capital gains arising from investment in debt, shares or units in India	The sunset clause for making the investment in debt, shares or units in India has been extended to 31 March 2025

- Sunset date for notification of Faceless scheme for undertaking transfer pricing assessment, dispute resolution proceedings and appeals to Tribunal extended from 31 March 2024 to 31 March 2025

- To improve taxpayer services, Interim Budget Speech announced withdrawal of petty, non-verified, non-reconciled or disputed direct tax demands up to INR 25,000 pertaining to the period up to financial year 2009-10 and up to INR 10,000 for financial year 2010-11 to 2014-15

- Tax collection at source rates for Liberalised Remittance Scheme (LRS) and overseas tour packages now codified

Nature of payment	Rates (up to 30 September 2023)	Rates (from 1 October 2023) – now codified
LRS for medical and education expenses	► Nil up to INR 700,000 ► 5% above INR 700,000	► Nil up to INR 700,000 ► 5% above INR 700,000
LRS for any purpose other than medical and education expenses	► Nil up to INR 700,000 ► 5% above INR 700,000	► Nil up to INR 700,000 ► 20% above INR 700,000
Purchase of overseas tour package	► 5% without any threshold	► 5% up to INR 700,000 ► 20% above INR 700,000

- Input Service Distributor – The office receiving invoices for or on behalf of distinct persons shall be required to get registered as Input Service Distributor and distribute the credit of GST to such distinct persons through prescribed document.

E. Expectations from main budget 2024

Some of the key expectations from budget are as under:

- One key expectation from the final budget which could impact the industry, is on the introduction of rules on the Global Minimum Tax and Subject to Tax Rules under Pillar 2 – BEPS program. The Revenue Secretary of India while commenting on the Interim Budget has said that a committee has been setup for Pillar 2 and clarity would be provided in the main budget.

- Considering varying parameters and complexities of current capital gain regime, streamlining of capital gain tax regime is one of the key expectations of the budget.

- Simplification of withholding tax regime is task of industry since some time as currently it has different rates and thresholds and can lead to lot of litigation.

F. Concluding thoughts

The Indian economy has been on a high sustainable growth path addressing and balancing change with new challenges due to the geo-political environment and global warming. In spite of slacking symptoms globally, India has seen effective and timely delivery of large infrastructure projects leading to increased GDP. The overall development and India's growth would have a direct incremental impact on the energy needs of India. The Government has given broad policy directions for achieving net zero by 2070.

The announcements and schemes for the oil and gas sector can strengthen India's roadmap to energy transition and security.

Since this is an Interim Budget, detailed policy announcements and tax related changes can be anticipated in the final budget post General Elections in India.

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

Events

India Energy Week 2024

Building on the success of the 2023 edition, inaugurated by Hon'ble Prime Minister of India Shri Narendra Modi, India Energy Week 2024 was held from 6th – 9th February 2024 in Goa, India. The four-day event, inaugurated by the Hon'ble Prime Minister Shri Narendra Modi, featured global oil, gas, biofuels and renewable companies, utilities & power generation, technology & services exhibiting their products and services. The platform allowed the global energy ecosystem to collaborate, innovate and grow through meaningful partnerships across the energy spectrum.

Hon'ble Prime Minister Shri Narendra Modi inaugurated India Energy Week (IEW) 2024 at IPSHEM- ONGC Training Institute, Goa, on 6th February 2024, under the theme of Growth, Collaboration, Transition. Held under the patronage of Ministry of Petroleum and Natural Gas (MoP&NG), Government of India and organised by the Federation of Indian Petroleum Industry (FIPI) from 6th to 9th February 2024, IEW highlighted India's leadership in the battle against climate change while allowing stakeholders across the energy spectrum to freely exchange ideas and explore opportunities under one roof.

With India's rising global stature in the global energy ecosystem, IEW 2024 hosted at Goa was termed to be more grand, diverse, and impactful than its inaugural edition. Hon'ble Governor of Goa, Shri P.S. Sreedharan Pillai, Hon'ble Chief Minister of Goa, Shri Pramod Sawant, Hon'ble Union Minister of Petroleum & Natural Gas and Housing & Urban Affairs, Shri Hardeep S. Puri and Hon'ble Minister of State for Petroleum & Natural Gas and Labour & Employment, Shri Rameshwar Teli graced the occasion. Further, the event witnessed over 35,000 attendees, 350 exhibitors, 400 speakers spread across 80 conference sessions and 4,000 delegates from over 120 countries.

In the inaugural address, Hon'ble Prime Minister Shri Narendra Modi emphasised India's commitment to unprecedented levels of investment in the energy sector while addressing the gathering of global energy leaders. The Prime Minister also underlined that the massive government spending in the sector will create new avenues for investment in India. Prime Minister Narendra Modi also inaugurated the integrated Sea Survival Training Centre, ONGC Institute in Goa.

During the inaugural day, Hon'ble Union Minister of Petroleum & Natural Gas and Housing & Urban Affairs, Shri Hardeep Singh Puri participated in a ministerial panel titled ''Ensuring energy security for nations and industry in a VUCA world" along with Hon'ble Minister(s), Saad bin Sherida Al Kaabi, Energy Affairs, Qatar, Vickram Bharrat, Minister of Natural Resources Republic of Guyana, and Secretary General OPEC, Haitham Al Ghais. In his press conference, Hon'ble Union Minister of Petroleum & Natural Gas and Housing & Urban Affairs, Shri Hardeep Singh Puri commended the technology innovations showcased at the exhibitions, including advancements in biofuels and renewable energy. The minister also highlighted that while India will account for 25% of incremental global oil demand over the next two decades, the growth will not only be restricted to exploration and production activities but will also extend to biofuels.

