FIPI

THE JOURNAL OF FEDERATION OF INDIAN PETROLEUM INDUSTRY
Voice of Indian Oil & Gas Industry

January-March 2023 | Vol. 22 Issue 1

Governing Council

Chairman

S.M. Vaidya
Chairman
Indian Oil Corporation Ltd.

Co-Chairman

Arun Kumar Singh
Chairman & CEO
Oil and Natural Gas Corporation Ltd.

Vice-Chairman

Sarthak Behuria
Chairman
Reliance BP Mobility Ltd.

Members

Dr. Pushp Kumar Joshi
CMD, Hindustan Petroleum
Corporation Ltd.

Sashi Mukundan
President, bp India &
Senior Vice President, bp group

Prabh Das
MD & CEO,
HPCL Mittal Energy Ltd.

G. Krishnakumar
CMD, Bharat Petroleum
Corporation Ltd.

Vartika Shukla
CMD, Engineers India Ltd.

Sandeep Kumar Gupta
CMD, GAIL (India) Ltd.

Dr. Ranjit Rath
CMD, Oil India Ltd.

Sunil Duggal
Group CEO, Vedanta Ltd.
(Cairn Oil & Gas, Vedanta Ltd.)

Dr. Anjan Ray
Director, CSIR-Indian
Institute of Petroleum

Prof. Rajiv Shekhar
Director, IIT (ISM) Dhanbad

Prasad K Panicker
Chairman & Head of Refinery,
Nayara Energy Ltd.

Ashay Kumar Singh `
MD & CEO
Petronet LNG Ltd.

Nitin Prasad
Country Chair,
Shell Companies in India

Gurmeet Singh
Director General, FIPI
Member Secretary

CONTENTS

Enhancing Energy Self-sufficiency of the Country 8-11

Design and Synthesis of Mixture of Polymeric Ester as Pour Point Depressant for Waxy Crude 12-15

Petroleum Hydrocarbon Content in Sediments around ONGC's Installations in the Western Offshore Region, Arabian Sea – A Temporal Study Spanning over a Decade 16-23

Design of Tank-Degasser Assembly for safe operation 24-25

Biofuels and Their Importance 26-27

Elemental proxies for paleosalinity analysis on sediment sample A Case study Assam and Assam Arakan Basin 28-32

IFSC – Ship leasing in GIFT City – Impact on Oil and Gas sector 33-34

Risk based schedule modelling of LSTK Offshore Brownfield Oil and Gas Projects using Project Management tools & methodologies 35-39

Balancing Profit and Planet: How the Oil and Gas Industry Can Become More Sustainable 40-44

In This Issue

DG's Page
Energy Self-sufficiency
Upstream
HSE
Finance
Sustainability
Events
New Appointments
Statistics

Editorial Board

FIPI

Edited, Designed & Published by :
Federation of Indian Petroleum Industry (FIPI)

3rd Floor, PHD House,
4/2, Siri Institutional Area, August Kranti Marg, New Delhi-110016,
Tel. No.: 91-11-40886000, Fax No.: 91-11-40886019
E-mail : dg.sectt@fipi.org.in, tksengupta@fipi.org.in
Website : www.fipi.org.in

From the Desk of the

Director General

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

Dear Members,

With the advent of the new financial year 2023-24 and energy sector's dedicated focus towards investment in clean energy technologies viz, green hydrogen, biofuels, decarbonization through CCUS etc., there is renewed optimism that exists within the Indian oil and gas industry this year. The industry has put all eyes on finding a new balance between energy security, affordability, and sustainability. The industry aims to achieve its long-term desire for an accelerated shift away from hydrocarbons towards low-carbon and green sources of energy. In this regard, G20 presidency gives India a unique opportunity to lead efforts on running the path of energy transition, and at the same time keeping climate goals in tandem with the net zero objective.

With a healthy growth of 6.8% for FY 2022-23, India exhibits as being one of the highest-growing economies in the world mainly driven by domestic consumption, improvement in government investments, industrial production, improvements to credit growth, and robust growth in exports. The resilience of India's growth process was deliberated in the union budget delivered by Hon'ble Finance Minister, Smt. Nirmala Sitharaman on 1st February, 2023. The finance minister presented a growth-oriented Budget which focused on 7 pillars– Inclusive Development, Reaching the Last Mile, Infrastructure and Investment, Unleashing the Potential, Green Growth, and Youth Power. These seven priorities adopted in the Budget complemented each other and acted as the 'Saptrishi' guiding us through the Amrit Kaal.

The Indian Government through formulation of policies and regulations, has laid out an ambitious vision to bring secure, affordable, and sustainable energy to all its citizens. In order to promote gas-based economy, the Union Budget laid special emphasis on circular economy by keeping Rs 10,000 crore for setting up biogas plants which comprises of 200 compressed biogas plants (CBG), including 75 in urban areas, and 300 cluster-based plants. 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 gas sector in India.

Further in the E&P segment, government had launched the VIII bidding round (covering 10 oil & gas blocks) under the Open Acreage Licensing policy (OALP) on July 7th, 2022. In the hope of attracting more bidders, the government has extended the time for submitting bids in the VIII exploration licensing round to March 30th, 2023.

With a view to shift towards green energy, Govt's initiative on spending Rs. 35000 crores for priority capital investments towards energy transition is a welcome step which would help in attaining net zero initiatives as envisioned by Honorable Prime Minister, Shri Narendra Modi. In this regard, India's renewable energy capacity has witnessed an unprecedented growth and amounts to a share of 42.5 % of the country's total installed energy capacity which is equivalent to 173 GW of clean energy capacity based on non-fossil fuels, as on January' 2023.

Further, to ensure green mobility, the government has decided that custom duty would be exempted from capital goods and machinery required to manufacture lithium-ion cells for batteries used in EVs and extend subsides on EV batteries for another year. This will ensure further surge in the adoption of EVs in the country.

In the area of hydrogen, the Union Cabinet, in January' 2023, has approved the National Green Hydrogen Mission with an outlay of Rs 19,744 crore with an aim to make India a global hub for manufacturing of green hydrogen and promote development of green hydrogen production capacity of 5 MMT per annum by 2030. This will ensure decarbonization of industrial, mobility and energy sectors and at the same time help in reduction in dependence on imported fossil fuels.

Various Events organized by FIPI during the quarter

India Energy Week (IEW) 2023, the first major event under India's G20 Presidency, was held between 6 – 8 February 2023 at the Bengaluru International Exhibition Centre (BIEC). The event was held under the patronage of the Ministry of Petroleum & Natural Gas (MOP&NG), Government of India, and sees participation from all the Indian oil & gas companies, majority of non-oil and gas PSUs, Ministry of Power, Karnataka State Government, SIAM from automobile industry, various startups etc. and is officially supported by Indian Oil Corporation Limited (IOCL) and the Federation of Indian Petroleum Industry (FIPI). This year's theme, "Growth Collaboration Transition," embodied India's energy transition with a view of connecting global energy community for innovation, ideas, and investment on the road to net-zero. The event brought together 30,000+ global energy leaders, 8,000+ conference delegates, 1,000+ exhibitors, and 500+ renowned speakers from 150 + countries. The following positive outcomes emanated from IEW 2023: -

- The India Pavilion provided an immersive digital experience, showcasing India's energy evolution, & strategy to diversify our energy mix, policy reforms, energy transition and sustainability actions and goals.
- The Strategic conference brought together the key stake holders from the integrated energy value chain to share insights on strategies and trends impacting global energy markets,
- Executive sessions convene leaders at the forefront of business operations to share best practices in pursuing the net zero agenda,
- Technical conference offered engineers and project managers access to latest industry expertise.

India also hosted the 9th Asian Ministerial Energy Roundtable in collaboration with International Energy Forum (IEF) with the objective of "Mapping Stable & Secure Energy pathways for achieving Energy security, Energy Justice, Growth and Innovation" and India- US Executive roundtable with US-Indian Business council and US-India Strategic partnership Forum.

Further, India launched a Global Biofuel Alliance to help develop a favorable ecosystem for promoting the development and deployment of biofuels with key stakeholders, including US, Brazil, EU and facilitating cooperation and intensifying the use of sustainable biofuels by putting emphasis on strengthening markets, facilitating global biofuels trade, development of concrete policy lesson-sharing and provision of technical support for national biofuels programs worldwide.

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

FIPI in association with EY organized a webinar on 'Online security systems for the Oil and Gas Sector' on 18th January 2023. The webinar was conducted in order to shed a light on the importance of having sound and secure technology systems to shield companies from the recent increase in cyber-attacks on the Operational Technology ('OT') of companies. The webinar witnessed an overwhelming response with participation of more than 100 professionals working across the oil and gas value chain.

Further, on 2 February, 2023, FIPI organized its flagship post budget analysis session. The session was organized with EY as the knowledge partner. The session witnessed fruitful deliberations on the recently announced budget and its short-, medium- and long-term impacts on the oil and gas sector. 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 200 delegates (virtually) and was appreciated in terms of content by everyone.

Ongoing FIPI Studies

FIPI on behalf of its member companies is currently carrying out an industry study on 'Emerging Hydrogen Market and its Opportunities in India' for assessing the hydrogen market potential in India. The study is being carried out by ICF as the Knowledge Partner. The draft report has been submitted by ICF after receiving comments from the study partners on the same. The findings of the study will assess the role of hydrogen in the provision of electricity, transport, and energy storage in a low-carbon energy system in India.

Further, FIPI, along with its study partner organizations, have initiated a study on “Scope and Role of Natural Gas in Mitigation of Industrial Air Pollution.” TERI has been engaged as the research partner for the study and was awarded the work in September 2021, consisting of three industrial clusters, namely Gurgaon (Haryana), Varanasi (UP) and Sangareddy (Telangana). The report's findings will present a pressing case to the policymakers for mandating gas in industrial clusters and serve as a single data point for all advocacy efforts in this direction.

FIPI, on advice from the MoP&NG, has awarded International Consultant “BCG” a Study on “Promotion of Indian E&P Sector for enhancing E&P activities among International Operators/Investors.” This study's main aim is to promote the Indian E&P sector for enhancing E&P activities on the domestic front to International Operators/Investors through roadshows in London and Houston. Both the roadshows at London & Houston led by the Secretary, Ministry of Petroleum & Natural Gas and DG, DGH have been completed. BCG has submitted a “Investors Engagement” report to the Ministry & DGH, capturing the priority issues requiring redressal and investors’ expectations to invest in India’s E&P sector. This is the 1st such report, and BCG will submit two additional reports on Policies related to E&P & Green energy.

FIPI has been taking lead in highlighting various issues related to oil and gas sector on behalf of its member companies and will continue to address their concerned matters at relevant forums in the future as well for their redressal.

Conclusion

While the age of green energy is inevitable, the importance of oil and gas cannot be undermined either. The oil and gas sector continues to play a vital role in influencing decision-making for all the other important sections of the economy. Energy efficiency in oil & gas sector along with green energy investments, both can help in improving energy security and increasing self-sufficiency. In this regard, I am confident that FIPI, on behalf of its member companies will continue to support the role of clean technologies for a low-carbon energy transition in India and further deliberate on industry issues to ensure a resilient, sustainable future ahead.

Wishing you the very best!

Gurmeet Singh

Enhancing Energy Self-sufficiency of the Country

Papia Mandal
General Manager (Structural)

Engineers India Limited

Background

Recent decade has opened up the vistas for phenomenal growth opportunities for the nation; during this initiatives various challenges as well as alternate perspectives have emerged for a thorough consideration. Burgeoning energy demand to cater economic and societal growth and sustainability aspects along with increasing import bill are the flip sides of the same coin.

Recently, a combination of disruptive technologies, such as electric vehicles, green hydrogen, renewable energies are emerging as sustainable solutions. Though these propositions seem to be fascinating, their contribution in the total energy basket is not so large vis-a-vis total energy demand globally. Fossil fuels still remain the primary source of energy besides enabling production of petrochemicals, which are an intrinsic part of our daily life.

The Country, being deficient in fossil fuels and natural gas, has to primarily resort to importing the same. On the contrary, though coal is domestically available in abundance, majority of coal is channelized to thermal power plants or captive power plants to meet the demand of power. Further, power generation needs are primarily fulfilled from coal, in the process direct firing of the coal emits significant CO_2, thus not meeting the sustainability aspects.

On the other side, in absence of natural gas availability, naphtha is used to produce hydrogen in the refineries, which in itself is a major source of CO2 emission along with burdening the import need. Therefore, it would be very essential to establish a balance between imports of fossil fuels, indigenization and exploration of domestically available resources to maintain an ecological balance (refer Fig.-1).

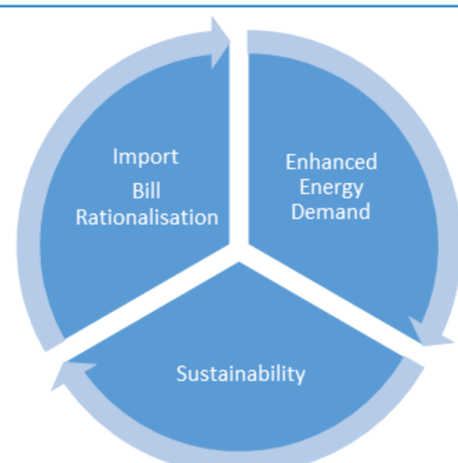


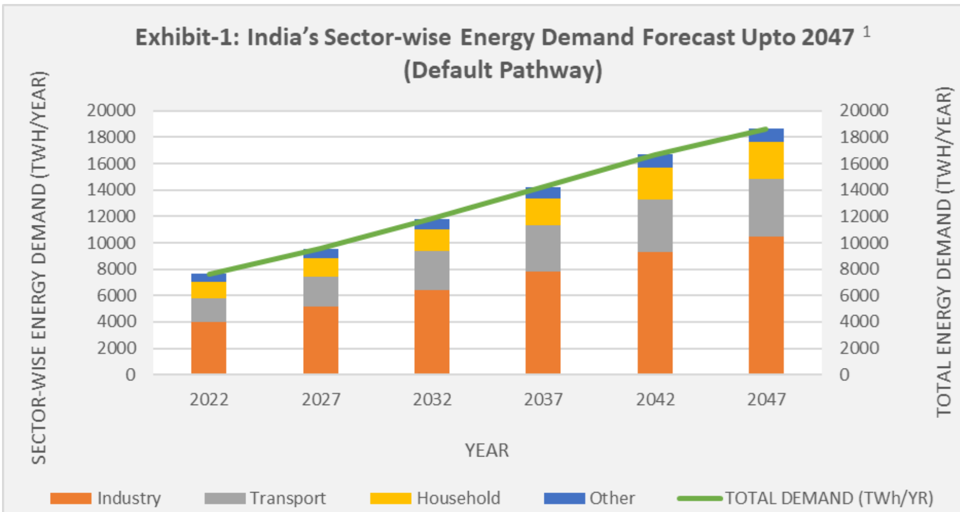
Fig. 1: Growth Perspectives

Energy Demand & Supply Forecast

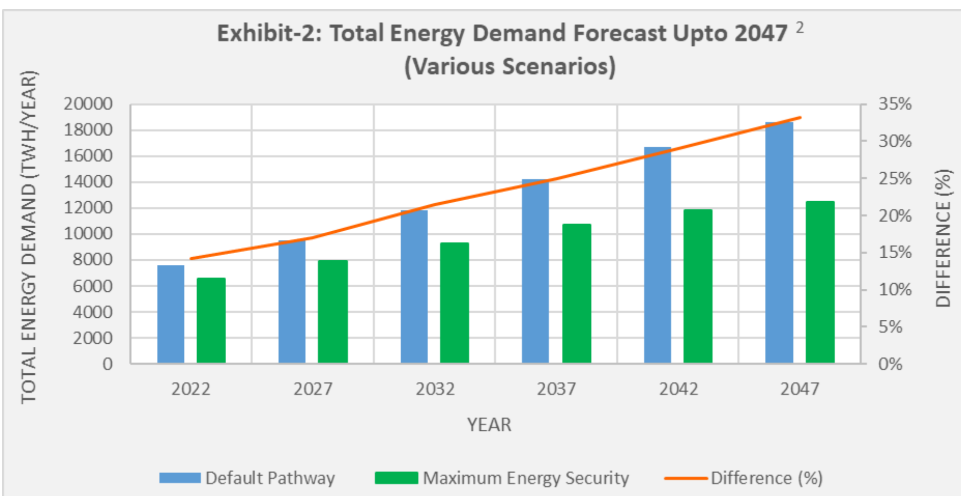
Upcoming decades of Amrit kaal, are bound to germinate monumental growth in the parameters, such as income per capita or per capita gross domestic product, the level of industrialization, the general standard of living, and the amount of technological infrastructure. Every aspect of this growth momentum will culminate in enhanced energy demand. Exhibit-1, indicates the trend of energy demand up to 2047, in a default scenario or pathway. Exhibit-2 indicates total energy demand in default pathway and maximum energy security (heroic effort in demand sectors). By ensuring maximum energy security in the country, the demand may be rationalised up to some extend only, maximum up to 33%.

To cater to the huge energy demand, supply from various sources is planned at the national level. Exhibit-3, indicates energy supply forecast up to 2047, corresponding to above-mentioned default scenario. It is evident from the forecast trend that, around 49-52% of the energy is planned from coal, another 27-29% is from oil, contribution of natural gas, bio fuel and other renewable sources are less than 10% each.

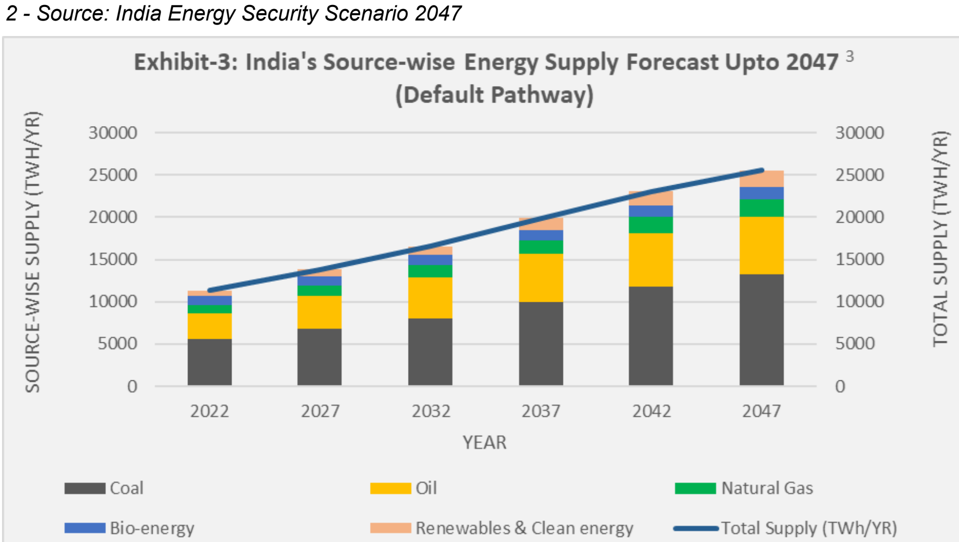
Since firing of coal produces substantial amount of CO_2, which is not desirable in the present context of sustainability. So alternatively, gasification of the domestic coal to generate syngas for further usage in Fertilisers and augmentation of other distillates may be worthwhile.



1 - Source: India Energy Security Scenario 2047



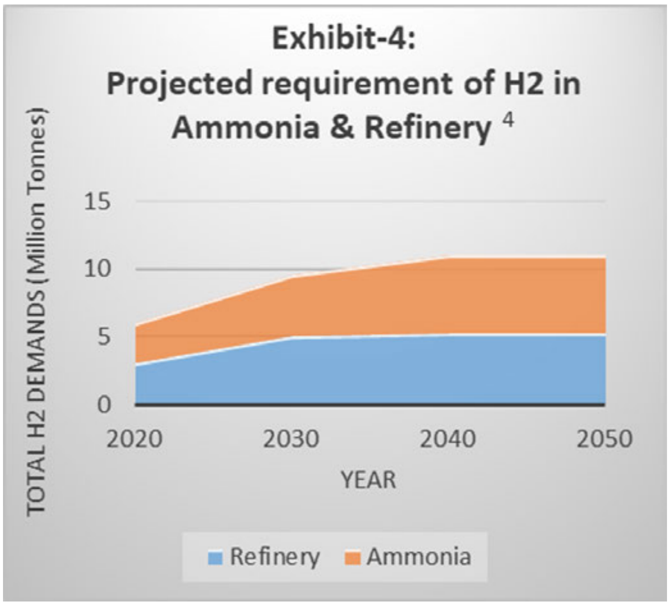
2 - Source: India Energy Security Scenario 2047



3 - Source: India Energy Security Scenario 2047

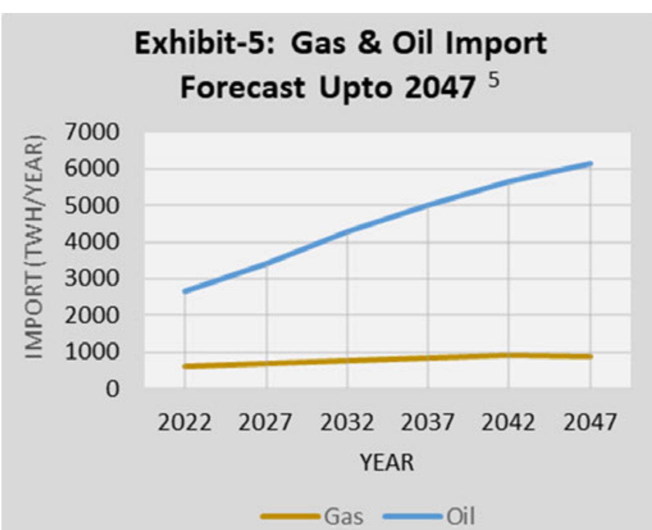
Hydrogen Demand

In addition to the Fertilisers, copious quantity of Hydrogen is required in the refineries to meet the quality of distillates. Exhibit-4, indicates projected total H_2 requirement in Ammonia plants and Refineries. Globally, hydrogen is primarily produced by steam reforming or Steam Methane Reforming (SMR) process, in which natural gas is used to produce hydrogen.



4 - Source: NITI Aayog, Report June 2022

In absence of natural gas availability domestically, imported natural gas or liquid naphtha are used to produce H_2. Along with increase in the import bill, emission of substantial amount of CO_2 act as a deterrent to this entire process. Exhibit-5 indicates gas and oil import forecast up to 2047 in a default pathway. Total import cost of gas and oil from 2022 to 2047 is around 47.5 and 430 trillion INR.