Further, several ministerial, leadership, technical sessions and roundtables were held that explored varied themes like energy transition of the global south, building a future ready energy stack, chartering the roadmap of alternate fuels for energy optionality and impact of localization, regionalization and globalization on energy-related industrialization and manufacturing processes.

To further enhance the event, FIPI exhibited a stall at IEW 2024. The stall displayed infographics related to its-core competencies and major advocacy areas, publications such as Annual Report and quarterly & monthly publications, member and partner organizations, various studies carried out etc. Further, as part of FIPI student chapter initiative, FIPI extended sponsorship support towards participation of two students from each of 11 FIPI chapter institutions in the event. Besides this, the students from local institutes were also given an opportunity to gain insights about developments in the oil and gas sector, particularly in the field of energy transition. In terms of coverage, the local citizens of the whole state of Goa including school and college students also visited the exhibition during the event.

At the closing ceremony, the Energy Startup Challenge awards were presented with Iron Technologies securing the first prize, followed by Vasitara Private Limited in the second place and Aloe Ecell in the third place. Honourable mentions went to Biofuels Junction and VDT Pipeline Integrity Solutions, showcasing the innovation and entrepreneurial spirit within the Indian energy sector.

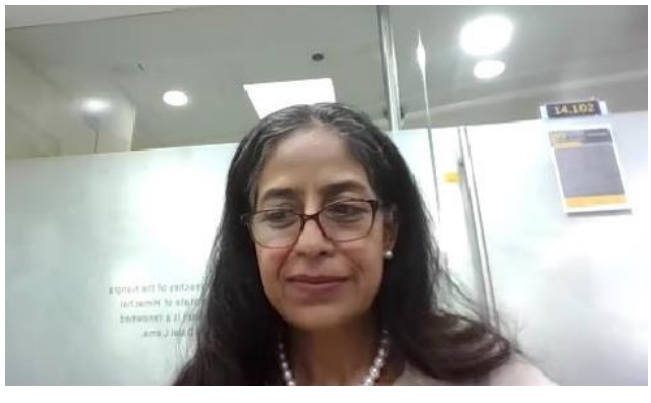
Reinforcing the event's significance in the global energy sector calendar, Hon'ble Union Minister of Petroleum & Natural Gas and Housing & Urban Affairs, Shri Hardeep S. Puri announced the next edition of IEW which will take place at Yashobhoomi, the India International Convention and Expo Centre in New Delhi from February 11-14, 2025.

Please visit https://www.indiaenergyweek.com/ for more highlights of India Energy Week 2023

FIPI Post Budget Analysis 2024

The Interim Budget for the year 2024-25 was announced by the Hon'ble Finance Minister of India Smt. Nirmala Sitharaman on 1 February, 2024. Keeping up with FIPI's long tradition, FIPI organized its flagship FIPI Post Budget Analysis 2024 session on 2nd February with EY as the knowledge partner. The Budget session was attended by nearly 100 delegates (virtually) and was appreciated in terms of content by everyone. The objective of the session was to analyze the recently presented Interim Budget 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. Vivekanand, Director (Finance, Taxation and Legal), FIPI, welcomed all the panelists during the budget analysis session organized by FIPI. He said that the Budget presented by the honorable Finance Minister had laid special focus on wide spectrum of energy including green energy areas such as bioenergy; incentives provided for solar rooftop, EVs; bio manufacturing and bio foundry and allocation of funds for research related work. Further, he highlighted that India is on a growth trajectory as India's GDP is projected to grow in real terms by 7.3% in 2023-24. With robust economic growth, he mentioned that average monthly gross collection of GST amounted to Rs. 1.66 lakh crores. He also said that the growth of the economy is supported by higher capex on infrastructure expansion with an infrastructure budget allocation of Rs. 11, 11,111 crores.



Setting the context for the session, Ms. Neetu Vinayek, Partner, EY, provided a backdrop to the Interim Budget 2024 by highlighting India as one of the fastest growing economies in the world despite the global headwinds faced during the current year. With India's real GDP growth estimated at 7.3% for FY 2024, emphasis on PLI incentive schemes have made Make in India a significant reform within Indian economy. She further highlighted that the tax reforms implemented by the Government have led to complete digitization of tax compliance as the prevalence of triangulation of GST, TDS and TCS have enhanced formalization. She mentioned some of the impact of tax reform measures including -widening of tax base to 32% increase in GST filers in comparison to April 2018 and an 123% increase in individual income tax filers in comparison to FY 2014 data. Another significant outcome has been - 80% of the tax refunds being currently issued within 30 days of filing last tax return, showing significant acceleration of the tax refund process.

Speaking about direct taxes, Mr. Hiten Sutar, EY talked about the tax incentives available to start ups and MSMEs who are important part of our ecosystem as service and technology providers. He said that the Section 80-IAC which was a 3-year tax holiday for startups out of their 10 years of incorporation, was expiring on 31st March 2024, have now been extended to 31st March, 2025. Further, the units in Gift City, which were into leasing of aircraft and ships including the oil and gas vessels, were eligible for incentives such as exemption of capital gain as well the royalty/interest payment made to the non-residents - these sunset clauses have been extended up to 31st March, 2025.

Ms. Uma Iyer, Partner, EY highlighted the provisions made under the indirect tax. She highlighted that there were no rate changes proposed under Customs and GST. Further, she highlighted that there was a change made in the law pertaining to input service distributor (ISD) wherein ISD registration was made mandatory to be obtained to avail and transfer input tax credit (ITC) on third party/self – Reverse Change Mechanism (RCM) invoices in respect of services received for or on behalf of other registrations.

The presentation on budget was followed by 'Panel Discussion on Interim Budget 2024-25, focusing on the outcome for oil and gas companies in the interim budget. The panel comprised of Shri A K Tiwari, Member, PNGRB; Shri. Hitesh Vaid, CFO, Cairn Oil & Gas, Vedanta Ltd and Shri Vinod Tahiliani, CFO, RBML. The panel discussion was moderated by Ms. Neetu Vinayek, Partner, EY.