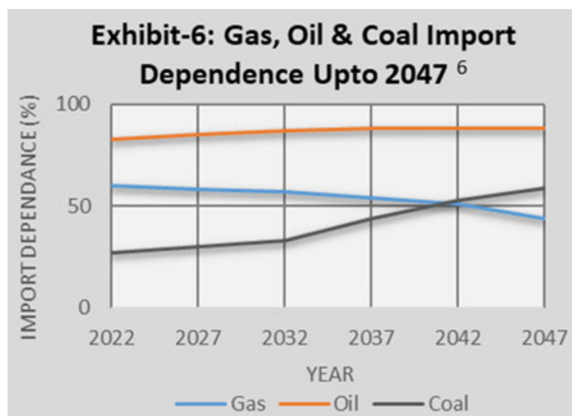
5 - Source: India Energy Security Scenario 2047

Coal Gasification

India is an agri-based economy with urea being one of the major prime movers, with coal to chemicals two major advantages could be realised,

- One, the cost of production of the urea will be the least. Sequestration of all the CO_2, produced in the plant, will enable reduction of the equivalent gas import. This can be a huge plus.

- Additionally, with syngas being available from the gasification unit, Methanol, Ethanol etc. could be produced for further blending into distillates. This not only will augment the distillate pools, but in a way will aid in reducing the differential crude import. Alternatively, replaced liquid naphtha can be utilised effectively in petrochemicals to get a better economy. This could certainly be a positive for the country, which is dependent to the extent of meeting over 90% of energy requirements through import of fossil fuels. Exhibit-6 indicates country's import dependence of gas, oil and coal up to 2047, in a default pathway.



6 - Source: India Energy Security Scenario 2047

The most significant part is that, Coal gasification now is a matured technology and with availability of domestic coal in bounty, in-spite of being of relatively poor quality, it could lead to make significant strides forward towards attaining self-sufficiency or atma nirbharta.

Green Hydrogen Integration

Since, Hydrogen is a prime necessity in the Refining Industry, the fuel for producing the same is always a major and important economic decision. In absence of gas, as mentioned above, one has to resort to utilisation of expensive liquid fuels such as naphtha to produce the same through the steam reforming process. The process is not only energy consuming but also leads to emission of substantial amount of CO_2. One of the prime requirements therefore, in the refineries, has to be to capture this CO_2 to improve the carbon footprints of the refineries. The central question though would remain how to utilise efficiently the captured CO_2?

Since, green Hydrogen in the country is gaining impetus, the trust is already there to promote the same in a mission mode. The GOI has already announced several important policy measures to encourage implementation of the same PAN India. Green Hydrogen, notwithstanding the solar energy price as INR 2/ unit still remains a bit uncompetitive, as the initial capex for the facility remains high. This of course is bound to change with time.

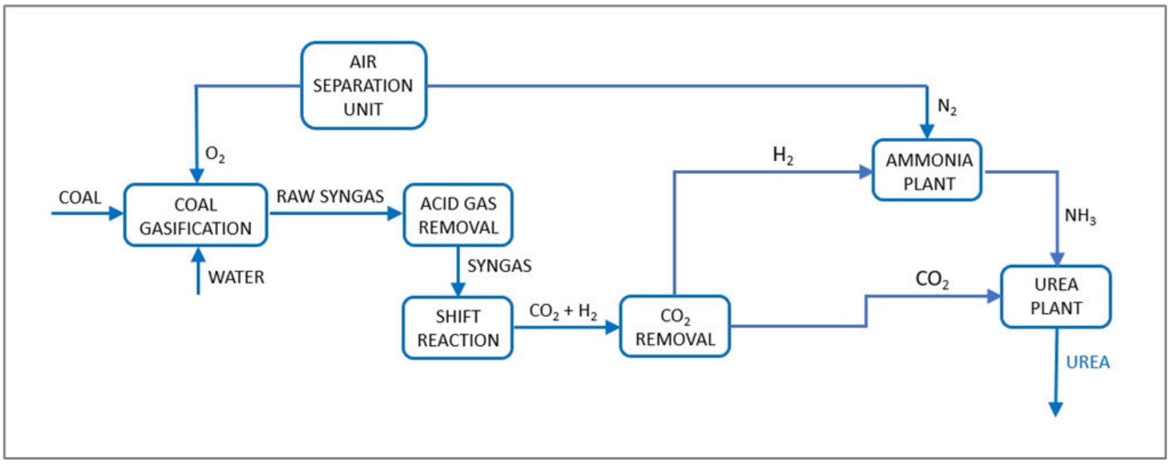


Fig. 2: Coal Gasification – Coal to Chemical

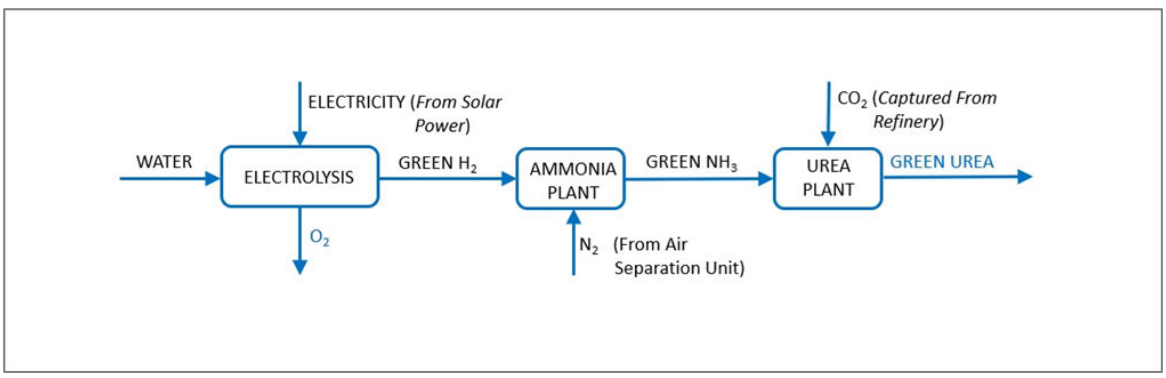


Fig. 3: Green Hydrogen to Green Urea & Oxygen

Conclusion

With the integration of coal gasification plants with fertilisers (refer Fig.-2) and further integration of green hydrogen plants with refineries and fertilisers (refer Fig.-3), following benefits could be realized,

Coal Gasification

- Coal gasification will enhance exploitation of domestic resources, indigenization and reduction of import bill.
- Least cost of production for fertiliser; thereby, also reduction in natural gas import.
- With displacement of gas as a fuel huge subsidy burden will be obviated.
- By generating methanol and ethanol as distillate blenders will reduce the overall fossil energy import.

Green Hydrogen Integration

- Utilisation of CO_2 from refineries as urea as raw material will lead to reduction in carbon footprint.
- Green ammonia through green hydrogen route and CO_2 recovery from refineries will substantially reduce import bill as the need of LNG import would reduce.
- Oxygen that will be produced as a by-product can be used for petrochemicals as well as for the medical purpose.

For green H_2 plants located in the coastal belt, possibility of exporting huge quantity of ammonia to crisis ridden European countries can be exploited and India could emerge as a major energy exporter. Both of these initiatives will prompt tremendous industrial activities and thereby provide boost to manufacturing, employment and industrialisation; and therefore, boosting the economy manifold.

Design and Synthesis of Mixture of Polymeric Ester as Pour Point Depressant for Waxy Crude

Dr. Utpal Kayal

Nidhi Verma

N. B. Joshi

Oil and Natural Gas Corporation Limited
The Institute of Oil & Gas Production Technology (IOGPT)

Abstract

Finding solution to the problem of paraffin wax deposition in crude oil production facilities is one of the major concerns in the oil industry. Chemical treatment had been most convenient and economical method for overcoming this problem. This report considered the study of laboratory synthesized mixture of polymeric ester as pour point depressant for Indian waxy crude oil. Five number of waxy crude oils from different area were characterized to determine their pour point, American Petroleum Institute gravity (APIg), wax content and viscosity using standard methods. The impacts of the blend of Ester polymer on the pour points of the crude oil samples were determined. The results obtained showed that blend of Ester polymer gave the depression of 3˚C on the pout points of the crude oil samples at concentration of 0.05%v/v of additive with crude oil. This result showed that the appropriate synthesized mixture of ester polymers can be used as more economical as a pour point depressant in crude oil facilities.

Introduction:

Wax deposition is one of the main flow assurance problems in the oil industry around the world including the offshore and onshore oil fields. When the inner wall temperature falls below the wax appearance temperature, wax deposition occurs on the cold pipeline wall due to precipitation and deposition of paraffin components in crude oil (alkanes with carbon numbers greater than 20) (Singh et al., 2000).

Wax inhibitors / pour point depressant (chemical inhibitors), chemical dilution, thermal management and pigging are used for mitigating wax deposition in the oil fields around the world. Although pigging is still a widely used technique for solving wax problems inside wells, despite being a costly procedure; thermal treatment is another frequent used technique, but it can cause formation damage. However, most of the oil companies are using wax inhibitors / pour point depressant (chemical additives), as a main mitigation method to reduce wax deposition in pipelines as chemical additives does not need to stop production for cleaning the pipe and considers as an online mitigation method (Huang et al., 2015). Several research proved that even though many wax inhibitors have been developed, there is currently no universal type of inhibitor that can be used for all kinds of crude oil due to the varying properties of crude oils (Ridzuan et al., 2014; Kang et al., 2014; Adeyanju and Oyekunle, 2014; Halim et al., 2011). There are several chemical suppliers in India that supply PPD / Wax inhibitor / flow improvers for waxy oil field. Such chemical suppliers always demand higher prices for such chemical additives / PPD / flow improver to ONGC without disclosing the composition of their product. Hence, the development of efficient synthesis of pour point depressant (PPD) / wax inhibitor / flow improver has been the focus of many researchers for decades and continues to be an active and rewarding area of research in oil industry. Therefore, the objective of this paper is to synthesize polymeric ester blend in laboratory and investigate their effect on pour point depression on crude oil from different field of India.

Key words: mixture of ester polymers, pour point, waxy crude oil, viscosity.

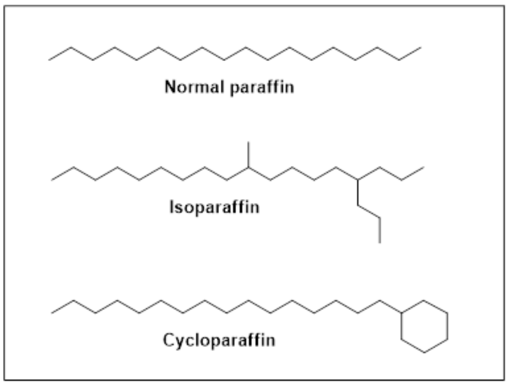


Fig. 1 Typical formulae of petroleum waxes

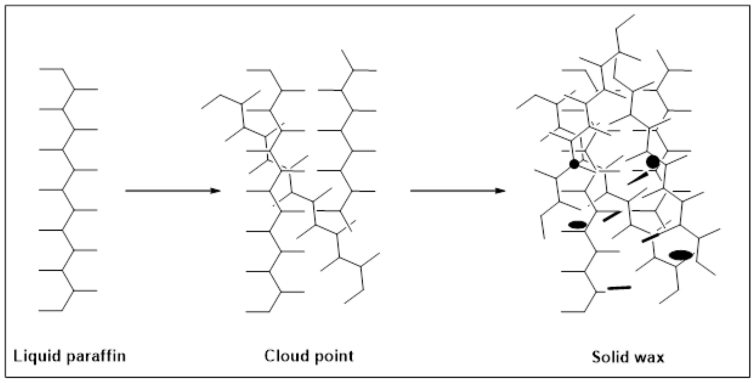


Fig. 2 Mechanism of wax deposition

Results and Discussion

Fluid interest

The objectives of this study were the development of pour point database for major crude oils produced in India, and characterization of the effects of laboratory synthesized polymeric ester blend as flow improvers (PPD) on these crude oils. Three waxy crude oils were obtained from the eastern offshore asset (Oil-A & Oil-B) and from western offshore asset (Oil-C) parts of the country used as test subjects in this investigation.

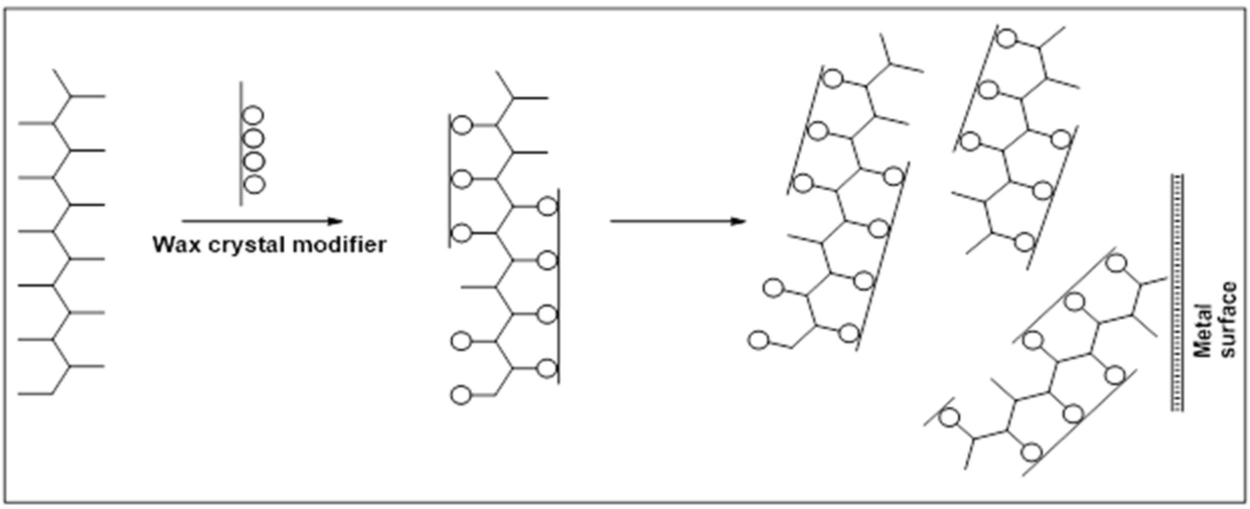


Fig. 3 Interaction between crude oil and PPD

Physical characteristics of crude oil samples

The physical characteristics of crude oil samples namely Oil-A, Oil-B and Oil-C collected from EOA & WOA are given in Table 1.1.

Table 1.1 – Physical characteristics of Oil-A, Oil-B and Oil-C crude oil sample

Properties	Unit	Oil-A	Oil-B	Oil-C
Density,15°C	g/ml	0.8877	0.8368	0.8505
Sp. Gravity, 60/60°F	-	0.8882	0.8372	0.8509
API gravity	Deg	27.81	37.52	34.79
Water content	% v/v	06	3%	1.7
Free water	% v/v	Nil	Nil	Nil
BS&W	% v/v	06	3	1.7

Asphaltene Deposition Potential

• The SARA distribution of the crude oil samples are presented in Table 1.2.
• The colloidal Instability Index (CII) has been calculated as the ratio of the sum of saturates and asphaltenes fractions to the sum of the aromatics and resins fractions.
• Similarly, A/R ratio and ΔRI (Refractive Index) have also been calculated depending upon SARA Analysis. However as per literature survey, the asphaltene deposition characteristic is more prominently indicated by CII and ΔRI (Refractive Index) rather than Asphaltene/Resin (A/R) ratio. Hence in all likelihood the crude will have the asphaltene deposition tendency which can be more accurately predicted through live crude oil studies with phase behaviour.

Table 1.2 – SARA distribution of Oil-A, Oil-B and Oil-C crude oil sample				
Properties	Unit	Oil-A	Oil-B	Oil-C
Saturates	% w/w	77.85	72.27	81.99
Aromatics	% w/w	17.85	25.06	14.85
Resin	% w/w	03.61	02.42	02.79
Asphaltene	% w/w	0.69	0.25	00.39
Colloidal Instability Index (CII)	-	3.66	2.64	4.67
Asphaltene/Resin (A/R) Ratio	-	0.19	0.103	0.14
ΔRefractive Index (ΔRI)	-	0.024	0.02	0.02

Wax Deposition Potential – by CND Method

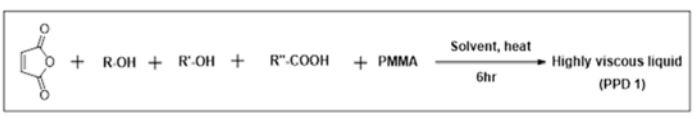
The salient parameters of wax and crude that can be obtained through carbon number distribution (CND) of crude and wax are concentration of each hydrocarbon, average carbon number, average molecular weight and normal and non-normal hydrocarbon.

Table: 1.3 - Wax content and pour points of Oil-A, Oil-B and Oil-C crude oil sample				
Properties	Unit	Oil-A	Oil-B	Oil-C
Pour point	°C	(+33)	(+30)	(+36)
Wax content	% w/w	10.91	9.16	15.46

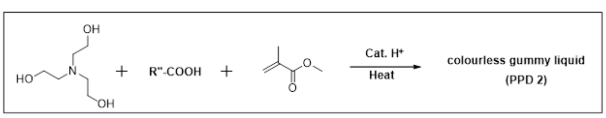
Schematic synthetic procedure of PPD

All reactions were carried out under the atmospheric pressure as well as in inert condition using flame-dried reaction vessels. Unless otherwise noted, all commercially available compounds were used as purchased without further purification.

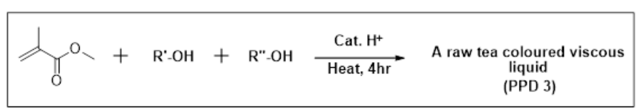
Scheme: 1



Scheme: 2



Scheme: 3



Pour point depression test

Table 1.4 shows the effect of pour point of the crude oil achieved by dosing of synthesized PPD-1

Table: 1.4 - Effect of pour point achieved by dosing of synthesized PPD-1 on Oil-A, Oil-B and Oil-C crude oil sample				
Sr. No.	Sample	Dosed Conc. (ppm)	Pour point (°C)	
			Before dosing	After dosing
1	Oil-A	250	33	33
2		500	33	33
3		1000	33	33
4		1500	33	33
5	Oil-B	250	30	30
6		500	30	30
7		1000	30	30
8		1500	30	30
9		250	36	36
10		500	36	36
11		1000	36	36
12		1500	36	36

Table 1.5 shows the effect of pour point of the crude oil achieved by dosing of synthesized PPD-2

Table: 1.5 - Effect of pour point achieved by dosing of synthesized PPD-2 on Oil-A, Oil-B and Oil-C crude oil sample				
Sr. No.	Sample	Dosed Conc. (ppm)	Pour point (°C)	
			Before dosing	After dosing
1	Oil-A	250	33	33
2		500	33	33
3		1000	33	33
4		1500	33	33
5	Oil-B	250	30	30
6		500	30	27
7		1000	30	27
8		1500	30	27
9	Oil-C	250	36	36
10		500	36	36
11		1000	36	36
12		1500	36	36

Table 1.6 shows the effect of pour point of the crude oil achieved by dosing of synthesized PPD-3

Table: 1.6 - Effect of pour point achieved by dosing of synthesized PPD-3 on Oil-A, Oil-B and Oil-C crude oil sample

Sr. No.	Sample	Dosed Conc. (ppm)	Pour point (°C)	
			Before dosing	After dosing
1	Oil-A	250	33	33
2		500	33	33
3		1000	33	33
4		1500	33	33
5	Oil-B	250	30	30
6		500	30	30
7		1000	30	30
8		1500	30	30
9	Oil-C	250	36	36
10		500	36	36
11		1000	36	36
12		1500	36	36

As can be seen from Table-1.5, treatment by PPD-2 leads to a significant pour point reduction of the Oil-B. Treatment with a dosage of 500 ppm achieved a remarkable pour point reduction of 3 °C. Further pour point depression can be achieve with higher dosage levels. Effect of dosing PPD to the rheology of the crude is under progress.

Conclusions

In conclusion, we have developed a novel and simple synthetic methodology for PPDs with mixed polymeric alkyl esters and applied to Indian waxy oils. By introducing a long alkyl branching into the polymer structure, the solubility of the polymer in toluene could be almost doubled and the final solvent based PPDs were still liquid at ambient temperature.

Acknowledgements

The authors would like to thank N. B. Joshi and Partha Sengupta of IOGPT, Panvel, for constant support and encouragement. The library and laboratory access provided at the Institute of Oil and Gas Production Technology, Mumbai, by Oil and Natural Gas Corporation is greatly appreciated.

Petroleum Hydrocarbon Content in Sediments around ONGC's Installations in the Western Offshore Region, Arabian Sea – A Temporal Study Spanning over a Decade



Nikita Chiripal
Sr. Chemist,
Environment Division

Shanker Jha
Suptdg. Chemist,
Environment Division

N.N. Ray
CGM (Chem)-Head
Environent

Oil and Natural Gas Corporation Limited
Institute of Petroleum Safety, Health and Environment Management (IPSHEM)

Abstract

ONGC deployed several drilling rigs and commissioned process platforms besides more than a hundred unmanned platforms in the Western Offshore Region, Arabian Sea, to extract crude oil from the reservoirs. This paper is written with the aim of studying the impact of its Exploration and Production (E&P) activities on the marine environment, by focusing on the most significant pollutant, Petroleum Hydrocarbon Content (PHC) in sediments.

Annual studies have been done to collect and measure the concentration of petroleum hydrocarbon in sediment samples in the vicinity of ONGC's installations from 2012-2021. A trend analysis has been done and data compared to the contaminant values in the region in 2001. Data of PHC in sediments from other seas have also been used to assess the environmental health of Arabian Sea.

1. Introduction

Since its inception, ONGC has been instrumental in transforming the country's limited upstream sector into a large viable playing field, with its activities spread throughout India and significantly in overseas territories. It went offshore in early 70's and discovered a giant oil field in the form of Bombay High, now known as Mumbai High.

Keywords: Petroleum Hydrocarbon Content (PHC), sediment, pollution, Arabian Sea

This discovery, along with subsequent discoveries of huge oil and gas fields in Western offshore changed the oil scenario of the country [1]. Today, ONGC accounts for around 71% of the country's total crude oil and natural gas output, of which 70 % is obtained from its offshore assets in the western and eastern regions [2]. Thus, due to the extensive E&P activities, it becomes imperative to ascertain a sustainable development with minimal adverse impact on the marine ecosystem of the region. ONGC has a robust Environment Management System in a bid to address environmental issues arising out of its E&P operations. It is deeply committed to the preservation of the environment & ecology and sustainable development. In its efforts towards environmental protection, ONGC started regular environment monitoring of its oil fields and installations around Western Offshore areas in 1994-95, through its pioneer institute IPSHEM.