During the discussion, the panelists highlighted the key positive outcomes of the interim budget in terms of increased focus on renewables and bio-energy. The panelist welcome the incentives provided to new sources of energy such as facilitating rooftop solar and large-scale adoption of rooftop solar across cities, providing financial assistance in procuring the machinery for biomass aggregation, assistance of VGF for offshore wind energy, fund allocation towards R&D in the sunrise sectors etc. Further, to ensure green mobility, the government allocation of funds under the FAME policy to develop a robust EV ecosystem within India, was also considered a positive step towards energy sustainability.

The panel had a consensus on inclusion of all petroleum products including natural gas under GST to avoid losing significantly in terms of input tax credits due to its non-inclusion under GST. Further, they highlighted that the necessary gas infrastructure is being laid down in the North- eastern region through the 12th CGD bidding round so that the Govt's vision of India becoming a gas-based economy can be achieved. The panelists believed that due to intermittency of renewables, combining solar/wind with natural gas can help in encouraging and defining the role of natural gas in the economy.

Ms. Uma Iyer and Ms. Neetu Vinayek from EY conducted the Q&A session and provided their views and opinions on various queries posted by participants.

In the concluding remarks, FIPI thanked all the panelists and the subject matter experts for providing their insights on the Interim Budget 2024-25 and its implications on the oil & gas industry and the economy.

Webinar on Biofuels in India

Federation of Indian Petroleum Industry (FIPI), in association with EY as knowledge partner, organized a webinar on '**Biofuels in India**' on 21st March, 2024. The webinar was conducted to shed light on the approaches that have been adopted by companies globally with respect to mature biogas/biofuel pathways, along with key opportunities and challenges in developing robust ecosystem for biofuels in India. The webinar witnessed an overwhelming response with participation of more than 300 professionals working across the oil and gas value chain.

Mr. Vivekanand, Director (Finance, Taxation & Legal), FIPI began the session with the opening remarks. He said that several government efforts that are already undertaken towards energy transition, decarbonization, and environmental sustainability. One of the initiatives adopted by Govt is the National Biofuels Policy which includes ethanol blending programme. He said that with the target of petrol supplies with 10% ethanol blending achieved in June 2022, ahead of the original schedule of November 2022, the government has moved the 20% volume blending target for ethanol forward by 5 years to 2025-26, from an earlier target of 2030. He then highlighted that the main aim of implementation of biofuel policy is to reduce India's reliance on crude oil imports and to reduce Greenhouse Gas (GHG) emissions. Further, he said that India also has other opportunities in biofuels space including biodiesel for use in diesel vehicles and bio jet fuel as a replacement for jet fuel. The government has already established a 5% biodiesel target by 2030 which would require almost 4.5 billion litres of biodiesel per year. In case of bio jet fuel, MoP&NG has also announced indicative blending targets of 1% by 2027 and 2% by 2028 for international flights leaving India. Therefore, he highlighted that as provided for ethanol, production support, guaranteed pricing, and feedstock support are also crucial elements for achieving targets for biodiesel and bio jet fuel.

On the global front, he said that the world leaders have joined hands to form the "Global Biofuel Alliance" ('GBA'). The GBA will act as an expert hub and as a central repository of knowledge besides accelerating technology development and developing standards/certifications.

Setting the context for the session, Mr. Kapil Bansal, Partner, Energy Transition & Decarbonization, EY, gave a broad overview about the categorization of biofuels into 3 varied forms- 1st generation conventional fuels – derived from sugar, grains etc.; 2nd generation advanced biofuels- derived from non-food crops, agricultural or municipal waste and synthetic fuels including renewable energy, water, and captured CO2. He said that at present, sustainable fuel volumes make up 2-4% of the global liquid fuel demand (3-4 tlp.a.), dominated by biofuels and with surge in demand beyond 2030, greater use of other types of feedstocks, including synfuels is expected.

He highlighted that with current policy scenario, global temperature is expected to rise by 2.5-2.9 degree Celsius by year 2100. Therefore, the role of bioenergy is crucial in decarbonizing industrial heating processes as well as in hard to abate sectors like aviation and shipping. He said that demand for biofuel is expected to increase as biofuels are going to play significant role in NZE target.

Mr. Rajesh Rawat, EY mentioned that globally biomass is expected to contribute 30% in fuel and heat energy mix and 15-20% in overall energy mix in 2050 net zero scenario with similar trend expected in India as well. He then mentioned about the commercially mature pathways that exist to produce biofuels and its derivatives such as Hydrotreatment for bio-gasoline, Anaerobic digestion for biomethane, Transesterification for biodiesel etc.

He mentioned that the Indian government has also been pushing for growth in the biofuels sector considering the country has an abundance of biomass with untapped energy potential of 50+GWe2. Various schemes and policies have like, National Biomass Programme, New national Biogas & organic Manure Programme (NNBOMP) scheme, National Biofuel Policy, National Biogas Mission, SATAT scheme, etc. have been implemented by the government within the last 6 years which helps boost the biofuels sector. He said that biomass contribution in Indian energy mix is expected to be around 15% by 2040 with majority of application in transport and industry. The use of biomass for tradition purpose of cooking is expected to be negligible and will be replaced by LPG-LNG with hydrogen blending and electricity.

He said that India currently has a total biomass-based electricity production capacity of 10.5 GW. Further he said that while ethanol blending with petrol has achieved 10% target in 2022 with further ambition to reach 20% by 2025, the bio-diesel market is still lagging due to lack of viable feedstock availability and limited govt incentives. He then listed the various sources of biomass-based energy potential of 50 GW which could be harnessed to achieve India's 2070 NZE target viz- 13 GW from forestry & wasteland (with potential states being Maharashtra, Madhya Pradesh, Chhattisgarh, Gujarat, J&K); 28.5 GW from agri-resdiues surplus (with potential states being Punjab, Uttar Pradesh, Gujarat, Maharashtra) and 9.5 GW from solid and liquid waste (with potential states being Uttar Pradesh, Gujarat, Tamil Nadu).

Mr. Rawat then highlighted the economic benefits of using biofuels viz; reduced reliance on fossil fuel imports, job creation and economic growth, promotion of rural livelihoods, and other benefits such as energy independence, diversified energy portfolio, and reduced GHG emissions.

He also mentioned the various demand side interventions namely- National Biofuel Policy 2018, Ethanol blending Petrol Programme 2019, Biomass Co-firing, and recently announced Budget 2024 regulations on blending of CBG in CNG and PNG; to propel biofuel demand in the market. Further, he highlighted the importance of integrated biorefineries with 2G, 1G, CBG and other biofuels to meet growth transition fuels demand, along with collaboration with Indian OMCs technology research, pilot testing and commercialization of technologies in 2G, 3G and 4G biofuels space.

Lastly, he spoke about various operational, economical, and technical challenges viz; feedstock availability, upfront costs for biomass technologies/infrastructure, price volatility of biomass feedstocks, seasonal fluctuations in biomass supply, crop burning thereby preventing residue collection etc.

Mr Kapil Bansal and Mr. Rajesh Rawat from EY, then conducted the Q&A session and provided their views and opinions on various queries posted by participants.

Lastly, Mr. DLN Sastri, Director (Oil Refining & Marketing), FIPI in his vote of thanks, emphasized the role of biofuels in meeting India's net zero targets. He complimented EY team for an elaborative presentation on the topic covering varied aspects related to demand, technology, government incentives, challenges etc. He also thanked the participants from the energy industry for their active and interactive participation during the event.

NEW APPOINTMENTS

Alok Sharma joins as Director (Research and Development), IndianOil

Mr Alok Sharma joined as Director (Research and Development) at Indian Oil Corporation (IndianOil) on 16.01.2024. He is a post graduate engineer in Chemical Engineering from IIT-Delhi and graduate from Gujarat University.

Mr Sharma has more than 3 decades of rich experience in the downstream energy sector and has made significant contributions to the Indian refining sector in Process, Projects, and Production. Prior to his elevation as Director (Research & Development), Mr Sharma was Executive Director at Centre for High Technology under the MoP&NG, where he played a pivotal role in coordinating refining, petrochemical, and alternative energy activities for pan Indian O&G industry.

Mr Sharma represents the O&G sector on various committees of NITI Aayog, MNRE, DST and Bureau of Energy Efficiency. He is also a member of International Association of Hydrogen Energy (IAHE) and founder member of Hydrogen Association of India (HAI).

M Shyamprasad Kamath takes over as Managing Director of MRPL

Mr. Mundkur Shyamprasad Kamath has taken over as the Managing Director of Mangalore Refinery and Petrochemicals Limited (MRPL) on 28.02.2024.

Mr. Kamath has a distinguished professional career spanning over 30 years in the downstream hydrocarbon industry. He holds a Bachelor's degree in Chemical Engineering from MIT Manipal (1989) and a Post-Graduation Diploma in Management from TA Pai Management Institute Manipal (1992).

During previous tenure as Executive Director (Refinery) at MRPL, he excelled in managing operations, maintenance, technical services, and production planning. His strategic vision prioritizes operational excellence, energy conservation, reliability, and digitalization.

Mr. Kamath's vision for sustained growth, operational efficiency, and technological innovation positions him as a key driver of MRPL's success and a leader at the forefront of the industry's advancement.

Rashmi Govil takes over as Director (HR), IndianOil

Ms. Rashmi Govil has taken charge as Director (Human Resources) at Indian Oil Corporation Limited (IndianOil), on 15.03.2024.

Ms. Govil joined IndianOil in 1994 and brings with her nearly three decades of rich experience in various facets of the human resources function. Ms. Govil is a seasoned professional with an MBA specializing in HR and a Postgraduate Diploma in Finance.

Prior to her appointment as Director (HR), she was serving as Executive Director (HRD & Employee Relations) at the Company's Corporate Office. Ms Govil has also worked at IndianOil's Refineries Headquarters, as well as handled the challenging environment at the Unit at Mathura Refinery.

Ms. Govil is known for her result-focused, collaborative, and inclusive style and has formulated several strategic initiatives for the Company as well as the industry. She has pioneered the unique innovation cell 'Srijan', steered the roll-out of enterprise-wide SAP solutions in HR, and has led multiple landmark settlements with the collectives, including long-term wage settlements with the Unions of IndianOil.

STATISTICS

INDIA: OIL & GAS

DOMESTIC OIL PRODUCTION (MILLION MT)

		2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	2022-23 (P)	April-Dec. 2023 (P)	
												% of Total
Onshore	ONGC	6.1	5.8	5.9	6.0	6.1	6.1	5.9	5.8	5.9	4.5	41.4
	OIL	3.4	3.2	3.3	3.4	3.3	3.1	2.9	3.0	3.2	2.5	23.1
	Pvt./ JV (PSC)	9.1	8.8	8.4	8.2	8.0	7.0	6.2	6.3	5.6	3.9	35.6
	Sub Total	**18.5**	**17.8**	**17.6**	**17.5**	**17.3**	**16.2**	**15.1**	**15.1**	**14.7**	**10.8**	**100**
Offshore	ONGC	16.2	16.5	16.3	16.2	15.0	14.5	14.2	13.6	13.5	9.9	88.8
	OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pvt./ JV (PSC)	2.7	2.5	2.1	1.9	1.9	1.5	1.1	1.0	0.9	1.2	11.2
	Sub Total	**18.9**	**19.1**	**18.4**	**18.1**	**16.9**	**16.0**	**15.4**	**14.6**	**14.5**	**11.2**	**100**
Total Domestic Production		37.5	36.9	36.0	35.7	34.2	32.2	30.5	29.7	29.2	22.0	100.0
	ONGC	22.3	22.4	22.2	22.2	21.0	20.6	20.2	19.5	19.5	14.4	65.5
	OIL	3.4	3.2	3.3	3.4	3.3	3.1	2.9	3.0	3.2	2.5	11.4
	Pvt./ JV (PSC)	11.8	11.3	10.5	10.1	9.9	8.4	7.4	7.3	6.5	5.1	23.2
Total Domestic Production		**37.5**	**36.9**	**36.0**	**35.7**	**34.2**	**32.2**	**30.5**	**29.7**	**29.2**	**22.0**	**100**