In this paper, the long term impact of E&P operations on the marine environment in Western Offshore Region is studied - elucidating the temporal distribution of PHC in the sediments. PHC has been chosen for the study as petroleum it is an important pollutant in the sea, with oil contamination being increasingly recognized as a major hazard to marine ecosystem. PHC in sediments has become a benchmark parameter, acceptable to most regulatory agencies nationally, and internationally. Though oil is lighter than water, due to down welling movement of ocean and in the process of food cycle involving planktons and benthos, petroleum hydrocarbon reaches bottom sediments, where they accumulate and undergo further weathering: dispersion, dissolution and biodegradation. They can even partition into pore water and then into tissues of the marine organism, proving toxic to the benthic life. As benthic communities play an important role in the transfer of materials from primary production through the detrital pool into higher tropic levels, including commercially exploitable fish, the hydrocarbon pollution in sediment can affect the entire food web of marine organisms as well as it can affect even human being also.

This paper studies the PHC in sediments collected from the vicinity of ONGC's installations in Western Offshore Region, from 2012 to 2021, with 2001 serving as a baseline data point. Petroleum hydrocarbon content in sediments in the area is also compared to the values of hydrocarbon found in sediments of other seas of the world.

2. Study Area

The study area extends geographically from latitude 18^0 to 21^0 N and longitude 70^0 to 73^0 E covering oil and gas fields of ONGC in the Western continental shelf. The installations are

1. Heera : HRA
2. Neelam : NLM
3. Bombay High North : NA , NQ
4. Bombay High South : ICP, BHS, SHP
5. Bassein : BLQ

The depth of water column varies from 30-90 m. The field, nearest to the coast, is at an aerial distance of about 60 km while the farthest station is approximately 180 km from the coast.

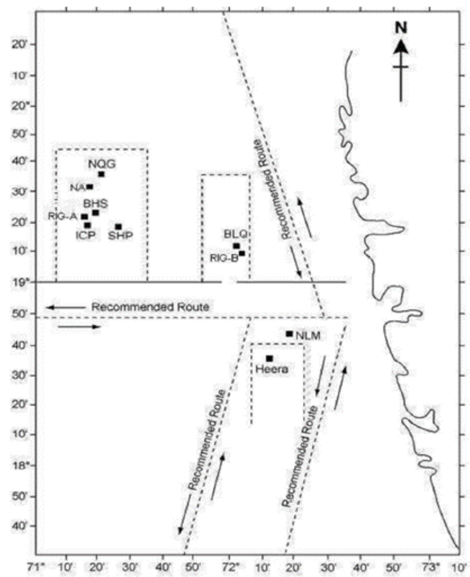


Figure 1: Location of offshore process oil platforms of ONGC in Western Offshore Region

3. Materials and Methods

3.1 Sampling

From 2012-2014, the sampling strategy was in line with PARIS Commission Guidelines [13], as shown in Figure 2. From 2015-2021, OSPAR (Oslo and Paris) Commission Guidelines [14] have been followed, as shown in Figure 3.

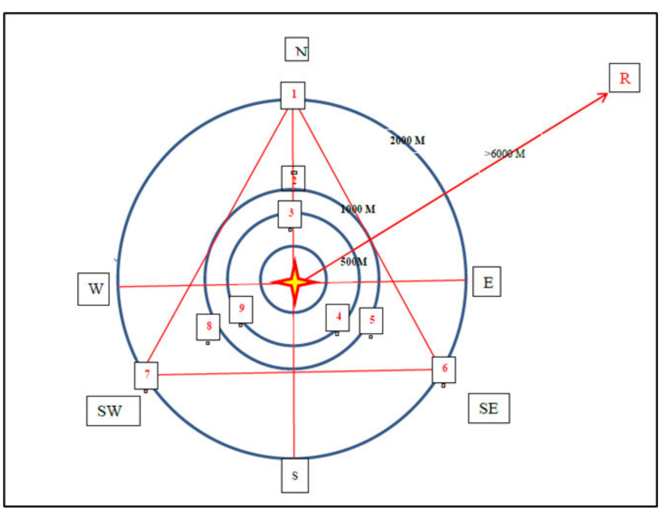


Figure 2: PARIS Commission Sampling Strategy [1 -9 are sampling points, R is reference location]

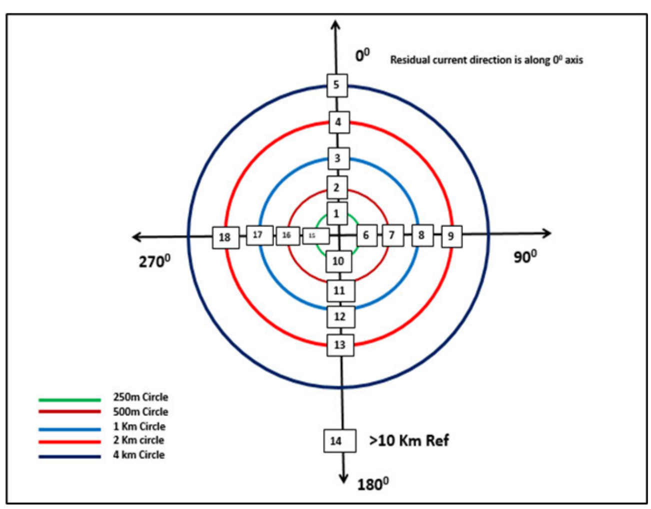


Figure 3: OSPAR Sampling Strategy [1-18 are sampling points]

Based on sampling guidelines and keeping in view the pipeline network in the vicinity of the platforms in addition to sea state and maneuverability of the sampling vessel around the installations, sediment samples were collected from various distances from the installation in various directions. The sampling was done post monsoon [November-December]. A Van Veen Grab of 25 cm dimension and approximately 1.5 kg capacity having a penetration depth of 10 cm was used for sampling. Prior to deployment, the grab was cocked with the safety key in place. The grab was then hoisted over the side, the safety key was removed, and the grab was lowered at 2 m/sec until it is 5 m above the bottom. From this point, it was lowered at 1 m/sec to minimize the effects of bow wave disturbance. After bottom contact was made (indicated by slack in the lowering wire), the tension on the wire was slowly increased, causing the lever arms to close the grab. It was then pulled up, onboard. Sediments of the upper 5 cm were collected with a plastic spoon and stored in clean vinyl bags to prevent the possible contamination. As soon as the field work was finished, sediment samples were carefully shipped and preserved at laboratory.

3.2 Sample Analysis

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

4. Results and Discussion

The value of PHC in sediment at the various installations are tabulated in Table 1 below, from 2012 to 2021, and data from 2001 is used for comparison. Graphical representations have been drawn in Figures 3 to 10.

Year	Installations							
	HRA	NLM	BLQ	NQ	NA	BHS	ICP	SHP
2001	***138.5***	***20.3***	***16.8***	***37.6***	***44.6***	***113.6***	***148.7***	***150.9***
2012	62.57	59.89	44.23	53.93	42.80	61.21	60.49	63.73
2013	54.82	61.50	48.22	51.66	44.00	52.76	62.47	61.28
2014	52.30	56.35	44.45	52.91	37.74	45.81	46.44	60.03
2015	82.26	95.84	106.11	103.12	100.17	95.52	99.34	98.60
2016	82.03	103.96	104.08	109.91	97.76	104.26	102.14	112.86
2017	82.08	59.21	88.02	149.15	109.57	96.94	108.03	98.38
2018	84.84	64.86	100.87	159.98	118.62	97.37	114.70	100.22
2019	85.52	66.36	100.88	155.23	126.39	97.64	116.93	102.19
2020	85.24	72.80	98.11	154.42	126.51	100.98	113.91	96.08
2021	85.16	74.38	121.07	157.07	122.8	105.28	121.15	93.54

Table 1: Average PHC in sediments (µg/g) of various installations in 2001 and 2012-2021

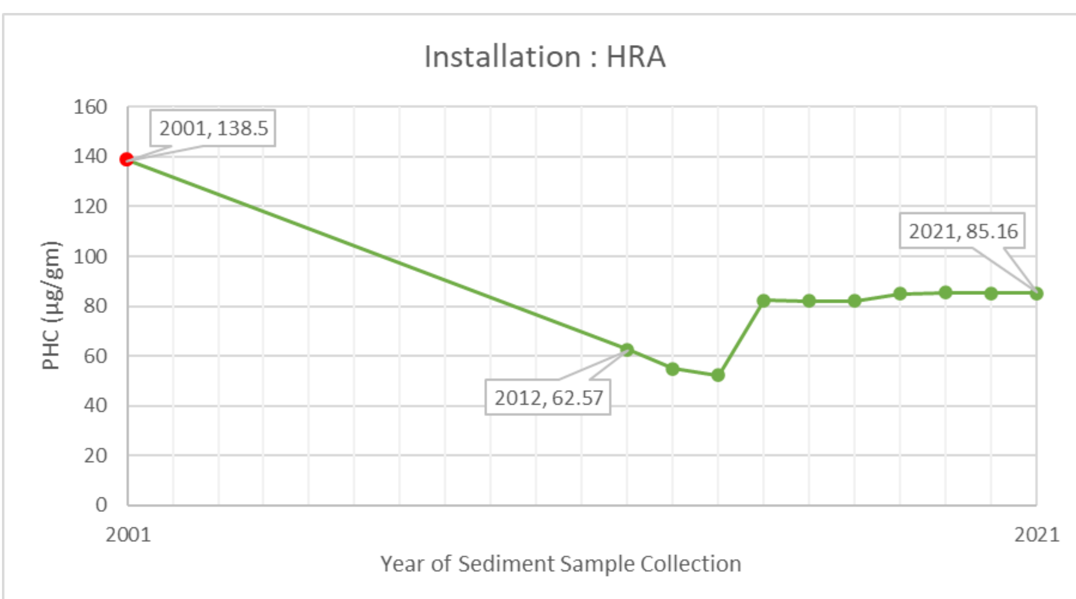


Figure 3: Trend of PHC in sediments from 2012-2021 at Heera (HRA)

PHC in sediments, at HRA, show more or less and stable trend since 2015, and the values have decreased when compared to 2001 level.

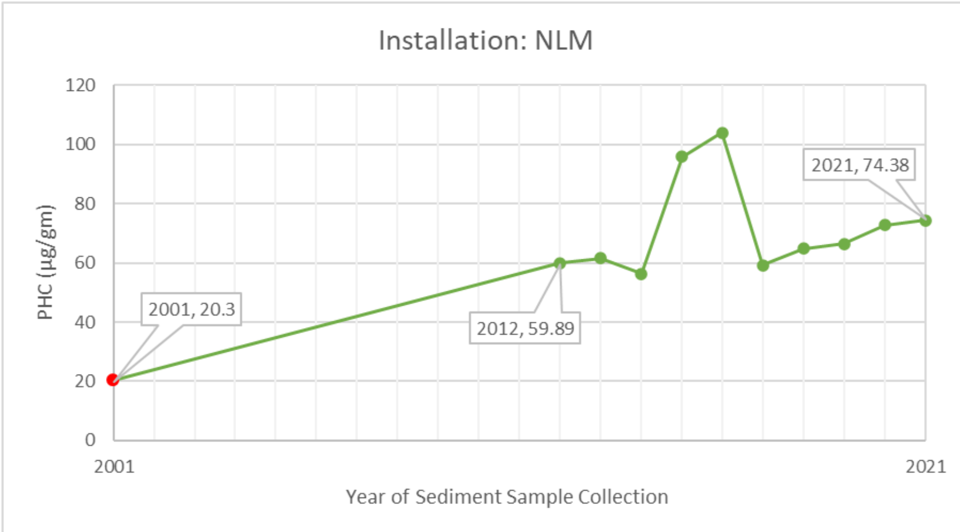


Figure 4: Trend of PHC in sediments from 2012-2021 at Neelam (NLM)

PHC in sediments, at NLM, show a rising trend with highest values recorded in 2015 and 2016.

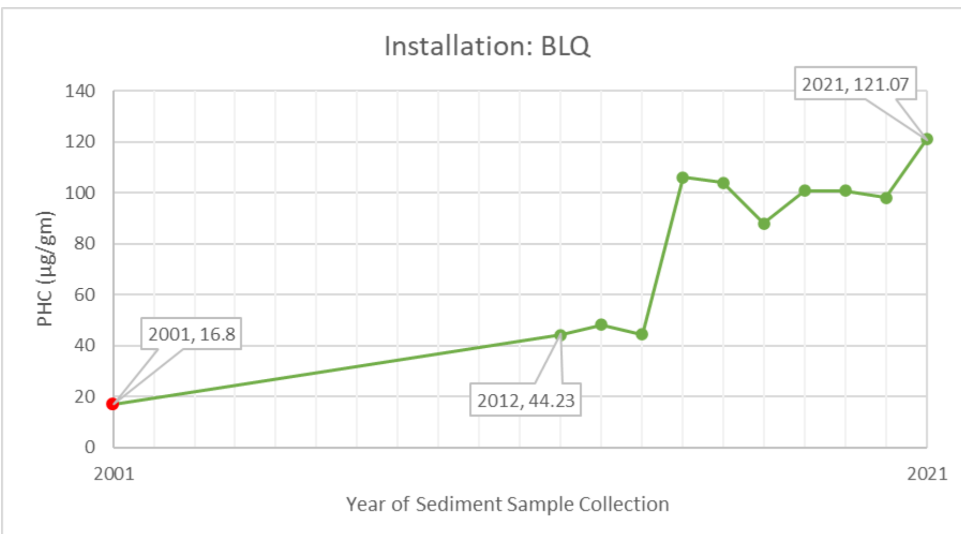


Figure 5: Trend of PHC in sediments from 2012-2021 at Bassein (BLQ)

PHC in sediments, at BLQ, show a rising trend with values peaking in 2015 and 2016.

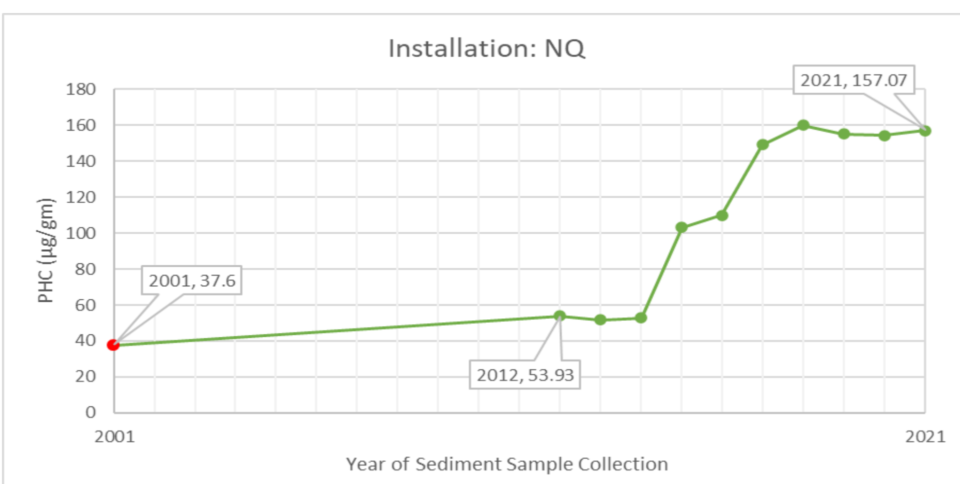


Figure 6: Trend of PHC in sediments from 2012-2021 at Bombay High North (NQ)

PHC in sediments, at NQ, show a stable trend since 2015, but have increased when compared to 2001 levels.

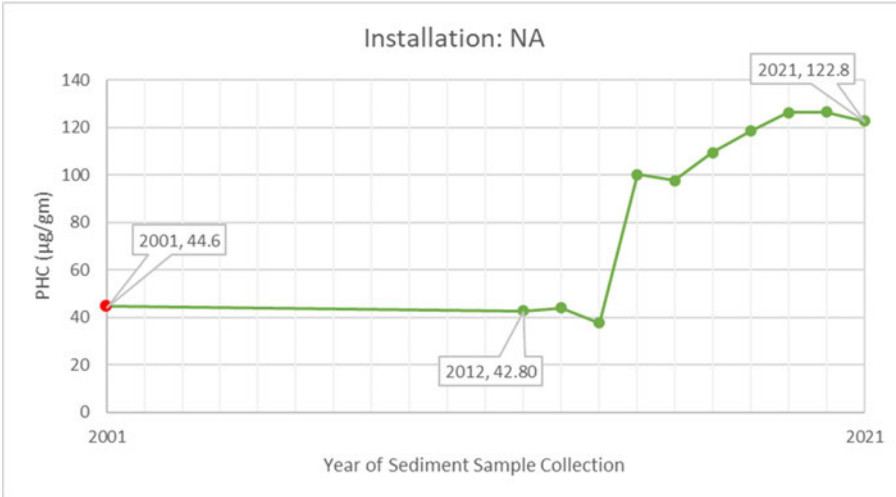


Figure 7: Trend of PHC in sediments from 2012-2021 at Bombay High North (NA)

PHC in sediments, at NA, show an overall rising trend.

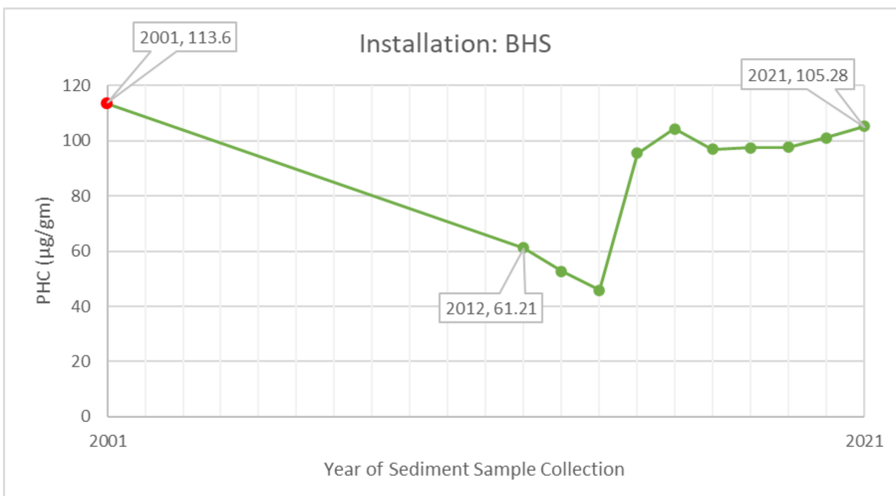


Figure 8: Trend of PHC in sediments from 2012-2021 at Bombay High South (BHS)

PHC in sediments, at BHS, show an almost stable trend since 2015, and is less when compared to the 2001 level, with a dip in 2014.

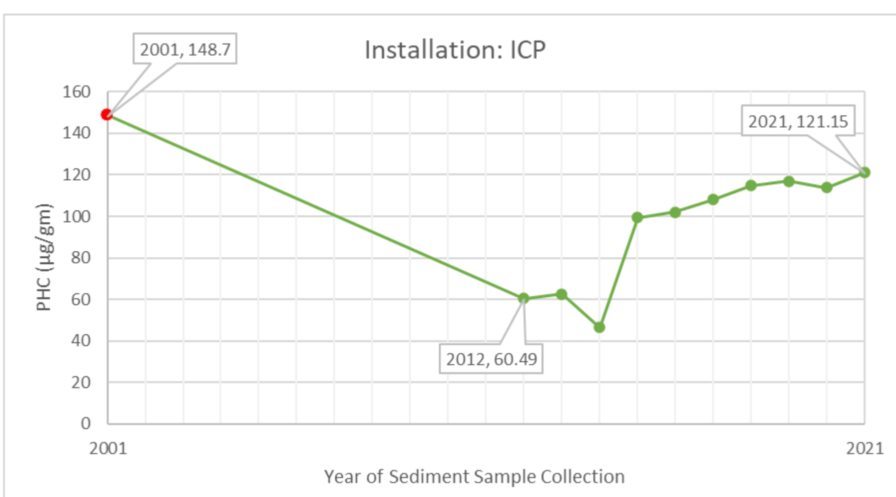


Figure 9: Trend of PHC in sediments from 2012-2021 at Bombay High South (ICP)

PHC in sediments, at ICP, show a rising trend since 2014, but has decreased considerably when compared to 2001 levels.

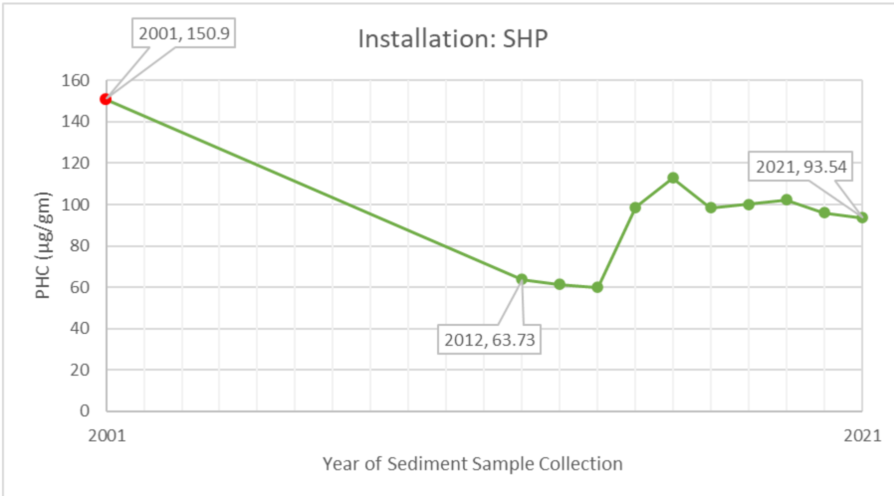


Figure 10: Trend of PHC in sediments from 2012-2021 at Bombay High South (SHP)

PHC in sediments, at SHP, show a stable trend since 2015, and has decreased considerably when compared to 2001 levels.

Area	Survey year	Total Petroleum hydrocarbons (µg/g)
Saudi Arabia, Gulf [4]	1991–1993	11-6900
Kuwait, Gulf [4]	1992–1993	40–240
Xiamen Harbour, China [5]	1993	3.1–33
Victoria Harbour, Hong Kong [5]	1992	60–646
Western Coast, Taiwan [6]	1990	869–10300
Rhone River, France, Mediterranean Sea [7]	1985–1986	25–170
Kuwait, Gulf [8]	1991	28
Saudi Arabia, Gulf [8]	1991	19–671
Great Barrier Reef, Australia [9]	1984	0.5–2
New York Bight, USA [10]	1971–1975	35–2900
Black Sea [11]	1988–1990	7–153a
Bosphorus, Black Sea, Turkey [12]	1995	12–76
Sochi, Black Sea, Russia [12]	1995	7.6–170
Odessa, Black Sea, Ukraine [12]	1995	110–310
Danube Coastline, Black Sea, Ukraine [12]	1995	49–220

Table2: PHC in various sea sediments

5. Conclusions

• The PHC values of all installations of Mumbai High are lesser than the PHC values of sediments in other seas of the world with extensive E&P activities.
• Over the years from 2001-2021, it has been observed that sediments around HRA, ICP, BHS and SHP are less contaminated with petroleum hydrocarbon.
• Focusing on Mumbai High area, it has been observed that sediments around Mumbai High South (ICP, SHP, BHS) are less contaminated than those of Mumbai High North (BHN, NQ), in recent years.
• The study reveals an increasing trend of PHC in sediments in the installations of NLM, BLQ, NQ and NA from 2012 to 2021, and also an increase from 2001 levels, although the overall values are still less than PHC in other sea sediments around the world.

6. Contributions and Declaration

Sampling and analysis carried out jointly by Environment Team, IPSHEM & CSIR-NIO (2001, 2012), Environment Team, IPSHEM & Detox Corporation Pvt. Ltd. (2013-2017) and Environment Team, IPSHEM & Vimta Labs Ltd. (2018-2021). Author contributions: Manuscript was conceptualized and prepared by NC, reviewed by SJ and NNR.

Views expressed in the study are of the authors alone, and not necessarily of ONGC. Authors declare no conflict of interests.Authors acknowledge the support of Head IPSHEM and ONGC management for funding of the project and preparation of the manuscript.

7. References

[1] https://ongcindia.com/web/eng/about-ongc/history
[2] ONGC's Annual Report 2021-22
[3] Offshore Environment Monitoring around ONGC installations in Western Offshore Region reports 2001,2012,2013,2014,2015,2016,2017,2018,2019,2020,2021
[4] Readman et al. (1996)
[5] Hong et al. (1995)
[6] Jeng and Han (1994)
[7] Bouloubassi and Saliot (1993)
[8] Fowler et al. (1993)
[9] Volkman et al. (1992)
[10] Farrington and Tripp (1977)
[11] Wakeham (1996)
[12] J W Readman and G Fillmann (1995)
[13] Paris commission(1989) Guidelines for monitoring methods to be used in the vicinity of platforms in the North Sea, Paris Commission
[14] https://www.ospar.org

Supplementary Tables

Sampling Station		Installations							
		HRA	NLM	BLQ	NQ	NA	BHS	ICP	SHP
N 2km	1	64.32	104.84	94.5	81.41	38.34	110.23	75.36	110.47
N 1km	2	81.74	34.52	62.54	56.32	64.35	38.17	34.57	87.35
N 0.5km	3	25.32	52.65	9.84	43.52	11.34	24.57	91.25	43.54
SW 2km	4	64.42	100.24	84.75	107.68	48.35	67.32	49.24	52.36
SW 1km	5	61.47	27.68	15.6	51.27	61.24	60.75	58.24	56.58
SW 0.5km	6	34.4	47.65	38.54	67.54	73.68	34.35	76.34	31.67
SE 2km	7	108.54	67.65	61.75	57.25	16.67	94.71	82.26	81.45
SE 1km	8	58.34	61.24	10.45	6.81	27.58	64.25	45.68	62.54
SE 0.5km	9	64.57	42.57	20.14	13.54	43.65	56.57	31.47	47.58

Table 3: PHC in sediments of various sampling points of selected installations (µg/g) in 2012

Sampling Station		Installations							
		HRA	NLM	BLQ	NQ	NA	BHS	ICP	SHP
N 2km	1	51.43	96.54	67.92	92.34	43.65	89.57	49.65	103.87
N 1km	2	74.32	46.71	43.68	43.57	54.31	46.74	59.75	72.41
N 0.5km	3	37.86	65.27	15.69	38.64	16.84	20.57	86.42	46.81
SW 2km	4	42.46	110.64	56.72	99.45	56.81	58.41	36.84	67.51
SW 1km	5	53.69	34.67	12.24	46.85	45.37	42.74	69.54	43.86
SW 0.5km	6	78.24	53.41	75.67	58.23	88.37	58.67	89.67	45.82
SE 2km	7	41.67	62.51	46.87	46.51	21.34	76.48	65.82	76.54
SE 1km	8	56.87	51.24	58.41	15.84	33.69	42.68	58.76	53.42
SE 0.5km	9	56.87	32.48	56.78	23.54	35.61	38.97	45.82	41.26

Table 4: PHC in sediments of various sampling points of selected installations (µg/g) in 2013

Sampling Station		Installations							
		HRA	NLM	BLQ	NQ	NA	BHS	ICP	SHP
N 2km	1	68.34	91.35	86.42	86.24	-	-	37.65	95.68
N 1km	2	37.54	37.65	34.71	-	37.64	71.25	-	31.25
N 0.5km	3	76.87	43.69	21.67	29.34	-	28.91	35.78	51.52
SW 2km	4	56.64	75.5	20.37	52.76	-	-	-	89.67
SW 1km	5	34.31	56.42	42.87	-	31.35	57.84	-	58.1
SW 0.5km	6	38.21	62.31	62.76	76.84	39.4	42.14	46.57	24.85
SE 2km	7	31.57	75.14	51.67	-	-	43.15	-	37.94
SE 1km	8	59.67	34.58	29.67	42.39	-	-	58.76	86.54
SE 0.5km	9	67.59	30.48	49.87	29.87	42.58	31.57	53.45	64.68

Table 5: PHC in sediments of various sampling points of selected installations (µg/g) in 2014

Sampling Station		Installations							
		HRA	NLM	BLQ	NQ	NA	BHS	ICP	SHP
N 0.25km	1	134.67	135.61	138.14	136.47	126.45	127.24	130.57	139.65
N 0.5 km	2	115.24	120.27	124.34	122.24	100.37	94.21	118.37	105.31
N 1 km	3	94.24	104.27	93.67	93.68	95.54	72.54	89.44	91.24
N 2 km	4	76.34	94.37	93.24	86.87	81.14	67.31	76.57	89.37
N 4 km	5	98.26	61.24	67.45	52.37	76.47	72.28	67.64	78.24
W 0.25km	6	64.67	116.34	124.24	122.98	118.27	132.67	134.52	126.47
W 0.5 km	7	51.37	93.67	114.38	104.75	98.57	123.41	120.41	112.38
W 1 km	8	75.14	97.32	87.38	85.64	72.16	121.38	84.41	89.27
W 2 km	9	67.45	54.68	58.94	75.75	74.14	82.57	75.97	74.41
S 0.25km	10	78.47	107.54	131.35	139.65	110.24	126.18	119.34	123.58
S 0.5 km	11	64.68	90.37	121.37	126.34	97.36	113.14	104.54	107.34
S 1 km	12	87.58	83.21	84.52	87.64	87.67	87.34	94.28	84.65
S 2 km	13	61.27	79.57	62.14	63.27	86.84	62.67	83.37	76.64
E 0.25km	14	79.34	124.64	129.42	131.67	137.34	66.41	124.21	121.32
E 0.5 km	15	68.51	104.62	106.34	128.24	108.35	118.62	108.61	103.58
E 1 km	16	83.74	85.28	139.57	113.32	124.67	87.47	87.32	89.41
E 2 km	17	97.45	76.34	127.37	82.21	107.24	68.34	69.24	63.41

Table 6: PHC in sediments of various sampling points of selected installations (µg/g) in 2015

Sampling Station		Installations							
		HRA	NLM	BLQ	NQ	NA	BHS	ICP	SHP
N 0.25km	1	116.47	121.41	132.41	146.74	105.64	148.5	124.78	159.53
N 0.5 km	2	94.32	114.85	104.2	112.35	78.12	115.34	135.61	131.72
N 1 km	3	84.35	92.67	118.6	102.35	92.71	88.5	86.4	112.42
N 2 km	4	62.58	85.21	71.25	98.34	67.24	86.21	95.62	93.24
N 4 km	5	143.25	109.47	82.5	71.68	91.78	90.2	68.5	86.34
W 0.25km	6	62.37	124.9	143	111.24	98.75	139.49	149	136.86
W 0.5 km	7	48.67	90.27	98.56	96.54	101.58	116.43	114.2	115.63
W 1 km	8	85.1	113.57	96.51	102.46	79.8	97.24	80.6	96.34
W 2 km	9	76.52	138.64	74.29	82.61	79.67	62.4	80.5	82.31
S 0.25km	10	78.47	116.58	133.58	142.35	130.67	74.25	135.25	142.67
S 0.5 km	11	64.68	88.63	106.75	130.63	85.31	118.7	116.98	131.22
S 1 km	12	87.58	94.52	74.5	115.24	116.59	102.6	96.52	112.34
S 2 km	13	61.27	85.43	89.54	102.34	94.58	75.64	78.41	83.64
E 0.25km	14	79.34	129.52	152.46	135.21	120.68	139.47	102.67	130.27
E 0.5 km	15	68.41	116.57	126.8	121.42	131.87	124.68	119.37	115.84
E 1 km	16	83.74	83.64	77.9	95.64	91.24	106.42	91.2	89.64
E 2 km	17	97.45	61.42	86.52	101.4	95.68	86.35	60.8	98.54

Table 7: PHC in sediments of various sampling points of selected installations (µg/g) in 2016

Sampling Station		Installations							
		HRA	NLM	BLQ	NQ	NA	BHS	ICP	SHP
N 0.25km	1	95.31	85.37	114.68	185.63	136.84	152.34	118.64	95.62
N 0.5 km	2	86.31	62.13	90.55	135.69	112.37	81.25	126.78	104.2
N 1 km	3	58.62	52.34	96.85	176.39	86.34	95.27	78.64	118.6
N 2 km	4	75.68	46.21	86.37	79.35	102.56	42.15	128.67	71.25
N 4 km	5	74.31	34.68	78.35	142.63	71.34	56.11	46.81	56.87
W 0.25km	6	86.93	74.38	121.37	218.35	175.39	184.32	235.61	103.58
W 0.5 km	7	102.35	53.27	86.92	169.67	154.23	98.41	69.51	126.94
W 1 km	8	66.89	61.29	75.38	131.75	111.24	86.26	56.38	96.51
W 2 km	9	89.21	39.67	44.15	149.68	85.36	75.92	131.27	124.63
S 0.25km	10	94.27	81.75	124.61	198.34	121.59	152.37	195.37	88.95
S 0.5 km	11	86.34	64.85	113.64	179.35	78.51	104.35	110.34	88.96
S 1 km	12	85.67	56.31	86.92	131.54	102.39	95.33	85.92	44.62
S 2 km	13	73.58	49.87	73.64	76.38	86.37	76.27	84.61	89.54
E 0.25km	14	102.38	98.35	98.65	176.39	131.26	95.32	113.61	178.34
E 0.5 km	15	86.37	37.56	67.58	162.31	112.34	98.39	105.26	126.8
E 1 km	16	92.46	43.68	84.11	143.67	112.35	62.53	86.94	70.53
E 2 km	17	38.64	64.85	52.61	78.35	82.24	91.37	62.08	86.52

Table 8: PHC in sediments of various sampling points of selected installations (µg/g) in 2017

Sampling Station		Installations							
		HRA	NLM	BLQ	NQ	NA	BHS	ICP	SHP
N 0.25km	1	102.6	94.3	152.3	211.4	152.6	147.2	126.3	112.5
N 0.5 km	2	98.62	75.3	110.2	152.6	135.2	94.6	132.5	94.6
N 1 km	3	108.2	61.6	102.3	185.6	112.2	81.6	84.6	102.3
N 2 km	4	86.52	54.2	95.3	95.7	98.6	53.2	112.3	69.6
N 4 km	5	73.26	42.6	82.6	154.6	87.8	62.3	52.4	51.2
W 0.25km	6	92.42	84.6	145.3	235.3	198.2	168.3	198.6	114.6
W 0.5 km	7	81.24	59.6	95.6	181.4	174.3	105.2	95.6	121.2
W 1 km	8	75.32	56.8	84.3	147.5	145.3	93.5	74.2	92.3
W 2 km	9	64.25	45.8	56.3	124.3	97.9	84.6	145.3	89.6
S 0.25km	10	82.86	78.5	161.3	235.7	136.9	161.6	215.3	114.6
S 0.5 km	11	84.26	71.6	128.5	195.7	86.8	98.5	152.3	92.3
S 1 km	12	79.62	62.3	93.6	147.6	115.2	84.2	102.3	53.8
S 2 km	13	92.46	52.6	69.8	84.6	91.6	67.6	91.6	96.5
E 0.25km	14	91.46	112.2	108.3	184.6	114.3	88.5	132.5	185.6
E 0.5 km	15	82.46	54.5	78.2	157.6	101.3	103.6	98.6	135.8
E 1 km	16	94.32	38.7	89.6	138.7	93.8	74.2	78.9	84.6
E 2 km	17	52.46	57.5	61.3	86.7	74.6	86.6	56.6	92.6

Table 9: PHC in sediments of various sampling points of selected installations (µg/g) in 2018

Sampling Station		Installations							
		HRA	NLM	BLQ	NQ	NA	BHS	ICP	SHP
N 0.25km	1	104.7	91.3	149.3	207.2	152.6	121.8	114.8	109.7
N 0.5 km	2	95.48	78.4	108.5	148.6	135.2	91.9	126.9	93.5
N 1 km	3	106.51	62.5	99.6	181.3	112.2	85.7	89.9	98.6
N 2 km	4	81.46	57.8	97.4	92.7	98.6	66.8	96.4	72.4
N 4 km	5	77.36	47.3	80.2	148.5	87.8	64.7	62.8	53.6
W 0.25km	6	95.88	87.2	143.2	228.7	198.2	151.9	182.7	110.8
W 0.5 km	7	84.26	61.5	93.6	177.6	174.3	142.8	99.6	125.7
W 1 km	8	72.46	57.2	81.7	144.3	145.3	104.2	76.4	96.4
W 2 km	9	67.65	48.3	59.8	121.5	99.9	95.7	131.9	92.5
S 0.25km	10	86.34	81.4	155.4	228.8	156.9	128.8	208.6	118.7
S 0.5 km	11	88.35	73.5	131.5	188.2	86.8	91.6	164.9	95.2
S 1 km	12	82.47	66.8	95.8	143.5	135.2	89.7	131.9	58.7
S 2 km	13	84.66	55.4	72.4	87.6	91.6	75.1	105.9	99.2
E 0.25km	14	88.72	109.7	112.3	177.3	184.3	82.9	122.4	188.4
E 0.5 km	15	86.52	55.2	82.4	152.4	101.3	96.7	112.7	141.4
E 1 km	16	95.41	41.4	92.1	126.5	93.8	79.8	96.3	87.2
E 2 km	17	55.67	53.2	59.8	84.2	94.6	89.8	63.7	95.3

Table 10: PHC in sediments of various sampling points of selected installations (µg/g) in 2019

Sampling Station		Installations							
		HRA	NLM	BLQ	NQ	NA	BHS	ICP	SHP
N 0.25km	1	93.25	89.6	149.3	228.7	152.6	119.8	119.4	125.4
N 0.5 km	2	98.47	72.4	108.5	178.6	135.2	97.5	132.5	96.8
N 1 km	3	89.55	60.1	99.6	207.2	112.5	79.8	95.6	112.4
N 2 km	4	75.36	62.9	96.4	148.6	98.6	74.6	1.02	93.5
N 4 km	5	79.66	51.6	80.2	152.3	87.8	102.3	71.6	98.6
W 0.25km	6	102.33	88.2	143.2	148.5	196.2	147.5	174.5	72.4
W 0.5 km	7	89.68	66.3	93.6	181.3	174.3	135.6	86.2	61.5
W 1 km	8	85.74	59.4	81.7	92.7	145.8	98.5	62.6	110.8
W 2 km	9	72.41	52.3	56.2	132.2	184.3	87.4	125.6	125.7
S 0.25km	10	92.76	76.3	146.2	214.7	105.2	135.2	195.6	96.4
S 0.5 km	11	81.64	86.3	142.3	174.6	98.6	89.5	179.6	104.5
S 1 km	12	79.36	76.8	48.6	154.2	101.3	95.6	145.2	97.6
S 2 km	13	80.69	52.3	74.2	112.5	125.6	114.2	121.4	110.8
E 0.25km	14	90.71	102.30	106.40	154.80	91.9	79.80	136.20	72.40
E 0.5 km	15	83.61	110.3	86.9	148.2	156.20	87.2	95.6	57.6
E 1 km	16	88.74	74.2	90.7	117.5	85.9	79.8	112.7	109.7
E 2 km	17	65.12	56.3	63.8	78.6	98.6	92.3	81.2	87.2

Table 11: PHC in sediments of various sampling points of selected installations (μg/g) in 2020

Sampling Station		Installations							
		HRA	NLM	BLQ	NQ	NA	BHS	ICP	SHP
N 0.25km	1	90.32	88.6	142.5	235.3	148.2	121.5	121.7	136.3
N 0.5 km	2	96.41	70.9	125.6	184.2	126.6	89.4	128.6	102.5
N 1 km	3	86.54	75.4	102.5	195.6	98.6	93.2	98.7	95.6
N 2 km	4	72.14	60.6	124.3	156.2	89.3	78.5	105.2	87.5
N 4 km	5	78.72	60.7	98.3	168.6	74.6	110.5	74.6	102.3
W 0.25km	6	98.36	80.4	147.5	154.2	187.2	135.2	165.2	89.6
W 0.5 km	7	102.36	74.1	142.3	196.3	162.6	146.7	95.3	74.2
W 1 km	8	84.21	68.2	124.5	102.5	151.2	102.5	71.4	95.4
W 2 km	9	74.81	50.2	142.3	142.5	178.5	95.3	131.2	118.9
S 0.25km	10	90.76	74.6	153.6	198.3	112.8	143.6	184.2	105.3
S 0.5 km	11	80.36	82.7	114.5	162.5	102.6	92.3	162.3	98.2
S 1 km	12	81.37	78.6	104.2	147.2	98.7	102.5	136.2	102.2
S 2 km	13	84.71	50.7	152.3	98.7	118.2	123.5	118.2	97.8
E 0.25km	14	92.78	98.6	124.3	167.2	112.2	86.3	142.8	67.8
E 0.5 km	15	84.33	108.4	135.6	154.2	145.3	98.3	112.2	52.3
E 1 km	16	86.74	79.3	78.6	125.2	93.5	86.3	124.2	89.6
E 2 km	17	62.74	62.5	45.3	81.5	87.5	84.2	87.5	74.6

Table 12: PHC in sediments of various sampling points of selected installations (μg/g) in 2021

Key for Supplementary Tables		
N- North	S- South	E- East
W-West	SE- South East	SW-South West

Design of Tank-Degasser Assembly for safe operation

Manish Kumar Gupta
Superintending Engineer Production (P)

V.K. Singh
General Manager(Production)

Oil and Natural Gas Corporation Limited

1.0 Background

In work-over operations, brine preparation tank is normally used for storage, pumping of well kill brine and receipt of return fluids from the well. The return fluid invariably has dissolved gases, which flows into the open tank along with brine and in absence of suitable degassing mechanism eventually escapes into the atmosphere posing unsafe condition. A broad schematic diagram of the philosophy for the same is shown in Figure 1.

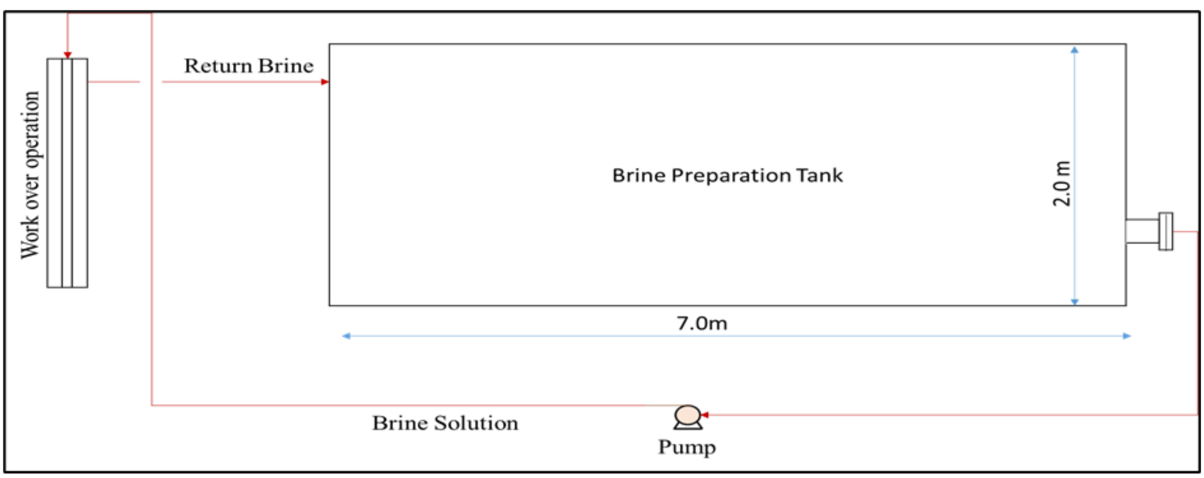


Figure 1: Brine circulation for work-over operation

2.0 Input data & basis of study:

- Maximum expected volume flow rate of return brine solution: 8 m3/hr
- Maximum gas to brine ratio (sm3/sm3): 50
- Density of brine solution: 1.01-1.2
- Maximum operating temperature: 50 deg C
- Operating pressure: Atmospheric to less than 0.5 kg/cm^{2}g
- Flare-vent line distance and size: 4” x 100 m.

3.0 Scheme Conceptualization:

In the instant case, various alternatives were explored to find suitable mechanism for enabling separation and safe disposal of the dissolved gas from the return flow in brine tank. The brine tank operates nearly at atmospheric pressure in normal condition, but its pressure could go up very high during well activity. Options such as separator, poor boy degasser etc. were evaluated as a possibility for adapting to the present case, but found not suitable due to inherent constraints such as limited operating pressure range, large footprint and bulkiness. In quest for evolving a fit-for-purpose technology, a Tank-Degasser was conceptualized and designed for installing in a brine tank for separation of gas and liquid from the return fluid and thus safely venting the released gas at a safe distance away from the rig site.

Based on the input data, simulation study was carried out to determine the vessel dimension of the degasser, which is shown in Figure 2.