Source : MoP&NG/PPAC

REFINING

Refining Capacity (Million MT on 1st April 2023)

Indian Oil Corporation Ltd.	
Barauni	6.00
Koyali	13.70
Haldia	8.00
Mathura	8.00
Panipat	15.00
Guwahati	1.00
Digboi	0.65
Bongaigoan	2.70
Paradip	15.00
Total	**70.05**
Chennai Petroleum Corp. Ltd.	
Narimanam	0.00
Chennai	10.50
Total	**10.50**
JV Refineries	
HMEL	11.30
JV Total	**11.30**

Bharat Petroleum Corp. Ltd.	
Mumbai	12.00
Kochi	15.50
Bina	7.80
Total	**35.30**
Hindustan Petroleum Corp. Ltd.	
Mumbai	9.50
Visakhapattnam	11.00
Total	**20.50**
Other PSU Refineries	
NRL, Numaligarh	3.00
MRPL	15.00
ONGC, Tatipaka	0.07
Total PSU Refineries Capacity	**154.42**
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 253.95 (5.02 million barrels per day)
Source : PPAC

CRUDE PROCESSING (MILLION MT)

PSU Refineries	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
IOCL	53.13	53.59	58.01	65.19	69.00	71.81	69.42	62.35	67.66	72.41	53.32
BPCL	22.97	23.20	24.10	25.30	28.20	30.90	31.53	26.22	29.84	38.40	27.59
HPCL	15.51	16.20	17.20	17.80	18.20	18.44	17.18	16.42	13.97	19.09	15.39
CPCL	10.70	10.70	9.60	10.30	10.80	10.69	10.16	8.24	9.04	11.32	8.17
MRPL	14.60	14.60	15.53	15.97	16.13	16.23	13.95	11.47	14.87	17.12	10.64
ONGC (Tatipaka)	0.10	0.05	0.07	0.09	0.08	0.07	0.09	0.08	0.08	0.07	00.05
NRL	2.60	2.78	2.52	2.68	2.81	2.90	2.38	2.71	2.62	3.09	1.68
Sub Total	**119.61**	**121.12**	**127.03**	**137.33**	**145.22**	**151.04**	**144.71**	**127.50**	**138.08**	**161.50**	**116.85**

JV Refineries	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
HMEL	9.27	7.34	10.71	10.52	8.83	12.47	12.24	10.07	13.03	12.74	9.41
BORL	5.40	6.21	6.40	6.36	6.71	5.71	7.91	6.19	7.41	-	-
Sub Total	**14.67**	**13.55**	**17.11**	**16.88**	**15.54**	**18.18**	**20.15**	**16.26**	**20.44**	**12.74**	**9.41**

Pvt. Refineries	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
NEL	20.20	20.49	19.11	20.92	20.69	18.89	20.62	17.07	20.16	18.69	14.75
RIL	68.03	68.10	69.50	70.20	70.50	69.14	68.89	60.94	63.02	62.30	61.94
Sub Total	**88.23**	**88.59**	**88.61**	**91.12**	**91.19**	**88.03**	**89.51**	**78.01**	**83.19**	**81.00**	**76.69**

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
All India Crude Processing	**222.40**	**223.26**	**232.90**	**245.40**	**251.90**	**257.25**	**254.38**	**221.77**	**241.70**	**255.23**	**202.96**

Source : MoP&NG/PPAC

CRUDE CAPACITY VS. PROCESSING

	Capacity On 01/04/2023 Million MT	% Share	Crude Processing April-Dec. 2023 (P)	% Share
PSU Ref	154.4	60.8	116.9	57.6
JV. Ref	11.3	4.5	9.4	4.6
Pvt. Ref	88.2	34.7	76.7	37.8
Total	**253.9**	**100**	**203.0**	**100**

Source : MoP&NG/PPAC

POL PRODUCTION (Million MT)

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
From Refineries	216.4	217.1	227.9	239.2	249.8	257.4	258.2	229.3	250.3	263.0	202.8
From Fractionators	3.9	3.7	3.4	3.5	4.6	4.9	4.8	4.2	4.1	3.5	2.6
Total	**220.3**	**220.7**	**231.2**	**242.7**	**254.4**	**262.4**	**262.9**	**233.5**	**254.3**	**266.5**	**205.4**

DISTILLATE PRODUCTION (Million MT)

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
Light Distillates, MMT	62.7	63.2	67.1	71.0	74.7	75.4	76.8	71.4	76.5	76.2	58.9
Middle Distillates , MMT	112.8	113.4	118.3	122.5	127.5	130.8	130.2	110.7	120.2	130.4	100.7
Total Distillates, MMT	**175.5**	**176.6**	**185.4**	**193.5**	**202.2**	**206.1**	**206.9**	**182.1**	**196.7**	**206.6**	**159.6**
% Distillates Production on Crude Processing	**77.6**	**77.8**	**78.5**	**77.8**	**78.8**	**78.6**	**79.9**	**80.6**	**80.0**	**79.9**	**77.6**