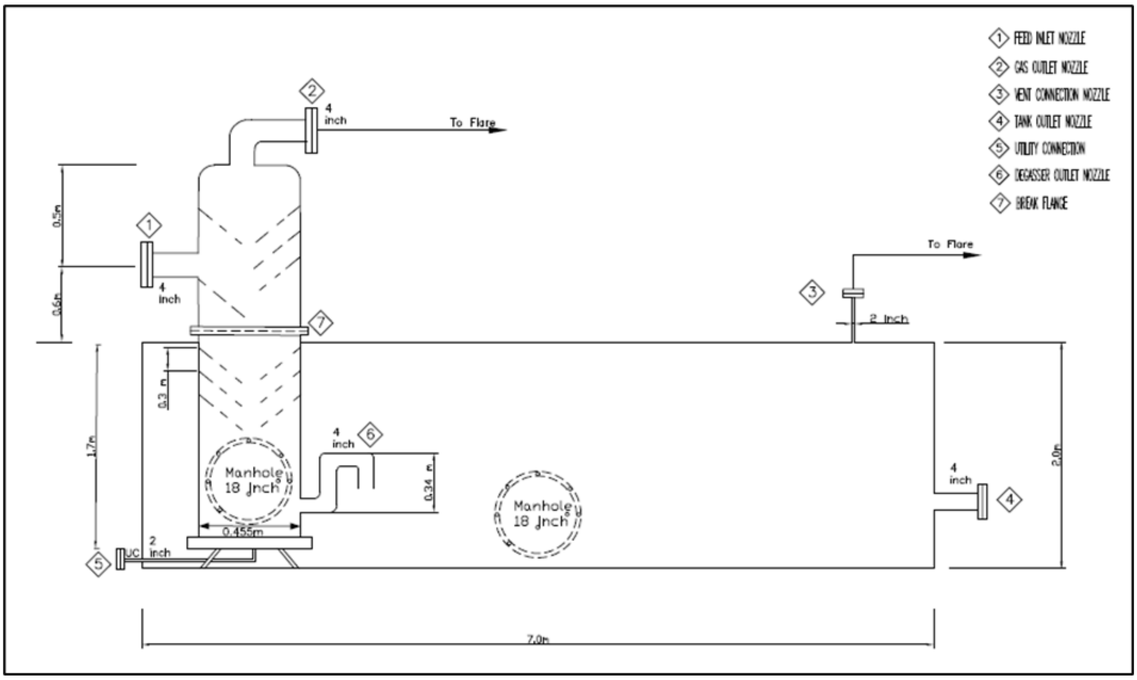


Figure 2: Tank Degasser Assembly

The conceptualized Tank-Degasser Separator system controls the gas flowing along with return fluid in to the brine tank during work-over operation. The brine and gas mixture returning from the well is fed into the Tank-degasser system and directed onto the impingement plate. This plate minimizes the erosional wear on the separator's internal walls and also helps in better separation of brine and dissolved gas. The fluid further falls over a series of vertically inclined baffles which increases the turbulence of the fluid in the upper section of baffles. The liberated dissolved gas is released through top of the Degasser and gets diverted for flaring through the flare header to a safe location. The separated brine is returned to the brine tank for recirculation. The conceptualized system has been designed with rectangular cut pattern on the periphery of the cylinder at its bottom, which enables in preventing solids from settling and plugging the brine outlet of the tank. In the tank section, modification was carried out to maintain a proper liquid seal to prevent any gas cut into the tank and beyond.

A picture of the Tank-Degasser Assembly installed at a site is shown in Figure 3.

Figure 3: Installed Tank-Degasser Assembly

4.0 Conclusion

The installed system possess conducive environment for safe operation. Additionally,it has advantages over the conventional systems, as it can operate over a wide range of operating pressure, requires lower foot print area and is easy to transport from one wellhead location to another.

The innovative Tank-Degasser assembly has been successfully fabricated locally and the scheme has been implemented in many work-over rigs of ONGC. The performance of the system has been found to be quite effective.

5.0 References

1. API RP 53, 2. SPE-20430-PA, Mud/Gas Separator Sizing and Evaluation

Biofuels and Their Importance

Hindustan Petroleum Corporation Ltd
Biofuel Division

Ethanol

Ethanol, also called alcohol, ethyl alcohol and grain alcohol, is a clear, colorless liquid. Ethanol is a natural byproduct of plant fermentation and also can be produced through the hydration of ethylene.

Ethanol Production

Ethanol production is based mainly on two basic processes regardless of the feedstock, which include the fermentation of a sugar-rich substrate followed by the distillation of the fermented solution. 'bioethanol': ethanol produced from biomass such as sugar containing materials, like sugar cane, sugar beet, sweet sorghum etc.; starch containing materials such as corn, cassava, rotten potatoes, algae etc.; and, cellulosic materials such as bagasse, wood waste, agricultural and forestry residues or other renewable resources like industrial waste.

Use of Ethanol

Personal Care Products
Ethanol is a common ingredient in many cosmetics and beauty products. It acts as an astringent to help clean skin, as a preservative in lotions and to help ensure that lotion ingredients do not separate, and it helps hairspray adhere to hair. Because ethanol is effective in killing microorganisms like bacteria, fungi and viruses, it is a common ingredient in many hand sanitizers.

Household Products
Ethanol mixes easily with water and many organic compounds, and makes an effective solvent for use in paints, lacquers and varnish, as well as personal care and household cleaning products.

Fuel
The most common use of ethanol as a fuel is in mixtures of motor gasoline. Most of the gasoline sold contains some fuel ethanol. Following are the Ethanol blends used as fuels:

Ethanol Blends:

Ethanol is blended in Petrol in different ratios ranging from 5% to 100% Ethanol like E5, E10,E15, E20 , E85 , E100. All fuels are different and vary from Gasoline properties. Ethanol blends upto E10 can be used in all vehicles but for blends greater than 10% requires modification in vehicle engine.

E10 Fuel - E10, a fuel mixture of 10% anhydrous ethanol and 90% gasoline sometimes called gasohol, can be used in the internal combustion engines of most modern automobiles and light-duty vehicles without need for any modification on the engine or fuel system.

E15 fuel – E15 is a fuel blend containing 15% ethanol and 85% gasoline. Currently BIS specifications for E15 fuel is not available.

E20 Fuel - This prescribes requirements and methods for two octane grades of E20 fuel. E20 is an admixture of anhydrous ethanol (IS 15464) at 20 per cent by volume and ethanol free motor gasoline (IS 2796) at 80 per cent volume, under BS IV and BS VI categories. This is suitable for use in automobile spark-ignition internal combustion engines in vehicles that comply with BS IV and BS VI emission norms.

E85 Fuel - E85 is an abbreviation typically referring to an ethanol fuel blend of 85% ethanol fuel and 15% gasoline or other hydrocarbon by volume.

ED95 Fuel - Hydrous ethanol is the main component in formulating ED 95 automotive fuel for modified compression ignition engines. ED95 is an ethanol based fuel for adapted diesel engines. It consists of 95 percent pure ethanol with the addition of ignition improver, lubricant and corrosion protection

E100 Fuel - E100 is otherwise known as hydrous ethanol; the designation is a misnomer because it contains about 4 (weight) percent water. It consists of ethanol that has been distilled to the ethanol-water azeotrope.

Ethanol blended fuel –effect on emission

Using ethanol as a vehicle fuel has measurable GHG (Green house gas) emissions benefits when considering the life cycle steps required for gasoline. Carbon dioxide (CO2) released when ethanol is used in vehicles is offset by the CO2 captured when crops used to make the ethanol are grown. As a result, vehicles running on high-level blends of ethanol produce less net CO2 than conventional vehicles per mile traveled. Ethanol blending leads to lean air/fuel mixture, which can cause increase in NOx emissions and decrease in CO emissions.

Scenario of Ethanol – India

India imports more than 80 percent of crude oil to meet annual demand, which poses a substantial price and quantity risk to a growing economy (90–95 percent of transportation in India is petro-based oil). These parallel realizations have led the Government of India (GOI) to increase its focus on developing a range of renewable energy sources owing to their eco-friendly nature and indigenous growth prospects.

India initiated its biofuel programme more than a decade ago and launched several policy measures to promote biofuels since then. In 2002, India launched its "Ethanol Blending Programme" and in aiming to achieve the target of 20% Ethanol Blending with gasoline by 2025.

Initiatives for Promotion of Ethanol

Within the span of 17 years, the Government of India has taken a number of initiatives to increase blending of Ethanol.

Govt. has introduced administrative price mechanism and fixed enumerative price for Ethanol from different feedstock. The other major interventions include allowing alternate feedstock for ethanol production, simplifying the Ethanol procurement procedures of OMCs, amending the provisions of Industries Development & Regulation Act, 1951, reducing GST on ethanol for blending in fuel from 18% to 5% and implementation of 10% blending of Ethanol in all States of India including Union territory except islands (Andaman & Nicobar, Lakshadweep), providing interest subvention scheme for capacity augmentation to Ethanol suppliers.

In 2018, Government of India notified National Biofuels Policy 2018, As per the policy, Government of India has prepared a road map to reduce the import dependency in Oil & Gas sector by adopting a five pronged strategy which includes, Increasing Domestic Production, Adopting biofuels & Renewables, Energy Efficiency Norms, Improvement in Refinery Processes and Demand Substitution. This envisages a strategic role for biofuels in the Indian Energy basket.

The Policy aims to increase usage of biofuels in the energy and transportation sectors of the country during the coming decade. The Policy aims to utilize, develop and promote domestic feedstock and its utilization for production of biofuels thereby increasingly substitute fossil fuels while contributing to National Energy Security, Climate Change mitigation, apart from creating new employment opportunities in a sustainable way. Simultaneously, the policy will also encourage the application of advance technologies for generation of biofuels. Biofuels policy has set indicative target of 20% Ethanol blending by 2025.

Elemental proxies for paleosalinity analysis on sediment sample A Case study Assam and Assam Arakan Basin




Dr. Sourav Biswas
Senior Chemist

Dr. Supriya Chopra
Suptdg. Chemist

Dr. Indu Singh
Suptdg. Chemist

Hari Das
Dy. General Manager

Oil and Natural Gas Corporation Limited
Keshava Deva Malaviya Institute of Petroleum Exploration (KDMIPE)

Abstract

Salinity is a fundamental property of water that is useful in paleo-environmental and paleo-ecological studies, yet the theory of application of geochemical proxies to paleo-salinity reconstruction is underdeveloped. Here, we explore the use of three elemental ratios for paleosalinity reconstruction: boron/gallium (B/Ga), strontium/barium (Sr/Ba), and sulfur/total organic carbon (S/TOC) ratios. Sediment data were limited to fine-grained siliciclastic units (muds/shales/mudstones) without significant carbonate content, in which the elements of interest were mainly acquired through adsorption of dissolved species, forging a connection between elemental proxy values and water chemistry. These relationships establish the basis for use of these elemental ratios as paleosalinity proxies. Elemental crossplots permitted estimation of approximate salinity thresholds for each proxy: (1) B/Ga is < 3 in freshwater, 3-6 in brackish, and > 6 in marine facies; (2) Sr/Ba is < 0.2 in freshwater, 0.2-0.5 in brackish, and > 0.5 in marine facies; and (3) S/TOC is < 0.1 in freshwater and > 0.1 in brackish and marine facies. S/TOC did not discriminate effectively between brackish and marine facies, probably because microbial sulfate reduction (MSR) is generally Corg-limited rather than sulfate-limited in both facies. Finally, we illustrate the application of these proxies with case studies of the Assam and Assam Arakan Basin.

1. Introduction

Salinity is an essential chemical feature of water, and it is routinely reported for modern aqueous systems. For many ancient sedimentary formations, either fully marine (e.g., Yan et al., 2018) or fully freshwater (Qiu et al., 2015) conditions can be inferred from general stratigraphic and paleogeographic considerations with little to no uncertainty. However, for ancient sedimentary formations deposited in marginal-marine or coastal terrestrial settings, water salinity may have been influenced by both freshwater and marine inputs (Dávila et al., 2002; Wei et al., 2018), and determination of secular variation or long-term mean paleosalinity conditions becomes important. For systems of this type, the availability of geochemical proxies that can track changes in water salinity in space and time would be highly useful. Paleosalinity analysis has a long history, and many different types of data—both geochemical and non-geochemical—have been used for this purpose. Various sedimentological and geochemical proxies have been used to constrain paleosalinity (Frederickson and Reynolds, 1960; Couch, 1971; Holmden et al., 1997; Ye et al., 2016). Primary evaporite minerals such as gypsum and halite provide evidence of elevated watermass salinity (Butler et al., 1999; Hay et al., 2006; Tosca et al., 2008). Paleosalinities can be estimated using isotopic techniques such as $\delta^{18}O$ in carbonates (Ingram et al., 1996) or phosphates (Joachimski and Lambert, 2015), which, however, generally requires an assumption regarding water $\delta^{18}O$. Biomarkers such as alkylated chromans and C_{20} isoprenoid thiophenes are potential paleosalinity proxies (Barakat and Rullkötter, 1997) and many more. To generalize somewhat, all of the techniques require special conditions, e.g., the presence of specific lithologies, fossils, or biomarkers, limiting their widespread application to ancient sedimentary formations. Here, we investigate the utility of three elemental proxies for paleosalinity analysis, i.e., boron/gallium (B/Ga), strontium/barium (Sr/Ba), and sulfur/organic carbon (S/TOC) ratios. Although most dissolved elements are present in higher concentrations in seawater than in brackish or fresh waters, certain elements show relatively higher concentrations in seawater (e.g., B and Sr) or freshwater (e.g., Ga and Ba) on a salinity-normalized basis. For such non redox- sensitive elements, adsorption and desorption processes on (mainly) clay minerals result in fine-grained sediments acquiring an elemental inventory that is proportional to that of the overlying water column. Thus, the bulk composition of fine-grained siliciclastic sediments can reflect the chemistry of the water in which they were deposited.

2. Methodology

2.1. Development and testing of the salinity proxy dataset

Samples were dried at 60 °C in oven, and grinded in mortar and pestle. 0.15 g of powdered sediment sample was then taken in teflon vessel and treated with 3 ml of suprapure Nitric acid, 3 ml of suprapure per-chloric acid and 4 ml of suprapure hydrofluoric acid. The resultant mixture was kept over hot plate to digest the mass completely to give dried residue. To the dried residue, 1 ml of suprapure HNO3 and 10-15 ml triple distilled water was added and the solution was transferred to a 50 ml volumetric flask and made up the volume with triple distilled water. Multi element analysis (MEA) (Sr, Ba, B, Ga and S) was carried out in the prepared solution using ICP Spectrometer (Optima 2000 DV). In the present study, 15 sediment samples of two different wells in A & AA Basin were investigated for the elements Sr, Ba, B, Ga, S and TOC.

Total organic carbon (TOC) content & Rock Eval analysis was performed using Rock Eval 6 (Turbo) instrument providing Tmax, and bulk parameters S1, S2 and S3. The following temperature programs were run: Pyrolysis: 300°C for 3 min then pyrolysed at 25°C /min to 650°C; Oxidation: 300°C (for 1 min) heated at 20°C/min to 850°C (held for 5 min).

2.2. Salinity facies thresholds and relative efficacies of paleosalinity proxies

Based on the relationships of modern sediment compositions to water salinity, we determined salinity facies thresholds for the three elemental proxies considered above. For B/Ga, freshwater and brackish sediments are most effectively separated by a ratio of 3, and brackish and marine sediments by a ratio of 6.

For Sr/Ba, freshwater and brackish sediments are most effectively separated by a ratio of 0.2, and brackish and marine sediments by a ratio of 0.5.

For S/TOC, freshwater sediments are most effectively separated from brackish and marine sediments by a ratio of 0.1 (S/TOC ratios are less effective at separating brackish and marine sediments, although a threshold of 0.5 distinguishes a range (i.e., 0.1-0.5) characterized by mixed samples Thus, samples with S/TOC ratios of 0.1-0.5 should be regarded as potentially either brackish or marine, whereas those with S/TOC > 0.5 are likely to be marine. The reason for the relatively poor discrimination of brackish versus marine sediments is that the S/TOC proxy depends not only on sulfate concentrations (i.e., as an electron acceptor) but also on the availability of labile organic substrates to drive microbial sulfate reduction (MSR) and thus generate a precursor (H2S) to sedimentary sulfide minerals (Sim et al., 2011). It should also be noted that S/TOC can become arbitrarily variable at low TOC and S concentrations, leading to erroneous salinity evaluations. We recommend limiting S/TOC analysis to samples containing at least 1.0 % TOC, a level below which determinations cannot be effectively made.

The relative efficacies of the three paleosalinity proxies are largely a function of their discriminatory power, which can be represented by the multiple of elemental concentrations and ratios between marine and freshwater sediments. In summary, B/Ga and S/TOC are generally more accurate predictors of paleosalinity than Sr/Ba. S/TOC is most effective at distinguishing freshwater from brackish-marine sediments, although the marine character of sediments can sometimes be recognized based on very high S/TOC ratios (i.e., > 0.5). However, all three proxies are valid for paleosalinity analysis, and we have found examples (i.e., specific formations) in which Sr/Ba appears to be more effective than B/Ga. Thus, the general patterns summarized here do not necessarily pertain to all ancient formations. We recommend the use of multiple paleosalinity proxies in all studies in order to identify potential problems with any single proxy that might arise and to ensure accurate paleosalinity determinations.

3. Case study of paleosalinity analysis

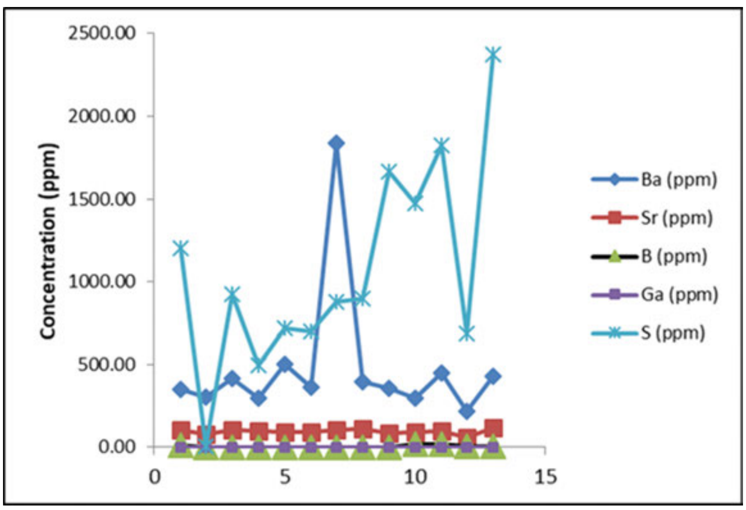
A total of 15 sediment samples of two different wells (13 samples of Well A#1 at different depth and two samples of Well B#1 at different depth) of A&AA Basin have been analysed for Ba, Sr, Ga, B, S and TOC. In Well A #1 and Well B #1 sedimentary samples were collected from 1092.71m to 4171.34m and 1619m to 2500.75m at different interval respectively. The elemental data generated are tabulated in Table 1.

The Ba concentration falls in the range of 219.02 ppm to 1836.95 ppm with average concentration being found 456.8 ppm while Sr concentration are varying in the range of 78.3 ppm to 117.37 ppm with average 94.7 ppm. The B concentration as expected falls in the narrow range (0-19.6 ppm) while Ga is not present in these samples. The S and TOC vary in the range of 5.25 ppm to 1667.23 ppm and 0.08 to 1. The variations of elemental concentration are depicted in Figure 1.

Table1: Elemental concentration of sediment samples of A#1 and B#1 at different depth.

Well	Interval	Ba (ppm)	Sr (ppm)	B (ppm)	Ga (ppm)	S (ppm)	TOC	Sr/Ba	S/TOC
A#1	1092.71-1099.71	352.63	107.12	12.97	0.00	1203.84	0.12	0.30	10.032
A#1	1555.74-1564.74	302.67	78.33	0.00	0.00	5.25	1	0.26	0.005
A#1	1586.17-1593.17	416.12	104.28	0.00	0.00	923.31	0.34	0.25	2.715
A#1	1713.65-1722.65	296.13	100.13	0.00	0.00	493.70	0.08	0.34	6.171
A#1	1886.06-1891.38	502.36	93.58	0.68	0.00	719.59	0.31	0.19	2.321
A#1	2105.92-2111.92	362.18	94.87	0.00	0.00	698.95	0.17	0.26	4.111
A#1	2388-2391.1	1836.95	107.82	0.00	0.00	878.45	0.27	0.05	3.253
A#1	2639.44-2645.44	398.14	115.13	0.00	0.00	900.25	0.19	0.29	4.738
A#1	2730.76-2733.76	355.17	87.70	2.02	0.00	1667.42	0.26	0.25	6.413
A#1	2772.82-2775-82	298.33	93.33	16.33	0.00	1472.58	0.2	0.31	7.362
A#1	2893.47-2895.0	447.33	98.00	19.67	0.00	1823.25	0.17	0.22	10.725
A#1	3619.26-3625.26	219.02	56.99	3.31	0.00	687.87	0.08	0.26	8.598
A#1	4165.34-4171.34	431.92	117.37	3.69	0.00	2374.16	0.33	0.27	7.194
B#1	1619-1624.75	245.89	72.65	0.00	0.00	164.94	0.16	0.29	1.030
B#1	2496.4-2500.75	387.03	93.58	0.00	0.00	591.04	0.22	0.24	2.686

Figure1. Variation of concentration of Ba, Sr, B, Ga and S.



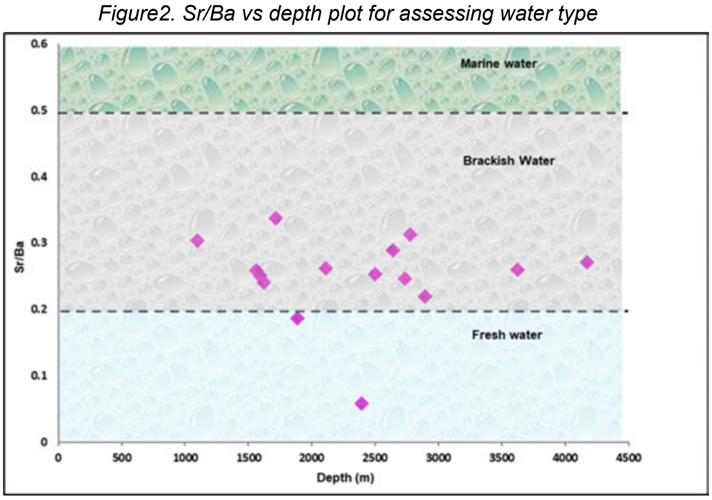
The concentration of Ba, Sr, B and Ga does not exhibit any variation pattern with respect to depth except sulphur which is gradually increasing in both well. This may be attributed to the fact that anoxic environment becomes progressively dominant with increasing depth where microbial sulphate reduction become favourable.

The use of elemental ratios as a proxy to predict the paleo-salinity of that area. These elemental proxies are Boron/ Gallium (Ba/Ga), Strontium/ Barium (Sr/Ba) and Sulphur/ total organic content (S/TOC) with the following threshold values for water facies:

a) B/Ga is < 3 in freshwater, 3-6 in brackish, and > 6 in marine facies;
b) Sr/Ba is < 0.2 in freshwater, 0.2-0.5 in brackish, and > 0.5 in marine facies
c) S/TOC is < 0.1 in freshwater and > 0.1in brackish and marine facies (Wei, 2018)

Our analysis reveals that the Sr/Ba ratio within the samples varies in the range of 0.06 to 0.34 with most of the values are greater than threshold value 0.2 and average 0.25, indicating brackish type water facies. This is depicted in figure-2.

Figure2. Sr/Ba vs depth plot for assessing water type



The S/TOC values range from 0.005 to 10.03 and most of the values are above the threshold value of 0.1 indicating towards brackish to marine water facies.

The values of B/Ga have not been incorporated in predicting water facies in view of the almost null concentration of B.

The results were validated from the formation water data of Bokabil-Bhuban Formation, which infers the formation water as brackish to saline (Table-2).

Table2: Compositional Data of Bokabil Bhuban Formation

Sl. No	Well Name	Formation	Depth	TDS	pH	Chloride (ppm)	Bicarbonate (ppm)	Carbonate (ppm)	Sulphate (ppm)	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Genetic type	Salinity (gpl)
1	A	Bokabil	2317-2331	14538.46	8.65	8520.00	213.50	150	14.40	40.00	42.56	5558.00	Bicarbonate-Sodium	14.04
2	B	Bokabil	1414-1419	9422.58	8.52	5183.00	488.00	120	19.20	32.00	29.18	3551.20	Bicarbonate-Sodium	8.54
3	C	Bokabil	720-730	1234.56	8.4	157.76	593.59	47.34	48.00	6.00	1.22	380.65	Bicarbonate-Sodium	0.26
4	D	Bokabil	2268	4603.02	8.2	959.56	1879.67	129.74	133.43	16.00	3.65	1480.97	Bicarbonate-Sodium	1.58
5	E	Bokabil	2543-2558	8308.00	7.94	2769.00	2501.00	165	11.52	14.00	6.08	2841.40	Bicarbonate-Sodium	4.54
6	F	Bokabil	2481-2484	2535.00	8.9	444.00	732.00	180	350.00	64.00	31.00	734.00	Bicarbonate-Sodium	0.73
7	G	Bokabil	2942-2946	7321.84	8.08	2520.50	2272.20	0	32.64	16.00	7.30	2473.20	Bicarbonate-Sodium	4.15
8	H	Bokabil	2394-2396.5	6000.86	8.7	1757.00	1708.00	420	15.00	40.00	4.86	2056.00	Bicarbonate-Sodium	3.42
9	I	Bokabil	2065-2069	5924.60	8.8	2077.00	1600.00	90	99.80	16.00	6.80	2035.00	Bicarbonate-Sodium	3.42
10	J	Middle Bhuban	2479-2504	14154.66	8.64	7455.00	1037.00	225	38.40	12.00	12.16	5375.10	Bicarbonate-Sodium	12.29
11	K	Middle Bhuban	1504-1521	337.00	7.8	13.00	200.00	0	38.00	37.00	12.00	37.00	Bicarbonate-Sodium	0.02
12	L	Middle Bhuban	2838-2844	12664.19	9	6687.00	892.70	146.35	104.64	24.00	8.50	4801.00	Bicarbonate-Sodium	11.01
13	M	Middle Bhuban	1174	18280.17	7.9	8875.00	2501.00	0	168.96	56.00	34.05	6645.16	Bicarbonate-Sodium	14.63
14	N	Middle Bhuban	742-750	17167.46	8.4	8165.00	2196.00	375	46.08	14.00	45.00	6326.38	Bicarbonate-Sodium	13.46
15	O	Upper Bhuban	1731-1735	18813.12	7.28	11005.00	457.60	0	49.92	100.00	63.70	7136.90	Bicarbonate-Sodium	18.13
16	P	Upper Bhuban	2192-2202	15169.30	8.87	7810.00	762.50	750	0.00	12.00	15.80	5819.00	Bicarbonate-Sodium	12.87
17	Q	Upper Bhuban	1407-1415	21504.44	7.2	12691.00	274.00	90	104.64	196.00	32.80	8116.00	Chloride-Calcium	20.90

4. Conclusions

• Our evaluation of modern aqueous and sedimentary geochemical data in this study establishes a solid basis for the use of boron/gallium (B/Ga), strontium/barium (Sr/Ba), and sulfur/total organic carbon (S/TOC) ratios as salinity proxies in fine-grained siliciclastic units (muds/shales/mudstones) lacking significant carbonate content.

• Aqueous B and Sr, which are present in much higher concentrations in seawater than in fresh water, are readily adsorbed onto clay minerals and, to a lesser degree, organic matter and Fe-oxyhydroxides, resulting in substantially higher B/Ga and Sr/Ba ratios in marine sediments relative to freshwater sediments.

• Calibration of these proxies as a function of salinity in modern water allows identification of optimal salinity facies thresholds. For B/Ga, sedimentary ratios of < 3, 3-6, and > 6 are indicative of freshwater, brackish, and marine facies, respectively. For Sr/Ba, sedimentary ratios of < 0.2, 0.2-0.5, and > 0.5 are indicative of freshwater, brackish, and marine facies, respectively. For S/TOC, sedimentary ratios of < 0.1, 0.1-0.5, and > 0.5 are indicative of freshwater, brackish or marine, and marine facies, respectively.

• The Sr/Ba ratio varies in the range of 0.06 to 0.34 with most of the values are greater than threshold value 0.2 and average 0.25, indicating brackish type water facies.

• The S/TOC values range from 0.005 to 10.03 and most of the values are above the threshold value of 0.1 indicating towards brackish to marine water facies.

• The values of B/Ga have not been incorporated in predicting water facies in view of the almost null concentration of B.

• Formation water data of Bokabil-Bhuban formation is validated, which infers the formation water as brackish to saline.

Acknowledgments

Authors express their sincere gratitude to ONGC management for permission to publish this paper.

Authors are thankful to Shri Nandan Verma, HoI-KDMIPE and Shri S.N Chitinis, Former HoI-KDMIPE for his constant encouragement, guidance and support for carrying out this study.

Our thanks are also due to Mr. Mahesh Paghwal and Mr. T.P. Chamola, IGC Lab for their analytical support during the course of the study.

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

References

Butler, R.W.H., McClelland, E., Jones, R.E., 1999. Calibrating the duration and timing of the Messinian salinity crisis in the Mediterranean: linked tectonoclimatic signals in thrust-top basins of Sicily. Journal of the Geological Society of London 156(4), 827-835.

Couch, E.L., 1971. Calculation of paleosalinities from boron and clay mineral data. AAPG Bulletin 55(10), 1829-1837.

Dávila, P.M., Figueroa, D., Müller, E., 2002. Freshwater input into the coastal ocean and its relation with the salinity distribution off austral Chile (35–55 °S). Continental Shelf Research 22(3), 521-534.

Frederickson, A.F., Reynolds, R.C., 1960. Geochemical method for determining paleosalinity. Clays and Clay Minerals 8, 203-213.

Hay, W.W., Migdisov, A., Balukhovsky, A.N., Wold, C.N., Flögel, S., Söding, E., 2006.Evaporites and the salinity of the ocean during the Phanerozoic: Implications for climate, ocean circulation and life. Palaeogeography, Palaeoclimatology, Palaeoecology 240(1-2),3-46.

Holmden, C., Creaser, R.A., Muehlenbachs, K., 1997. Paleosalinities in ancient brackish water systems determined by 87Sr/86Sr ratios in carbonate fossils: A case study from the Western Canada Sedimentary Basin. Geochimica et Cosmochimica Acta 61(10), 2105-2121.

Ingram, B.L., Conrad, M.E., Ingle, J.C., 1996. Stable isotope and salinity systematics in estuarine waters and carbonates: San Francisco Bay. Geochimica et cosmochimica Acta 60(3), 455-467.

Joachimski, M.M., Lambert, L.L., 2015. Salinity contrast in the US Midcontinent Sea during Pennsylvanian glacio-eustatic highstands: Evidence from conodont apatite δ18O. Palaeogeography, Palaeoclimatology, Palaeoecology 433, 71-80.

Qiu, X.W., Liu, C.Y., Wang, F.F., Deng, Y., Mao, G.Z., 2015. Trace and rare earth element geochemistry of the Upper Triassic mudstones in the southern Ordos Basin, Central China. Geological Journal 50(4), 399-413.

Sim, M.S., Bosak, T., Ono, S., 2011. Large sulfur isotope fractionation does not require disproportionation. Science 333(6038), 74-77.

Tosca, N.J., Knoll, A.H., McLennan, S.M., 2008. Water activity and the challenge for life on early Mars. Science 320(5880), 1204-1207.

Wei, W., Algeo, T.J., Lu, Y., Lu, Y., Liu, H., Zhang, S., Peng, L., Zhang, J., Chen, L., 2018. Identifying marine incursions into the Paleogene Bohai Bay Basin lake system in northeastern China. International Journal of Coal Geology 200, 1-17.

wei : Elemental proxies for paleosalinity analysis of ancient shales and mudrocks, 2019, Geochimica et Cosmochimica Acta

Yan, C., Jin, Z., Zhao, J., Du, W., Liu, Q., 2018. Influence of sedimentary environment on organic matter enrichment in shale: A case study of the Wufeng and Longmaxi Formations of the Sichuan Basin, China. Marine and Petroleum Geology 92, 880-894.

Ye, C., Yang, Y., Fang, X., Zhang, W., 2016. Late Eocene clay boron-derived paleosalinity in the Qaidam Basin and its implications for regional tectonics and climate. Sedimentary Geology 346, 49-59.

IFSC – Ship leasing in GIFT City – Impact on Oil and Gas sector




Neetu Vinayek
Partner

Ratish Iyer
Senior Manager

Hitanshu Mehta
Senior Consultant

Dipen K Patoliya
Consultant

Ernst & Young LLP

Oil and gas exploration and development in India is considered crucial for the country's energy security and economic growth. India is heavily dependent on imports to meet its energy needs and increasing domestic production of oil and gas can reduce the country's dependence on foreign sources.

ONGC will be investing around INR 31,000 crore (approx. USD 3900 Mn) in the next 3 years to boost the oil exploration as a part of its Exploration & Production ('E&P') plan which will play a vital role for furthering the development of the industry (like providing boost to players engaged in provision of ocean vessel/ ship or services or in executing the exploration contracts) and delinking the India's dependence on imports.

More regulations designing to support and promote growth in Oil and gas industry can be rolled out to create competitive market, leading to increased investment, and economic growth. One of the recent initiatives is development of Gujarat International Finance Tech-city (GIFT) as International Financial Service Centre (IFSC), being a multi service Special Economic Zone (SEZ). We have discussed below the emergence of IFSC as a business centre, and permissible activities to be carried out from IFSC.

Emergence of IFSC and permissible activities:

The International Financial Services Centres Authority (IFSCA) was established in 2020 as the dedicated regulator for IFSCs in India, responsible for developing, regulating, and promoting financial services like Banking, Insurance, Broking, IT and legal consultancy, trading and investment and leasing, etc in IFSC.

Although IFSC was setup to provide impetus to financial sector, considering India's growth in airlines and maritime sector, the authorities have also developed leasing framework for airlines and shipping industry, to be routed through IFSC.

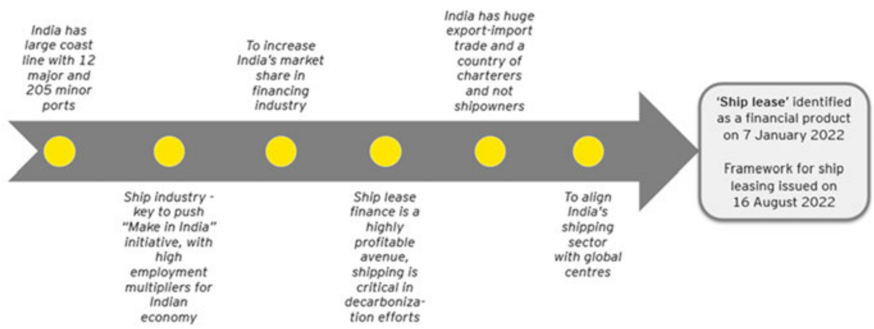
Brief discussion on ship leasing framework and its interplay with oil and gas sector is discussed in detail as under:

Ship leasing framework:

Ship leasing has played a pivotal role in India due to the economic development of the country and the rising demand for cargo transportation services. India is one of the fastest-growing economies in the world, and its growth is creating a need for efficient and reliable shipping capabilities. Ship leasing allows companies to access vessels quickly and easily, without the costly upfront investment of buying a vessel. Additionally, it allows companies to access vessels that are more suitable for their specific needs, as ship leasing companies typically have a wide range of vessels to choose from. Ship leasing also eliminates the hassle of hiring and maintaining crews, as the leasing company provides the personnel. This can save companies both time and money. It provides companies with the flexibility to scale up or down as needed, allowing them to respond quickly to fluctuations in demand.

Considering the above and the government's focus on the maritime sector of the economy, the ship leasing industry in India has witnessed some great initiatives like the Sagar Mala project in 2015, which was aimed at developing ports and port-related infrastructure in India. To provide further boost to the sector, the government has issued a ship leasing framework on 16 August 2022.

Factors necessitating ship leasing in IFSC:



Ship leasing framework, inter alia, provides for the following:

- Definition of key terms (Operating lease, finance lease etc);
- Forms of legal entity who can register and operate;
- Permissible operations;
- Minimum capital requirements / Minimum owned funds;
- Procedural aspects

The definition of ships and ocean vessels provided in ship leasing framework seems wide enough to cover all floating structures on water like LNG Carrier, barges, Mobile Offshore Drilling units and may also include speciality structures like Floating Production Storage and Offloading (FPSO), Floating Storage and Regasification Units (FSRU), etc, which may be stationed at a point.

IFSC – key tax benefits / incentives:

Tax incentives are important tools to boost an industry by encouraging investment and activity. They can help businesses reduce their costs and make investments to improve productivity and profitability. To make IFSC more lucrative, the Indian government has brought various direct tax incentives like tax holiday to IFSC units, concessional MAT to IFSC units and also sector incentives like exemption of royalty income of Non-resident on account of "ship" lease.

Interplay of ship leasing framework with oil and gas industry:

Tax exemption for non-residents:

As explained above, although ship leasing framework was issued to bolster the shipping industry, considering the above definition and coverage of ships and ocean vessels, the framework could be extended even to the Oil and Gas industry.

As mentioned above, income earned by non-resident in the nature of royalty ie lease rentals earned on leasing out ship/ ocean vessel to a unit in IFSC is tax exempt. However, current definition of royalty under income-tax excludes equipment royalty ie income earned on account of equipment leasing in connection with oil and gas exploration activities. A pertinent question arises in case where the non-resident earns royalty income from leasing of equipment used in connection with oil and gas exploration activities, considering the exclusion in definition of royalty, whether such lease income would not be considered as royalty and hence not be tax exempt. In other words, this would imply that if non-residents provide ship/ ocean vessel on dry lease to a unit in IFSC for the purpose of oil and gas exploration activities, such royalty income may not be tax exempt.

Accordingly, the current interplay suggests that royalty tax exemption for non-residents would extend only to cases where ship/ocean vessel is used for activities which are not in connection with oil and gas exploration activities. A quick clarity on this would be needed to encourage groups/ entities engaged in providing facilities or services in connection with oil and gas exploration activities to consider structuring their operations through IFSC.

Contract bidding:

Considering that 'ship leasing' is considered as a financial activity in IFSC and ship leasing framework covers both operating and finance lease, it would be interesting to observe if entities set up in IFSC could enter into a service contract, say a drilling contract, which would envisage provision of services using vessels.

Further, if an entity setup in IFSC were to own vessels and not lease in from overseas (ie outside India), clarity would be required with respect to flagging provisions under Merchant Shipping Act[1] and whether such entities would be entitled to any benefit of Right of First Refusal (ROFR)[2], especially with respect to Public Sector Undertaking contracts.

Concluding thoughts:

Considering the importance of shipping and maritime sector, the Government has adopted right initiatives to attract business volumes into India to provide overall boost to the sector.

[1] In India, the Ministry of Shipping is responsible for the regulation of merchant shipping. The Indian Merchant Shipping Act, 1958 and the Merchant Shipping Rules, 1959 are the main legislations governing merchant shipping and seafarers in India.

[2] Right of first refusal in government bids is a process whereby the government gives an entity the first opportunity to bid on contracts for goods or services subject to conditions. This process is often employed to ensure that the process of awarding contracts is fair and that the best value for money is achieved.

Risk Based Schedule Modelling of LSTK Offshore Brownfield Oil and Gas Projects Using Project Management Tools & Methodologies

Karishma Laskar
Executive Engineer (E)

Kangkan Thakuria
Suptdg. Engineer (E)

Oil and Natural Gas Corporation Limited

Abstract

Offshore Oil and Gas projects are very complex, with each phase susceptible to risks and uncertainties. Lump Sum Turnkey offshore oil and gas projects are riskier as the entire onus of project execution lies with the EPC contractor. For offshore projects, it is imperative not only to identify the risks but also to follow and adopt risk mitigation measures to complete these projects on time and within budget. The purpose of this research is to study, analyse and quantify the risks and recommend risk mitigation measures at all phases. In this research, first all risks were identified through surveys and extensive interviews. Later, these were translated into numerical values based on discussion and expert opinions of project management professionals. The numerical values served as inputs to the Monte Carlo simulation performed through the @risk add-on in excel and simulations were run 1000 times. This time estimation methodology is developed to be used as a management decision making tool. With appropriate risk management plans and by adopting best practices, the delays and other project complexity can be addressed with the support of stakeholders at all levels.

Key words: *Risk analysis, Risk assessment, Risk Mitigation, Monte Carlo Simulation, PERT, Project Management.*

1.0 Introduction

1.1 Background:

Energy requirement has been tremendously increasing with per capital consumption of the country on rise. Oil and Gas Industry is one of the major contributors of socio- economic growth of India. As per 2030 projections, India's oil demand is set to rise at a faster pace and reach 10 million barrels per day and gas by 12.2% CAGR (IBEF, 2022). Since economic growth is linked to energy demand, therefore the need for oil and gas will rapidly grow making the industry conducive for investment. To achieve the energy targets, a lot of capital- intensive projects of high risk-high reward nature are carried out particularly offshore. These projects are for creating new offshore facilities such as pipelines, production platforms for processing of the oil and gas, trunklines etc. and revamping of old structures for production enhancement through Lump sum turnkey contracts.

These projects are undertaken to either create new facilities (Green field works) or modify existing facilities to augment oil and gas production (brownfield works). The brownfield jobs can be categorised as life extension, facility upgradation, small modifications jobs and painting/structural replacement projects.

Hence, it is of utmost importance to have a data driven time and a precise risk-based time estimation methodology in context of operational requirements.

1.2 Problem Definition

The major challenges of Lump Sum Turnkey offshore oil and gas projects lies in executing brownfield project scope within time and budget under challenging offshore environment constraints. Schedule modelling of Lump sum turnkey projects that have brownfield scope are carried out considering two to three construction seasons based on historical data of similar complexity project scope and expert judgement. However, a lot of variables come into picture depending on barge mobilization, scope of work, financial muscle of contractor, uncertainties at site, environmental constraints, multiple stakeholder involvement, statutory clearances, and execution methodology of contractors. The outcomes of stretched timelines or delays leads to as cash flow issues of bidder after award of work, schedule delays leading to costs overrun and change orders, litigation issues, less mobilization of resources (manpower, barges etc.) and low participation of bidders in other tenders. These delays can lead to loss of revenue and delayed well operations impacting the company's financials.

1.3 Research objective

1. To identify critical risks associated at all stages of execution of LSTK Offshore Brownfield Oil and Gas Projects.

2. To devise a risk-based methodology using Project Management and statistical tools for time estimation and schedule control of LSTK Offshore Brownfield Oil and Gas Projects.

3. To identify, assess and recommend mitigation measures to reduce probable risks of projects in project planning, scheduling and control of projects.

2.0 Research Design and Methods

2.1 Research Approach:

Project scheduling tools such as Monte Carlo and PERT are used extensively for schedule modelling but there has been no attempt made to develop a time estimation methodology particularly for oil and gas offshore brownfield modifications jobs.

A sample project of life extension of existing platforms scope has been considered for the purpose of this study to estimate the expected time using Monte Carlo and PERT. The DPRs of past similar nature projects with similar complexities were studied along with planning package to estimate the number of days for each project phase by using advanced work package or WBS. The daily progress reports of these last two projects were studied to estimate activities such as survey, procurement, fabrication and offshore execution. This research investigated the possible risks and developed a comprehensive list of 38 validated risks with likelihood and impact for each event. The risk ranking and likelihood is obtained based on the risk ranking matrix. Regarding this study, a questionnaire is developed, and interviews are conducted to identify the potential risks and its likelihood and impact. Data has been collected from expert project management professionals such as Project Managers of the company and EPC contractors having extensive experience of handling offshore projects and stakeholders associated with offshore projects.

Excel with @risk add on has been used for simulation and modelling of the project duration. Probability and probability category has been assigned based on the values obtained in the risk scoring matrix. The risks identified per activity such as pre-engineering survey, design engineering, procurement, fabrication and offshore execution-installation and hook up activities are grouped, and a weightage has been assigned based on average or weighted average of each risk for each phase. The risks that have an impact on schedule are only considered for assigning weightage factors. Accordingly, this numerical value which gives the risk rank is integrated into the schedule. For low uncertainty of risk rank 2, risk range of 90%-115% is considered. For medium uncertainty of risk rank 3, 95%-115% risk range is considered. For high uncertainty of risk rank 4, risk range of 95%-125% is considered. Time estimation of three activities is calculated -Pre engineering survey, Design/ Procurement/Fabrication and Offshore Execution. Design engineering and procurement, procurement and fabrication are parallel activities. The score of the risk against pre-engineering survey, design/ procurement/fabrication and offshore execution has been mapped into the schedule and a three-point estimation is obtained. The most likely value is obtained by taking mean of the days taken from the past two projects of a similar nature. The probability distribution for the activities is considered as PERT for design & survey and triangular for offshore execution. The probability distribution and risk range for these activities is in Table-1. The expected time is calculated for most likely, optimistic, and pessimistic scenarios. The detailed time estimation for offshore execution is also in Table-1.

Table 1: Time Estimation for the sample project

Activities	Optimistic	Mostlikely	Pessimistic	Risk Rank	Risk Category	Distribution
Pre egg. survey	58.5	65	74.75	2	LOW (90%-115%)	PERT
Design, Proc, Fabrication	365.75	385	442.75	3	MEDIUM (95%-115%)	PERT
Offshore Execution	420.85	443	553.75	4	HIGH (95%-125%)	TRIANGULAR
Total Estimated days	845.1	893	1071.25			TRIANGULAR

After feeding all data, Monte Carlo simulation is performed with 1000 iterations to generate the most probable time. The simulated duration is then compared to practical duration to find possible deviations, which can be mitigated by risk mitigation measures.