PETROLEUM PRICING
OIL IMPORT - VOLUME AND VALUE

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
Quantity, Million Mt	189.2	189.4	202.9	213.9	220.4	226.5	227.0	196.5	212.0	232.6	172.9
Value, INR '000 Cr.	864.9	687.4	416.6	470.2	566.5	783.2	717.0	469.8	899.3	1260.9	814.3
Value, USD Billion	143.0	112.7	64.0	70.2	87.8	111.9	101.4	62.2	120.4	157.5	98.4
Average conversion Rate, INR per USD (Calculated)	60.5	61.0	65.1	67.0	64.5	70.0	70.7	75.5	74.7	80.1	82.7

OIL IMPORT - PRICE USD / BARREL

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
Brent (Low Sulphur - LS- marker) (a)	107.5	85.4	47.5	48.7	57.5	70.0	61.0	44.3	80.7	96.0	83.1
Dubai (b)	104.6	83.8	45.6	47.0	55.8	69.3	60.3	44.6	78.1	92.4	82.6
Low sulphur-High sulphur differential (a-b)	2.9	1.7	1.8	1.7	1.6	0.7	0.6	-0.3	2.7	3.5	0.5
Indian Crude Basket (ICB)	105.52	84.16	46.17	47.56	56.43	69.88	60.47	44.82	79.18	93.15	82.77
ICB High Sulphur share %	69.90	72.04	72.28	71.03	72.38	74.77	75.50	75.62	75.62	75.62	75.62
ICB Low Sulphur share %	30.10	27.96	27.72	28.97	27.62	25.23	24.50	24.38	24.38	24.38	24.38

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

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
Gasoline	114.3	95.5	61.7	58.1	67.8	75.3	67.0	47.5	89.7	107.2	93.6
Naphtha	100.2	82.2	48.5	47.1	56.3	65.4	55.1	43.9	79.9	78.4	68.0
Kero / Jet	121.2	66.6	58.2	58.4	69.2	83.9	70.4	45.8	87.3	125.5	103.9
Gas Oil (0.05% S)	122.0	99.4	57.6	58.9	69.8	84.1	74.1	50.0	90.2	132.8	105.2
Dubai crude	104.6	83.8	45.6	47.0	55.8	69.3	60.3	44.6	78.1	92.4	82.6
Indian crude basket	105.5	84.2	46.2	47.6	56.4	69.9	60.5	44.8	79.2	93.2	82.8

CRACKS SPREADS ($/ BBL.)

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
Gasoline crack											
Dubai crude based	9.7	11.7	16.1	11.1	12.0	5.9	6.7	2.9	11.7	14.7	11.0
Indian crude basket	8.8	11.3	15.6	10.6	11.4	5.4	6.5	2.6	10.5	14.0	10.8
Diesel crack											
Dubai crude based	17.4	15.7	12.0	12.0	13.9	14.8	13.8	5.5	12.2	40.3	22.6
Indian crude basket	16.5	15.3	11.5	11.4	13.4	14.2	13.6	5.2	11.0	39.6	22.4

DOMESTIC GAS PRICE ($/MMBTU)

Period	Domestic Gas Price (GCV Basis)	Price Cap for Deepwater, High temp Hingh Pressure Areas
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
April 22 - September 22	6.10	9.92
October 22 - March 23	8.57	12.46
1 April 23 - 7 April 23	9.16	12.12
8 April 23 - 30 April 23	7.92	
1 May 23 – 31 May 23	8.27	
1 June 23 – 30 June 23	7.58	
1 July 23 – 31 July 23	7.48	
1 August 23 – 31 Aug. 23	7.85	
1 Sept. – 31 Sept. 23	7.85	
1 Oct. – 31 Oct. 23	9.20	9.96

Source: MoP&NG/PPAC/OPEC

GAS PRODUCTION

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec.. 2023 (P)
ONGC	21177	22088	23429	24677	23746	21872	20629	19969	14550
Oil India	2838	2937	2881	2722	2668	2480	2893	3041	2311
Private/ Joint Ventures	8235	6872	6338	5477	4770	4321	10502	11440	10352
Total	**32250**	**31897**	**32648**	**32875**	**31184**	**28672**	**34024**	**34450**	**27213**

		2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
Onshore	Natural Gas	8845	9294	9904	10046	9893	9601	10471	10368	7548
	CBM	393	565	735	710	655	477	518	673	486
	Sub Total	**9237**	**9858**	**10639**	**10756**	**10549**	**10078**	**10989**	**11042**	**8034**
Offshore		23012	22038	22011	22117	20635	18428	22869	23409	19179
	Sub Total	**23012**	**22038**	**22011**	**22117**	**20635**	**18428**	**22869**	**23409**	**19179**
	Total	**32249**	**31897**	**32649**	**32873**	**31184**	**28506**	**33858**	**34450**	**27213**
	(-) Flare loss	1120	1049	918	815	927	721	727	786	528
	Net Production	**31129**	**30848**	**31731**	**32058**	**30257**	**27785**	**33131**	**33664**	**26685**

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
Net Production	31129	30848	31731	32058	30257	27785	33131	33664	26685
Own Consumption	5822	5857	5806	6019	6053	5736	5760	5494	4103
Availabilty	25307	24991	25925	26039	24204	22049	27371	28170	22582

AVAILABILITY FOR SALE

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
ONGC	16076	17059	18553	19597	18532	16972	15874	15519	11357
Oil India	2314	2412	2365	2207	2123	1930	2190	2287	1769
Private/ Joint Ventures	6917	5520	5007	4235	3549	3147	9307	10364	9456
Total	**25307**	**24991**	**25925**	**26039**	**24204**	**22049**	**27371**	**28170**	**22582**

CONSUMPTION (EXCLUDING OWN CONSUMPTION)