The barge days for installation is dependent on certain factors such as piping inch dia, equipment installed, tonnage data etc. Therefore, DPRs were studied to find out correlation of these parameters. Based on Daily progress reports of past project, the data has been collected to find out the dependent and independent variables. Based on preliminary data, regression was performed and found the R square to be 87% which means 87% of the model fits the data. Refer Table-2 for Regression analysis.

The Regression model is, **Y= X1*Piping Inch Dia+ X2* Tonnage + X3* No of equipment + X4* Painting area +C.**
Y is the number of barge days.
X1, X2, X3, and X4 are coefficients of independent variables.
C is the unexplained variance or error Certain assumptions were considered for the project:

1. Communication risks, political risks, economic risks are not considered.

2. Time period for offshore execution is considered as 195 days considering Oct 15-May 15 as the time period with 16 days nonoperational considering operational standby, anchor handling, gangway installation and weather standby. Total construction seasons days is 211 days.

3. During offshore execution, 3 barges are deployed, and time is calculated considering 3 barges at 3 platforms at one time. 10 platforms are considered for the study.

The methodology can be broken down into following steps:

1. Defining the activities/project phases
2. Preparing the risk register
3. Quantitative Risk assessment
4. Risk Mitigation Plan
5. Integrating risks into schedule
6. PERT and Monte Carlo

Table 2: Regression Analysis

Inputs for Regression

Sl. no.	Total No. of barge Days	Piping scope (Piping inch dia.)	Structural scope (MT)	Equipment Installation	Painting (sq mm.)
1	122	3481	208.91	45	11473
2	133	4453	160	132	12901
3	142	3248	159.45	109	10617
4	102	4287	208.99	114	10617
5	110	4387.4	187.48	46	11439
6	108	4200	153	110	12065
7	145	3685.5	203.56	17	9293
8	110	4003.75	190.37	55	9597
9	173	4697	38.32	22	10697
10	124	4655.75	183.88	27	7856
11	132	4285	160	28	9597
12	132	4771	179	45	9575
13	169	4400	87.17	42	10339
14	159	4124	191.65	48	9500
15	35	900	90	4	1100
16	35	500	50	5	1254
17	35	916	41	4	1134
18	35	1136	42.2	4	1385
19	35	990	40	4	1187
20	35	849.25	50.24	7	1068

•Regression output

Regression Statistics	
Multiple R	0.937449992
R Square	0.878812488
Adjusted R Square	0.846495818
Standard Error	19.47044866
Observations	20

	Coeff-icient	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	23.2865	10.9642	2.12	0.050	-0.08310	46.656	-0.08310	46.6561
X Variable 1	0.01277	0.008816	1.44	0.167	-0.00601	0.0315	-0.00601	0.03157
X Variable 2	-0.12829	0.100448	-1.27	0.220	-0.34239	0.0858	-0.34239	0.08580
X Variable 3	-0.34683	0.178551	-1.94	0.071	-0.72740	0.0337	-0.72740	0.03373
X Variable 4	0.00933	0.003852	2.42	0.028	0.00112	0.0175	0.00112	0.01754

*The regression model is Y= .0128*Piping Inch dia+(-0.128) *Structural tonnage (in MT) +(- 0.347) *No of equipment installed+0.009*Painting area(in sqmm).*

3.0 Findings and Discussion

3.1 Sample Case study Project - Projectschedule analysis

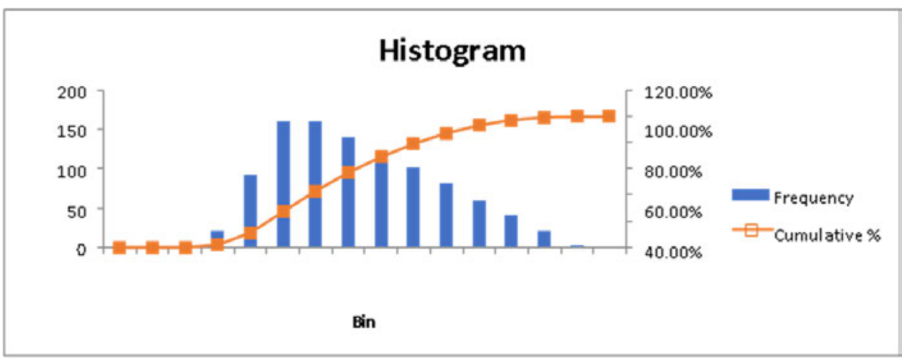
The case study considered for this study is the scope for life extension of 10 nos. of offshore oil and gas platforms. The erstwhile life extension project constituted 40 offshore well platforms which covered major as well as minor structural revamping. For the simulation, following assumptions were considered:

• Triangular distribution is considered for offshore execution and overall project completion.
• PERT distribution is considered fordesign and survey.
• Only risks that are validated during project planning are considered

3.2 Findings of the study:

• The barge days at offshore is collected from DPRs for 20 platform installations and found that actual average days for 1 platform to complete is ***133 days*** with one barge, total barge days is ***1861 days*** & total tonnage replacement is ***2625.22 MT.*** This data is considered for calculating the most likely offshore execution days.
• The installation rate per day is 1.4 MT.
• For 10 platforms, considering 195 working days at offshore gives total barge seasons as 7(1330/195). As per calculation, barges required considering 3 construction seasons is 2.3 and with 2 construction seasons comes around 3.4. Hence, considering 3 barges and 1330 as total barge days, the number of offshore days for completing 10 platforms is 443(1330/3) offshoredays.
• Regression of the data at that 87% of the data fits well. The barge days are dependent variables and independent variables are piping inch dia, tonnage, no of equipment and painting area.
• The simulation output which is a frequency distribution is shown in Figure-1.

Figure 1: Cumulative % of completion vs Frequency of duration (excel results)



• The mean value after simulation is 936 days.
• After simulation, the probability of 10%, 50%, and 90% are 877, 930, and 1007 days. Probability of 50% value gives a value closer to mean. 1007 days at 90% probability over 99% is considered as already higher margin is considered over and above 433 days for offshore execution. However, on a practical scenario, it takes 100-120 days per platform for completing works withone barge.

• This implies that the highest estimate that the project can be completed is 1007 days at probability of 90% with no risk mitigation applied. So, 114 days is the probable delay (considering worst case) that can incur from the most likely estimate of 893 days which was obtained based on past project experience.
• With appropriate risk mitigation measures in place, the expected duration can be brought down.

Note: The trial version of Risk software addon is used for the study.

4.0 Recommendations and Conclusions

4.1 Recommendations

In order to avoid delay in projects and stretched timelines, it is necessary that risks are managed well with actionable mitigation measures.

It is recommended that stochastic method of time estimation (Monte Carlo simulation) is used during project planning using collaborative workflows rather than traditional approach of expert judgement as market scenarios may be different and contingencies has to be accounted. To determine the criticality index and perform sensitivity analysis, software such as Risky Project professional, @Risk etc. can be used.

Project planning tools such as Primavera can be used to plan duration of project, create look ahead look schedule and create shared workspace for stakeholders to have better monitoring & control. A standard template can be created taking parameters such as barge days, tonnage, piping inch dia, etc. and collected from contractors/digital DPRs to have a data pool of time taken for all equipment/replacement jobs. The same can be used as an input for time calculation for future projects.

Other measures include opting for right contracting model (EPC, T&I, time material, fixed material etc.) & contract terms shall be explored considering the bestpractices of the industry. The industry can transform by fostering a culture of efficiency through collaboration by conducting annual meets to discuss industry practices/white paper presentations etc. and reliable execution using project management tools. Risk mitigation measures such as following proper documentation & legal procedure and keeping back up documents to substantiate any deviation or arbitration related matters, ensuring check lists are updated for all work such as survey, commissioning & fabrication related jobs, escalation factors to adjust inflation/demand supply mismatch factors for costing related risks, follow ups & readiness checks during execution at offshore, timely release of payments, pro active ordering of long lead items & vendor selection etc. for procurement related risks, meeting with statutory bodies for vessel clearances & internal interface meetings, micro level planning with CA/TPI during commissioning of packages, regular meetings between client & contractor etc.

4.2 Conclusion

The challenges of limited construction period, challenging work environment, marine spread availability and logistics constraints will be there for capital projects. Similarly, there will be risks that are dynamic in nature such as getting fair windows for hook up & installation of brownfield jobs, but all these risks can be addressed only by assuming contingencies and maintaining a record of past projects shut down time & robust data of time required for each package installation/hook ups.

With changing dynamics in the offshore industry in India with limitations in terms of marine spread regulations, limited bidder participation etc., the need of the hour is to have a robust risk-based time estimation methodology by taking into account both singular & distributional information throughout project life cycle and also having quantified risk register for each nature of project. The study concludes the project can be completed in 1007 days at probability of 90% with no risk mitigation applied. Hence, it can be concluded that considering the worst- case scenario, 1007 days can be considered over 893 days (which is also close to original planned time duration using traditional approach) giving a more realistic timeline. This model using an Advanced Work Package gives a glimpse of how a Project Manager can use this tool for decision making in choosing an ideal number of days with risk inbuilt. Factors that impact on the overall duration depend on risk rank, number of barges deployed, and number of days required per platform. Hence, it is imperative that these factors are analyzed meticulously before project schedule estimation.

References:

1. https://www.ibef.org/industry/oi l-gas-india

2. Al-Hajji, H., & Khan, S. Keeping oil & gas EPC major projects under control: strategic & innovative project management practices. In Abu Dhabi International Petroleum Exhibition & Conference. OnePetro. (2016, November)

3. ubin, S., Jahan S., & Gavrishyk, E. Monte Carlo simulation and modelling of schedule, cost and risks of Dasu Hydropower Project. Mehran University Research Journal of Engineering & Technology, 38(3), 557-570 (2019)

Balancing Profit and Planet: How the Oil and Gas Industry Can Become More Sustainable

Sujay Sarkar
Senior Assistant Director (Gas)

Federation of Indian Petroleum Industry

Introduction

The Oil and Gas industry has been the backbone of the global economy for more than a century. It provides energy to power everything from cars to aeroplanes, and its by-products are used in a wide range of products, including plastics, fertilizers, and pharmaceuticals. However, the industry has also been associated with environmental challenges, as the sector is responsible for significant greenhouse gas (GHG) emissions, contributing towards climate change.

The need for a sustainable oil and gas sector has never been more critical, given the urgent need to mitigate climate change and secure access to clean energy for the world's population. The Intergovernmental Panel on Climate Change (IPCC), in its latest report, released on March 20, 2023, sets out that to keep within the 1.5°C limit, emissions need to be reduced by at least 43% by 2030 compared to 2019 levels, and at least 60% by 2035. This is the decisive decade to make that happen and there are multiple, feasible and effective options available to reduce greenhouse gas emissions and adapt to human-caused climate change.

This article has tried to explore how the Oil and Gas sector can become more sustainable, including investing in renewable energy, improving efficiency, reducing emissions, and adopting circular economy principles to contribute to a cleaner, healthier, and more equitable future for all.

Challenges Facing the Oil and Gas Industry

The oil and gas industry is facing numerous challenges in its journey towards sustainability. One of the main challenges is the carbon emissions associated with fossil fuel extraction, production, and consumption.

Another challenge is the limited availability of natural resources. Oil and gas reserves are finite, and there is a risk of depletion in the near future. This creates a need to find alternative energy sources to ensure long-term sustainability.

Finally, the oil and gas sector is also facing pressure from stakeholders, including investors, consumers, and governments, to adopt sustainable practices. These stakeholders are increasingly demanding that the sector reduce its carbon footprint, minimize environmental impact, and ensure ethical practices throughout the supply chain.

Need for a Sustainable Oil and Gas Industry

The need for a sustainable oil and gas industry is clear, it is not only necessary for the environment, but also for the industry itself. The industry must balance the need for energy with the need to protect the environment and communities. This requires a commitment to innovation, collaboration, and responsible business practices.

As the world moves towards a low-carbon economy, companies that fail to adapt and innovate will be at risk of becoming obsolete. Therefore, the industry must invest in new technologies and business models that reduce its environmental and societal impact while remaining competitive and profitable. By taking action to become more sustainable, the oil and gas industry can play a critical role in addressing the challenges of climate change and building a more sustainable future for all.

Case Studies

Several oil & gas companies across the globe have implemented sustainable practices to address the challenges. Here are some examples:

A. Global Oil & Gas Companies

1. Equinor: Equinor has set a target of becoming a net-zero company by 2050. It is investing in renewable energy sources like wind & solar and is also exploring carbon capture and storage (CCS) technology. It has implemented energy efficiency measures across its operations and measures to reduce methane emissions, such as using drones to detect leaks. It has implemented circular economy practices & developed a process called Grind2Energy, which converts food waste into renewable energy and fertilizers. It has also implemented biodiversity measures to protect and enhance ecosystems.

2. British Petroleum (BP): BP has set a target of becoming a net-zero company by 2050, which involves increasing its investment in renewable energy sources, and has also developed technology to capture carbon dioxide from industrial processes. It is implementing energy-saving measures in its offices and production facilities, such as LED lighting, energy-efficient HVAC systems, and process optimization. It is also working to restore habitats and ecosystems, as well as implementing measures to reduce the impact of its operations on wildlife.

3. Shell: Shell has set a target of becoming a net-zero company by 2050, with a focus on reducing emissions from its own operations. The company is investing in renewable energy and carbon capture and storage (CCS) technology. Shell has also implemented measures to reduce methane emissions, such as using advanced technologies to detect leaks and implementing best practices in well completions and production. Towards circular economy practices, it has developed a process called Shell Recharge, which converts waste plastic into chemicals and transportation fuels.

4. TotalEnergies: Total has set a target of reaching net-zero emissions by 2050, which involves investing heavily in solar power and other renewable energy sources.. TotalEnergies is also exploring carbon capture and storage (CCS) technology and has implemented measures to reduce methane emissions. It is involved in the production of bioplastics, which are made from renewable resources such as corn or sugarcane and also has implemented measures to protect and enhance biodiversity in areas where it operates.

As a country, India has set a net-zero target of 2070, an important step towards a sustainable future. The country's efforts towards achieving this goal will significantly impact global climate change mitigation efforts.

B. Indian Oil & Gas Companies

1. ONGC: ONGC has implemented several sustainable practices to reduce its environmental impact. The company is investing in renewable energy sources like wind and solar power and is also exploring carbon capture and storage (CCS) technology. It has implemented measures to reduce its water usage and improve energy efficiency in its operations. It has also undertaken several initiatives to conserve biodiversity, including afforestation, reforestation, and restoration of degraded lands.

2. Oil India Limited (OIL): OIL has installed solar panels at several of its facilities, including oil wells and administrative buildings, to lower its carbon footprint. It is using recycled water for its operations, converting waste oil into usable fuel, and recycling drilling waste into construction materials. It has taken several steps to conserve biodiversity which includes reforestation projects, conservation of endangered species, and monitoring of air and water quality to minimize the impact of its operations on local ecosystems.

3. Indian Oil Corporation Limited (IOCL): IOCL has implemented several sustainable practices to reduce its carbon footprint. It has installed solar power plants and is using biofuels in its operations to reduce its reliance on fossil fuels. IOCL has also implemented measures to reduce its water usage and improve energy efficiency. The company has developed a technology called the Plastic2Textile process, which involves converting plastic waste into polyester fiber, which is then used to make textiles, setting a good example of a circular economy.

4. Reliance Industries Limited (RIL): RIL is actively working towards a low-carbon future and has set a target of becoming a net-zero carbon company by 2035. It is investing in renewable energy sources like solar and wind power and has implemented measures to reduce its greenhouse gas emissions and improve energy efficiency in its operations. It has constructed several green buildings that are energy-efficient and use sustainable materials and is also promoting a circular economy by developing products that can be recycled and reducing waste.

5. GAIL (India) Limited: GAIL has set a net-zero target to achieve carbon neutrality by 2050 and has implemented several sustainable practices to reduce its carbon footprint. The company is investing in renewable energy sources like wind and solar power and is also expanding Sustainable Transport through use of CNG & biogas as an alternative fuel. GAIL has implemented measures to reduce its greenhouse gas emissions and improve energy efficiency in its operations. It has constructed several green buildings that are energy-efficient and use sustainable materials, and also providing access to education, healthcare, and clean water to underprivileged communities.

Lessons Learned

From these case studies, we can learn several lessons about how the oil and gas industry can become more sustainable:

1. Setting Ambitious Targets: Companies in the oil and gas industry must set ambitious targets to become more sustainable. Targets must be clear, measurable, and time-bound, and companies must be held accountable for meeting them.

2 Diversifying Energy Sources: Diversifying their portfolio to include renewable energy sources like wind and solar can provide companies with new revenue streams and reduce their reliance on fossil fuels. This can not only reduce its carbon emissions and help mitigate the effects of climate change but also tap into new revenue streams.

3. Implementing Carbon Capture and Storage (CCS) Technology: CCS technology involves capturing carbon dioxide emissions from power plants and other industrial sources, and storing them underground or using them for other purposes, such as enhanced oil recovery. This technology has the potential to significantly reduce carbon emissions from the oil and gas sector

4. Reducing Methane Emissions: Reducing methane emissions can be an effective way to reduce the industry's impact on climate change. There are several ways to reduce methane emissions such as using technology to detect and repair leaks, improving equipment efficiency, and implementing best practices in well completions and production.

5. Improving Energy Efficiency: Improving energy efficiency is another strategy for the oil and gas industry to become more sustainable. There are many ways in which the sector can increase efficiency. For example, adopting advanced technologies, such as machine learning & artificial intelligence, and investing in energy-efficient equipment can help optimize various processes, thereby reducing energy consumption and waste.

6. Adopting Circular Economy Principles: Adopting circular economy principles, such as reducing, recycling and reusing materials, can help minimize waste and reduce the environmental impact of the sector. This can also involves designing products and processes with sustainability in mind, with the aim of reducing waste and maximizing the use of resources.

7. Ensuring Ethical Practices throughout the Supply Chain: Adopting ethical practices throughout the supply chain, can help in achieving sustainability in the oil and gas sector. This involves ensuring that all stakeholders, including suppliers, contractors, and employees, adhere to ethical standards like Respect for human rights, Transparency, Environmental & Social responsibility, etc. in all aspects of their work.

8. Collaborating with Stakeholders: Collaborating with stakeholders, including governments, NGOs, and local communities, is essential for the oil and gas industry to become more sustainable. By engaging with stakeholders, companies can gain valuable insights and build trust with the communities where they operate.

Sustainability Reporting: With the increasing focus on sustainability and corporate responsibility, it is becoming increasingly important for companies to demonstrate their commitment to sustainable practices. One way oil and gas companies achieve this is through sustainability reporting. It discloses a company's environmental, social, and governance (ESG) performance to its stakeholders. By reporting on its sustainability performance, an oil and gas company can provide transparent information about its ESG impacts and demonstrate its commitment to sustainability.

Here are some ways that the oil and gas industry can become more sustainable through sustainability reporting:

1. Measure and report on ESG performance: The first step to becoming more sustainable is to measure and report on ESG performance. This can include metrics such as greenhouse gas emissions, water usage, waste generation, and employee diversity. By tracking and reporting on these metrics, companies can identify areas for improvement and demonstrate progress over time.

2. Set sustainability goals and targets: Once ESG performance has been measured, companies can set sustainability goals and targets. These could include reducing greenhouse gas emissions, increasing energy efficiency, or improving employee safety. By setting ambitious targets and reporting on progress towards them, companies can demonstrate their commitment to sustainability and hold themselves accountable for achieving their goals.

3. Engage with stakeholders: Stakeholder engagement is a critical component of sustainability reporting. Companies should engage with their stakeholders to understand their concerns and expectations around sustainability. This can include holding stakeholder meetings, conducting surveys, and responding to stakeholder feedback. By engaging with stakeholders, companies can build trust and demonstrate their commitment to sustainability.

4. Use reporting frameworks: Several sustainability reporting frameworks are available that companies can use to guide their reporting process. The Global Reporting Initiative (GRI) is one of the most widely used frameworks for sustainability reporting, and it provides a comprehensive set of sustainability reporting standards. By using a reporting framework, companies can ensure that their reporting is consistent and transparent, and they can benchmark their performance against industry peers. tries, including the oil and gas sector. The GRI's Oil & Gas Sector specific standards aim to help oil and gas organizations - irrespective of location, specialism or size - to effectively disclose on their sustainability performance, including their social, environmental, and economic impacts.

5. Use IPIECA-WBCSD SDG Roadmap: The IPIECA (International Petroleum Industry Environmental Conservation Association) -WBCSD (World Business Council for Sustainable Development) SDG Roadmap is a tool that oil and gas companies can use to guide their sustainability efforts. It can help to achieve the Sustainable Development Goals (SDGs) by providing a structured approach to identifying and addressing sustainability challenges, and by promoting best practices for managing environmental and social impacts.

6. Embed sustainability into business strategy: To truly become more sustainable, companies need to embed sustainability into their business strategy. This means incorporating sustainability into decision-making processes, setting sustainability targets and goals, and integrating sustainability into the company's culture. By embedding sustainability into the business strategy, companies can ensure that sustainability is a core part of their operations and not just an afterthought.

Thus, Sustainability Reporting can play a critical role in helping the oil and gas industry become more sustainable.

Benefits of a Sustainable Oil and Gas Industry

It's important to note that while it may be true that larger oil and gas companies are often better equipped to invest in sustainable initiatives, it doesn't mean that smaller and mid-sized companies should not take steps towards sustainability. In fact, smaller companies can often be more agile and have greater flexibility to implement changes quickly.

There are several reasons why all oil and gas companies, regardless of size, should consider taking sustainable initiatives, as the benefits are numerous for all the stakeholders, society, environment and the industry itself. Here are some of the key benefits:

1. Reduced environmental impacts: By adopting sustainable practices, the oil and gas industry can significantly reduce its environmental impact including carbon emissions, water use, and waste generation.

2. Improved resource efficiency: Sustainable practices can help the industry to use resources more efficiently, reducing waste and improving productivity. This can lead to cost savings and increased profitability for companies.

3. Increased innovation: By investing in sustainable technologies and practices, the oil and gas industry can drive innovation and develop new solutions to address the challenges of the future. This can help the industry to stay competitive and adapt to changing market conditions.

4. Enhanced reputation: Companies that adopt sustainable practices can enhance their reputation among customers, investors, and other stakeholders. This can help to attract new business and investment and improve brand value.

5. Increased competitiveness: Sustainable production practices can help companies remain competitive by adapting to changing market conditions and customer preferences.

6. Cost savings: Sustainable production practices can help companies reduce costs by improving energy efficiency, reducing waste, and optimizing resource use.

7. Improved stakeholder engagement: Sustainable practices can help the industry to engage more effectively with stakeholders, including local communities, governments, and NGOs. This can help to build trust and strengthen relationships with key stakeholders.