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
Total Consumption	46695	49677	53364	54779	58091	54910	59277	54817	45438
Availabilty for sale	25307	24991	25925	26039	24204	22049	27371	28170	22582
LNG Import	21388	24686	27439	28740	33887	32861	31906	26647	22856

GAS IMPORT DEPENDENCY

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23 (P)	April-Dec. 2023 (P)
Net Gas Production	31129	30848	31731	32058	30257	27785	33131	33664	26685
LNG Imports	21388	24686	27439	28740	33887	32861	31906	26647	22856
Import Dependency (%)	40.7	44.5	46.4	47.3	52.8	54.2	49.1	44.2	46.1
Total Gas Consumption*	**52517**	**55534**	**59170**	**60798**	**64144**	**60646**	**65037**	**60311**	**49541**

* Includes Own Consumption

Source: MoP&NG/PPAC

SECTOR WISE DEMAND AND CONSUMPTION OF NATURAL GAS

		2021-22	2022-23 (P)	2023-24									
				April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Fertilizer	**R-LNG**	**12363**	**15315**	1376	1528	1372	1415	1520	1506	1619	1488	1615	**13439**
	Domestic Gas	**5716**	**4085**	234	251	242	251	255	262	275	341	250	**2361**
Power	**R-LNG**	**2670**	**1235**	511	234	267	215	397	292	332	35	101	**2384**
	Domestic Gas	**6260**	**6918**	522	553	562	507	582	531	545	528	531	**4861**
City Gas	**R-LNG**	**5238**	**3164**	201	270	232	265	276	209	240	348	315	**2356**
	Domestic Gas	**6890**	**8864**	839	839	812	839	842	880	937	745	867	**7600**
Refinery	**R-LNG**	**3924**	**2437**	265	302	262	278	278	295	306	271	290	**2547**
	Domestic Gas	**1389**	**1472**	71	171	171	214	240	183	188	195	180	**1613**
Petrochemical	**R-LNG**	**2425**	**1116**	164	132	75	88	117	110	126	132	159	**1103**
	Domestic Gas	**334**	**843**	92	115	93	131	108	96	102	78	83	**898**
Others	**R-LNG**	**3376**	**2506**	225	200	303	240	335	256	316	276	314	**2465**
	Domestic Gas	**8933**	**10748**	822	873	995	1123	1184	1161	1154	1185	1182	**9679**

Qty. in MMSCM Source: PPAC

2023-24 WORLDWIDE ACTIVE RIG COUNT

REGION	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
US	753	752	728	687	673	647	632	623	619	623	621	623	625
Canada	196	109	90	146	186	189	188	192	197	161	198	232	197
Latin America	183	178	190	189	177	173	175	175	175	174	170	165	165
Europe	118	120	109	122	124	121	115	122	118	122	122	114	118
Middle East	323	337	339	329	334	329	327	337	347	336	348	349	344
Africa	97	93	94	101	102	109	105	111	120	109	111	111	115
Asia Pacific(1)	132	144	158	151	148	143	141	140	141	137	140	142	147
India	77	75	75	75	76	77	77	77	77	77	74	77	82
TOTAL	**1879**	**1808**	**1783**	**1800**	**1820**	**1788**	**1760**	**1777**	**1794**	**1739**	**1784**	**1813**	**1793**

Nature of pipeline		GGL	DFPCL	ONGC	GIGL	GITL	Others*	Total
Operational	Length	73	42	24				15,895
	Capacity	5.1	0.7	6.0				
Partially commissioned#	Length				1,285		365	7,403
	Capacity				122.5			-
Total operational length		73	42	24	1,285	0	365	23,298
Under construction	Length				916	220	4,361	10,009
	Capacity							-
Total length		73	42	24	2,201	220	4,726	33,307

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

Source: PPAC/PNGRB

EXISTING LNG TERMINALS

Location	Companies	Capacity (MMTPA) As on 01st Dec.'23	Capacity Utilisation (%) April- Oct.'23
Dahej	Petronet LNG Ltd	17.5	95.1
Hazira	Shell Energy India Pvt Ltd	5.2	37.1
Dabhol*	Konkan LNG Ltd	5	34.3
Kochi	Petronet LNG Ltd	5	19.5
Ennore	Indian Oil LNG Pvt Ltd	5	16.8
Mundra	GSPC LNG Ltd	5	12.2
Dhamra	Adani Total Pvt Ltd	5	26.0
Total Capacity		47.7 MMTPA	

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

2023 WORLDWIDE ACTIVE RIG COUNT

REGION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
US	772	758	753	752	728	687	673	647	632	623	619	623
Canada	226	248	196	109	90	146	186	189	188	192	197	161
Latin America	170	181	183	178	190	189	177	173	175	175	175	174
Europe	117	111	118	120	109	122	124	121	115	122	118	122
Middle East	318	327	323	337	339	329	334	329	327	337	347	336
Africa	92	94	97	93	94	101	102	109	105	111	120	109
Asia Pacific(1)	126	125	132	144	158	151	148	143	141	140	141	137
India	78	77	77	75	75	75	76	77	77	77	77	77
TOTAL	1899	1921	1879	1808	1783	1800	1820	1788	1760	1777	1794	1739

Source: Baker Hughes, (1) Excluding India's Rig Count

Member Organizations

S.No	Organization	Name	Designation
1	Adani Welspun Exploration Ltd.	Mr. Arvind Hareendran	Sr. Vice-President (Exploration)
2	ASAP Fluids Pvt. Ltd.	Mr. Vivek Gupta	Managing Director
3	Axens India (P) Ltd.	Mr. Siddhartha Saha	Managing Director
4	Baker Hughes, A GE Company	Mr. Neeraj Sethi	Country Leader
5	Bharat Petroleum Corporation Ltd.	Mr. G. Krishnakumar	Chairman & Managing Director
6	Bliss Anand Pvt. Limited	Mr. Vikas Anand	Managing Director
7	BP Exploration (Alpha) Ltd	Mr. Sashi Mukundan	President, bp India & Senior Vice-President, bp Group
8	Cairn Oil & Gas, Vedanta Ltd	Mr. Sunil Duggal	Group CEO, Vedanta Ltd
9	Central U.P. Gas Ltd.	Mr. Rathish Kumar Das	Managing Director
10	Chandigarh University	Mr. Satnam Singh Sandhu	Chancellor
11	Chennai Petroleum Corporation Ltd.	Mr. Arvind Kumar	Managing Director
12	Chi Energie Pvt. Ltd.	Mr. Ajay Khandelwal	Chief Executive Officer
13	CSIR- Indian Institute of Petroleum	Dr Harender Singh Bisht	Director
14	Decom North Sea	Mr. Will Rowley	Interim Managing Director
15	Dynamic Drilling & Services Pvt. Ltd.	Mr. S.M. Malhotra	President
16	Engineers India Ltd.	Ms. Vartika Shukla	Chairman & Managing Director
17	Ernst & Young LLP	Mr. Rajiv Memani	Country Manager & Partner
18	ExxonMobil Gas (India) Pvt. Ltd.	Mr. Monte Dobson	Chief Executive Officer
19	FMC Technologies India Pvt. Ltd.	Mr. Housila Tiwari	Managing Director
20	GAIL (India) Ltd.	Mr. Sandeep Kumar Gupta	Chairman & Managing Director
21	GSPC LNG Ltd.	Mr. Anil K. Joshi	Chief Executive Officer
22	Goa Natural Gas Private Limited	Mr. Mohd Zafar Khan	Chief Executive Officer
23	h2e Power Systems Pvt Ltd.	Mr. Siddharth R. Mayur	MD &CEO
24	Hindustan Petroleum Corporation Ltd.	Dr. Pushp Kumar Joshi	Chairman & Managing Director
25	HPCL Mittal Energy Ltd.	Mr. Prabh Das	Managing Director & CEO
26	IIT (ISM) Dhanbad	Prof. J. K. Pattanayak	Director (Officiating)
27	IMC Ltd.	Mr. A. Mallesh Rao	Managing Director
28	Indian Gas Exchange Ltd.	Mr. Rajesh Kumar Mediratta	Managing Director & CEO
29	Indian Oil Corporation Ltd.	Mr. S.M. Vaidya	Chairman
30	Indian Strategic Petroleum Reserves Ltd.	Mr. L.R. Jain	CEO & MD
31	IndianOil Adani Ventures Ltd.	Mr. Anubhav Jain	Managing Director
32	Indradhanush Gas Grid Ltd.	Mr. Ajit Kumar Thakur	Chief Executive Officer
33	Indraprastha Gas Ltd.	Mr. Kamal Kishore Chatiwal	Managing Director
34	International Gas Union	Mr. Milton Catelin	Secretary General

Member Organizations

S.No	Organization	Name	Designation
35	IPIECA	Mr. Brian Sullivan	Executive 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 Pvt. Ltd.	Dr. Jennifer Holmgren	Chief Executive Officer
39	Larsen & Toubro Ltd.	Mr. S.N. Subrahmanyan	CEO & Managing Director
40	Mangalore Refinery & Petrochemicals Ltd.	Mr. M Shyamprasad Kamath	Managing Director
41	MIT World Peace University Pune	Mr. Rahul V. Karad	Executive President
42	Nayara Energy Ltd.	Mr. Prasad K. Panicker	Chairman & Head of Refinery
43	Numaligarh Refinery Ltd.	Mr. Bhaskar Jyoti Phukan	Managing Director
44	Oil and Natural Gas Corporation Ltd.	Mr. Arun Kumar Singh	Chairman & CEO
45	Oil India Ltd.	Dr. Ranjit Rath	Chairman & Managing Director
46	Petronet LNG Ltd.	Mr. Akshay Kumar Singh	Managing Director & CEO
47	Pipeline Infrastructure Ltd.	Mr. Akhil Mehrotra	Chief Executive Officer
48	Rajiv Gandhi Institute of Petroleum Technology	Prof. A.S.K. Sinha	Director
49	Reliance BP Mobility Ltd.	Mr. Harish C Mehta	Chief Executive Officer
50	Reliance Industries Ltd.	Mr. Mukesh Ambani	Chairman & Managing Director
51	S&P Global Commodity Insights	Mr. Saugata Saha	President
52	Scottish Development International	Mr. Richard Baker	Head of Trade – Energy and Low Carbon Transition
53	Secure Meters Ltd.	Mr. Sunil Singhvi	CEO-Energy
54	Shell Companies in India	Ms. Mansi Madan Tripathy	Country Chair
55	Siemens Ltd.	Mr. Guilherme Vieira De Mendonca	CEO (Siemens Energy - India)
56	SLB	Mr. Vinay Malhotra	Manging Director
57	SNF Flopam India Pvt. Ltd.	Mr. Shital Khot	Managing Director
58	South Asia Gas Enterprise Pvt. Ltd.	Mr. Subodh Kumar Jain	Director
59	Sun Petrochemicals Pvt. Ltd.	Mr. Padam Singh	President
60	THINK Gas Distribution Pvt. Ltd.	Mr. Hardip Singh Rai	Chief Executive Officer
61	Topsoe India Private Limited	Mr. Alok Verma	Managing Director
62	TotalEnergies Gas & Power Projects India Pvt. Ltd.	Ms. Ahlem Friga-Noy	Country Chair
63	University of Petroleum & Energy Studies	Dr. Sunil Rai	Chancellor
64	VCS Quality Services Pvt. Ltd.	Mr. Shaker Vayuvegula	Director
65	World LP Gas Association	Mr. James Rockall	CEO & Managing Director

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