8. Reduced regulatory risk: By adopting sustainable practices, the oil and gas industry can reduce its exposure to regulatory risks, such as fines, penalties, and legal action. This can help to improve the long-term viability of the industry and reduce uncertainty for investors.

Overall, a sustainable oil and gas industry can deliver significant benefits for both the industry and the environment.

Conclusion

The oil and gas industry faces significant challenges in becoming more sustainable, including carbon emissions, water usage, waste management, and social responsibility. However, by adopting strategies like investing in renewable energy, implementing carbon capture and storage (CCS) technology, improving efficiency and reducing methane emissions, the industry can reduce its environmental impact and become more sustainable. Companies that set ambitious targets, invest in new technologies, adopt circular economy principles and collaborate with stakeholders will be better positioned to thrive in a low-carbon future.

Oil and Gas companies must take a long-term view and prioritize sustainability in their business practices. This may involve making difficult choices and significant investments in new technologies and infrastructure. The benefits of a sustainable Oil and Gas sector will be felt by everyone, from the environment to the global economy.

By balancing profit and the planet, the oil and gas industry can play a critical role in addressing the challenges of climate change and building a more sustainable future.

Events

India Energy Week 2023

India Energy Week (IEW) 2023 with the theme of Growth, Collaboration, Transition - under India's G20 Presidency, was inaugurated by Hon'ble Prime Minister Shri Narendra Modi in Bengaluru, Karnataka, on 6th February 2023. Held under the patronage of Ministry of Petroleum and Natural Gas (MoP&NG), Government of India and supported by the Federation of Indian Petroleum Industry (FIPI) from 6th to 8th February 2023, IEW provided an unparalleled opportunity to participants to meet, network and engage with the full energy value chain including access to leading NOCs, IOCs, NECs and IECs and companies operating within alternative & renewables, utilities & power generation, construction, technology & services and government & academia.

IEW aimed to showcase India's rising prowess as an energy transition powerhouse and is a testament to Hon'ble Prime Minister Shri Modi's Panchamrit – five nectar element – pathway that offers a step-by-step guide to securing a reliable, affordable and sustainable energy system for India and the world. Governor of Karnataka, Shri Thawar Chand Gehlot, Chief Minister of Karnataka, Shri Basavaraj Bommai, 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 also graced the occasion.

As a part of the event, Hon'ble Prime Minister also launched multiple initiatives in the field of Green Energy:

I. E20 Fuel: In line with the Ethanol Blending roadmap, Prime Minister launched E20 fuel at 84 Retail Outlets of Oil Marketing Companies in 11 States/UTs. E20 is a blend of 20% ethanol with petrol. The Government aims to achieve a complete 20% blending of ethanol by 2025, and oil marketing companies are setting up 2G-3G ethanol plants that will facilitate the progress.

II. Green Mobility Rally: Prime Minister flagged off Green Mobility Rally organised by HPCL. The Rally witnessed participation of 57 vehicles running on sustainable green energy sources viz., E20, E85, Flex Fuel, Hydrogen, Electric etc. The Rally helped in creating public awareness for the green fuels.

III. 'Unbottled' initiative of Indian Oil: Prime Minister launched the uniforms under 'Unbottled' initiative of Indian Oil. Guided by the vision of the Prime Minister to phase out single-use plastic, Indian Oil has adopted uniforms for retail customer attendants and LPG delivery personnel made from recycled polyester (rPET) & cotton. Each set of uniform of Indian Oil's customer attendant shall support recycling of around 28 used PET bottles.

IV. Twin-Cooktop Model of Indoor Solar Cooking System: Prime Minister dedicated the twin-cooktop model of the Indian Oil's Indoor Solar Cooking System and flag-off its commercial roll-out. Indian Oil had earlier developed an innovative and patented Indoor Solar Cooking System with single cooktop. On the basis of feedback received, twin-cooktop Indoor Solar Cooking system has been designed offering more flexibility and ease to the users.

During the Opening Ceremony, Hon'ble Prime Minister said: "The energy sector plays a major role in deciding the world's future in the 21st century. India is one of the strongest voices in the world for energy transition and developing new energy resources. As a result, unprecedented possibilities are emerging for the energy sector in India, which is determined to become a developed nation." He also highlighted the four major verticals of the strategy for the energy sector:

I. Increasing domestic exploration and production
II. Diversification of supplies
III. Expansion of alternate energy sources fuels such as bio fuels, ethanol, compressed biogas and solar
IV. De-carbonisation via electric vehicles and hydrogen

Addressing the gathering, Union Minister for Petroleum & Natural Gas and Housing Affairs, Shri Hardeep S. Puri, said that "The India Energy Week was borne out of PM Modi's long-standing vision for India's role in the global energy transition while ensuring energy security, affordability, and accessibility for Indian citizens." Further he said that, it captures India's dreams and aspirations of an 'Amrit Kaal', whilst also underlining India's role in the 21st Century global economy as a 'Vishwaguru' following ideals of 'Vasudhaiva Kutumbakam'.

Elaborating on the positive outcomes of IEW, Shri Puri said that the India Pavilion provided an immersive digital experience, showcasing India's energy evolution, innovation, achievements, multi-pronged strategy to diversify energy mix, policy reforms, energy transition and sustainability actions and goals.

Various agreements and Memorandums of Understanding (MoU) were signed on the side-lines of India Energy Week leading to further strengthening of collaborations and partnerships in energy sector. Some of the major MoUs/agreements signed during the IEW were:

I. MoU between Directorate General of Hydrocarbon, Ministry of Petroleum & Natural Gas (MoP&NG) and University of Houston, Texas, USA signed as a step forward in strengthening a strategic partnership between India and the United States for establishing a data center with University of Houston.

II. Statement of Intent (SoI) between Petroleum Planning and Analysis cell (PPAC) and International Energy Agency (IEA) to strengthen cooperation in the field of data and research in the energy sector to enhance global energy security.

Alongside the India Energy Week, India also hosted the 9th Asian Ministerial Energy Roundtable in collaboration with International Energy Forum (IEF) with the objective of "Mapping Stable & Secure Energy pathways for achieving Energy security, Energy Justice, Growth and Innovation" and India-US Executive roundtable with US-Indian Business council and US-India Strategic partnership Forum.

During the event, various executive, strategic and technical sessions were conducted, including:

I. Ministerial Sessions: Five Ministerial sessions were conducted on various themes such as Strategies for sustainable and decarbonized future, Building supply chain for the future, and Adapting to an uncertain future: reshaping of global partnerships among others. Energy ministers and policymakers discussed key issues surrounding global energy markets, net-zero ambitions, energy security, and the new energy landscape.

II. Leadership Panels: Eleven leadership panel sessions took place during IEW 2023 on multiple themes such as Pipeline for transition: Natural Gas a necessary solution, The importance for continued investment in E&P, and Green Hydrogen economies: Matching demand and supply among others. Global business leaders and industry experts shared their views and the way forward for a just energy transition as well as meeting the energy needs of today.

III. Spotlight Sessions: Five spotlight sessions took place on themes such as India: The critical cog in the global growth machine, Biofuels: A strategic complement for energy optionality, OPEC: World Oil Outlook. Deliberations and discussions focused on the country's energy sector were carried out by Indian policymakers and energy leaders.

IV. Technical Sessions: Twenty technical sessions were organized during IEW 2023 covering the entire value chain of oil and gas. Deliberations and discussions were carried out by industry professionals on various themes such as Gas/LNG production and operation, Hydrogen infrastructure and application, Clean energy business models, Optimising efficiencies in refining and petrochemical operations and Technology applications for decarbonisation and energy transition among others.

To showcase India's growth story and achievements multiple theme-based and state-oriented Pavilions and Zones were set up such as:

I. Ministry of Power Pavilion: Hosted by Ministry of Power, the pavilion showcased how the Indian Power sector has revolutionised and provides initiatives that shapes India's future of power through various initiatives including Smartcity, Green Energy Financing, Electric Charging Infrastructure, Pumped-Storage Plants and Renewable Energy Integrations across India.

II. O2C & Circularity – Towards Lower Carbon Footprint: Hosted by Indian Oil Corporation Ltd, the pavilion showcased Crude oil-to-chemicals (COTC) technology that allows the direct conversion of crude oil to high value chemical products instead of traditional transportation fuels. COTC helps refiners to tackle current market dynamics and remain profitable.

III. Indian Aviation Pavilion: Hosted by Indian Oil Corporation Ltd and based on the theme of Indian Aviation sector and development of Sustainable Aviation Fuel (SAF), the Indian Aviation Pavilion focused on the entire aviation ecosystem of the country. The Pavilion attracted various stakeholders such as Indian Air Force, Praj Industries, IndianOil Skytanking Ltd, MRPL along with oil marketing companies - IndianOil, Bharat Petroleum and Hindustan Petroleum among others. The pavilion showcased a cross section of Indian aviation industry and depicted various milestones of the Indian Aviation Sector including initiatives such as Sustainable Aviation Fuel, AVGAS 100 LL, new technologies in aviation, UDAN, RCS, Jet fuel supply landscapes, Jet fuel storage and logistics.

IV. CGD Pavilion: Hosted by Bharat Petroleum Corporation Limited and based on a theme of transforming carbon footprint to Gas footprint, the CGD pavilion showcased India's thriving City Gas Distribution (CGD) story. The pavilion demonstrated how the CGD ecosystem is positively impacting lives in many arenas and showcased how India is making rapid progress to become a gas-based economy with the target of increasing gas consumption to 20% of its energy mix by 2030. The pavilion was divided into three zones; Zone 1 showcased a typical end-to-end CGD network to enable visitors to visualise how a CGD network in a city or geographic area works; Zone 2 presented booths of India's leading CGD companies; Zone 3 provided a glimpse into the future of India's gas-based economy and a sneak peek into the huge opportunity it presents for investors.

V. LNG EcoSystem Pavilion: Hosted by Petronet LNG Limited, the LNG EcoSystem Pavilion presented a journey of downstream LNG supply chain in India ranging from bringing LNG in large cryogenic ships to unloading the same at jetties equipped with all the sophisticated infrastructure, storing into onshore full containment cryogenic tanks, regasification and dispatching into the National Gas Grid.

VI. Make In India Pavilion: Hosted by Engineers India Limited (EIL) under the aegis of the Ministry of Petroleum & Natural gas, the Make In India pavilion showcased the capabilities and capacities available on Indian soil with respect to design, engineering, manufacturing and testing of the entire hydrocarbon value chain.

VII. Karnataka Renewables Pavilion: The pavilion showcased how renewable energy will meet half of Karnataka's energy needs by 2030, and also provided information on new and upcoming renewable energy projects and to explore Karnataka's journey towards clean energy and hydroelectric power generation.

VIII. Start-Up Pavilion: Active participation was also witnessed from promising clean energy start-ups with the potential to elevate, innovate and deliver first-of-its kind green energy technology and solutions across key verticals. Around twenty start-up companies participated in IEW 2023 and on the basis of detailed discussion, presentation and clarifications on the detail of the companies, following 3 best companies were selected for start-up awards, namely

i. Beta Tank Robotics Pvt. Ltd.
ii. Caliche Pvt. Ltd.
iii. VDT Pipeline Integrity Solutions Pvt. Ltd.

IX. Rajasthan Renewables Pavilion: Showcased the green initiatives and policy incentives by Rajasthan state in Renewable Energy. The State is blessed with high solar irradiation and boasting large areas of barren land, emerging as the solar hub of the country.

X. Assam Pavilion: Addressed new investments and projects in Assam and also provided information where power distribution projects offer unparalleled growth opportunities for energy production, and improvements to reliabilities of the grid.

XI. The India Experience Zone: Hosted by 7 oil and gas PSUs (Indian Oil Corporation, Hindustan Petroleum Corporation, Bharat Petroleum Corporation, Oil and Natural Gas Corporation, Oil India Limited, Gail India Limited and Engineers India Limited) and Petronet LNG limited, the India Experience Zone showcased India's growth story and the central role of energy on its road to net-zero by 2070. Innovative technologies and upcoming projects were showcased as state-of-the-art display.

XII. Future Mobility Zone: As the world is set to experience advancements in mobility in the coming years, India forges ahead to pave the way of the Indian integrated mobility ecosystem. Depicting the future, India's mobility pioneers, government and senior stakeholders showcased automotive R&D, automobile regulation, electrical vehicle market, promising business models and connected mobility technologies.

For IEW 2023 an essay competition was conducted for school students by CBSE, Bengaluru on the topic "Energizing Life". The winners of the essay competition were felicitated by Hon'ble Union Minister of Petroleum & Natural Gas and Housing & Urban Affairs, Shri Hardeep S. Puri.

The event saw an active participation of around 1,500 personnels from major oil and gas PSUs (Indian Oil Corporation, Hindustan Petroleum Corporation, Bharat Petroleum Corporation, Oil and Natural Gas Corporation, Oil India Limited, Gail India Limited and Engineers India Limited) and Petronet LNG limited. IEW also witnessed participation from private oil and gas players such as Reliance, BP, Nayara Energy, Cairn Oil & Gas, Essar Oil & Gas Exploration and Production Limited among others. Also, as a part of FIPI student chapter initiative, FIPI supported participation of 20 students from 11 colleges in the event. IEW presented an opportunity for the budding professionals to interact, discuss and gain insights on the ongoing, new and upcoming trends in the energy sector.

The first edition of IEW 2023 witnessed a total of 35,500+ Attendees, 4,400+ conference delegates with 29 Ministerial, keynote, strategic & technical sessions and 280+ speakers. The event witnessed active participation from 130+ countries, and 315+ exhibiting companies displayed their products and technologies in over 45,500+ Gross Sqm of floor space. Acknowledging the unprecedented possibilities emerging in energy sector, the next edition of India energy week will be held in Goa in 2024.

IEW-2023 Highlights


IEW
INDIA ENERGY WEEK 2023
MINISTRY OF PETROLEUM AND NATURAL GAS
6-8 February 2023, Bengaluru, India


FIPI

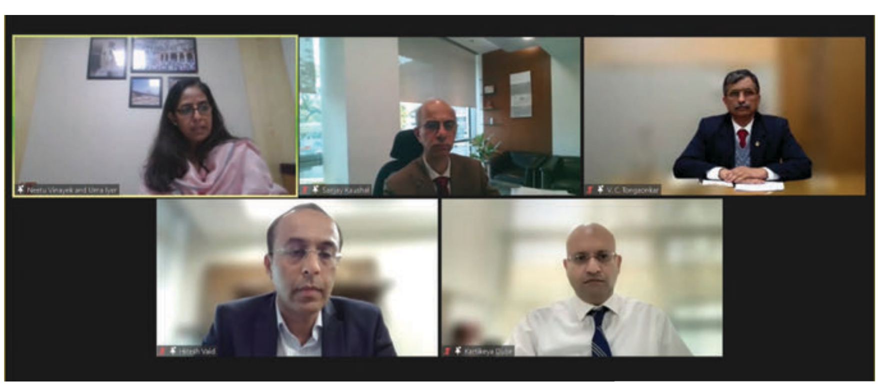
FIPI Post Budget Analysis 2023

The Union Budget for the Year 2023-24 was announced by the Hon'ble Finance Minister of India Smt. Nirmala Sitharaman on 1 February, 2023. Keeping up with FIPI's long tradition, FIPI organized its flagship FIPI Post Budget Analysis 2023 session on 2nd February with EY as the knowledge partner. The Budget session was attended by nearly 200 delegates (virtually) and was appreciated in terms of content by everyone. The objective of the session was to analyze the recently presented Union Budget 2023-24 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 is a growth-oriented budget with a long- term view of social and infrastructure development. He spoke about some of the key announcements highlighted in the Economic Survey and Union Budget 2023-24. He mentioned that India is on a growth trajectory as India's GDP is projected to grow in real terms by 7% in 2022-23 and 6-6.8% in 2023-24. He highlighted that the growth of the economy will be supported by private consumption, higher capex on infrastructure expansion, credit growth to small businesses and easing of regulations. He said that the Budget focused on 7 pillars viz. Saptrishi – Inclusive Development, Reaching the Last Mile, Infrastructure and Investment, Unleashing the Potential, Green Growth and youth Power.

Setting the context for the session, Ms. Neetu Vinayek, Partner, EY, presented the Pre-budget survey analysis and discussed about the industry expectations from the Budget. She then presented the key takeaways of the Economic Survey as well as mentioned the developments related to Direct tax amendments. She welcomed Govt's decision to increase capex to Rs. 10 lakh crore as it will attract more private investment, promote job opportunities and thus attract economic growth. She further said that with fiscal deficit targeted at 6.4% in FY 23, the increase in government investment will have a positive impact in terms of demand generation and employment opportunities in various sectors. She said that currently govt's focus is primarily on clean energy transition and welcomed Govt's initiatives on spending Rs. 35000 crore for priority capital investments towards energy transition which would help in attaining net zero initiatives.

Ms. Uma Iyer, Partner, EY highlighted the provisions made under the indirect tax. She highlighted that the input tax credit would be denied in relation to CSR expenses. Further she mentioned developments such as - time limit prescribed for filing returns beyond due date – maximum three years from due date; Goods and Services Tax Network portal becomes authorized to share consent-based information to other notified systems; among other developments.



The main highlight of the session was the 'Panel Discussion on Union Budget 2023-24, focusing on the outcome for oil and gas companies in the new budget. The panel comprised of Mr. Vivek Tongaonkar, Executive Director- ONGC, Mr. Sanjay Kaushal, Chief Financial Officer- IOCL, Mr. Hitesh Vaid, Chief Financial Officer- Cairn Oil & Gas, Vedanta Ltd. and Mr. Kartikeya Dube, Chief Financial Officer- Reliance BP Mobility Ltd. The panel discussion was moderated by Ms. Neetu Vinayek, Partner, EY.

During the course of the discussion, the panelists highlighted the key positive outcomes of the budget in terms of allocation of capex towards energy transition which will ultimately help in attaining the net zero objectives. The panelists welcomed the incentives provided to new sources of energy in the Union Budget in order to lower carbon emissions and move towards green energy transition. The excise duty concession provided to CBG blended with natural gas, the launch of National Green Hydrogen Mission, Viability gas funding for Battery Energy Storage Systems with capacity of 4,000 MWH, and 500 new 'waste to wealth' plants to be established are all welcome moves to promote clean energy. Further, to ensure green mobility, the government has decided that custom duty would be exempted from capital goods and machinery required to manufacture lithium-ion cells for batteries used in EVs and also extend subsides on EV batteries for another year. This will ensure further surge in the adoption of EVs in the country.

Delivering the closing remarks at the session, Mr. Praveen Rai, Deputy Director, FIPI, said that with Govt spending on infrastructural development of Rs. 10 lakh crores, and focus towards green energy, Indian economy can achieve its targeted growth of 7% by 2023. In his concluding remarks, he thanked all the panelists and the subject matter experts for providing their insights on the Union Budget 2023-24 and its implications on the oil & gas industry and the economy as a whole.

Webinar on 'Online Security Systems for the Oil & Gas Sector

The Federation of Indian Petroleum Industry (FIPI) in association with EY organized a webinar on 'Online security systems for the Oil and Gas Sector' on 18th January 2023. The webinar was conducted in order to shed a light on the importance of having sound and secure technology systems to shield companies from the recent increase in cyber-attacks on the Operational Technology ('OT') of companies. The webinar witnessed an overwhelming response with participation of more than 100 professionals working across the oil and gas value chain.

Mr. Vivekanand, Director (Finance, Taxation & Legal), FIPI began the session with the opening remarks. He spoke about the recent trends indicating that the Oil and Gas companies have shown a drastic increase in implementing the latest technology in the existing systems to monitor real time developments and to keep a track on production cycle. He mentioned that as companies begin to incorporate more of technology be it with regards to production or exploration, they are highly exposed to cyber-attack threats. Hence, having a sound and secure security system is of utmost importance for any organisation.

Mr. Sambit Sinha, Partner EY (Technology Consulting) made a presentation on 'Online security systems for the Oil and Gas sector'. He spoke about the requirement of having robust cyber security defence in the critical infrastructure sector of our country which include the Oil & Gas sector along with Power & Utilities. The critical infrastructure plays an important role in the economy and hence is of crucial significance. Cyber-attacks impact all the facilities and operations across the value chain which can cause a slowdown in production that would have a domino effect on the loss of income of the organisation. Not only would it cause a breach of confidential data but more importantly it will affect the availability of systems. Off late, the attacks happening are observed to be more on the safety systems of the organisations followed by on production systems, hence jeopardizing human life and the environment.

Mr Sinha then concluded the presentation by speaking about a holistic approach in order to build a cyber secure culture within an organisation followed by conducting a Q&A session and wherein he answered on various queries posted by our participants.

Lastly, Mr. Vivekanand, Director (Finance, Taxation & Legal), FIPI thanked the EY and FIPI team who worked hard to make this event successful. He thanked the attendees for their active and interactive participation during the event.

NEW APPOINTMENTS

G. Krishnakumar takes over as Chairman and Managing Director of BPCL

Mr. G Krishnakumar has taken over as the Chairman and Managing Director of Bharat Petroleum Corporation Ltd (BPCL), on 17th March 2023.

Mr. Krishnakumar is an Industry veteran with diverse leadership experience across businesses and functional domains in his 36-year journey at BPCL. He has been at the core of BPCL's pioneering work in revolutionising the downstream fuel retailing industry in the country. He has lead the organisation's customer-centric ventures into convenience retailing, premium fuels and also been the one to introduce new tech and digital initiatives in the company, a first in the Indian Oil Industry.

Mr. Krishnakumar has developed and nurtured winning brands like Petro Card, SmartFleet, Speed, In & Out, which have been significant contributors to BPCL's differentiated customer value proposition in the marketplace, reinforcing the Pure for Sure customer promise.

Prior to his elevation to the board, as the head of BPCL's Lubricants business, he spearheaded brand MAK's aggressive growth in the domestic and international markets, and in the expansion of the product portfolio to cover new and emerging industrial, agricultural, passenger and commercial vehicle segments. He also championed the expansion of the service dimension of the MAK brand - MAK Quik, for quick oil change for 2-wheelers which has since been adopted by millions of customers.

He is an Electrical Engineer from NIT Tiruchirapalli and has done his Masters in Financial Management from Jamnalal Bajaj Institute of Management Studies, Mumbai.

Sushma Rawat takes charge as Director (Exploration) of ONGC

Ms. Sushma Rawat, Executive Director-Basin Manager, Assam & Assam Arakan Basin and OSD – Exploration, has taken over the charge of Director (Exploration), ONGC from 1 January 2023.

An industry veteran with 33 years experience and Exploration Manager par excellence with diverse professional and industry expertise, she brings with her a richness and diversity of perspectives that will benefit the organization in its exploration strategies.

As Basin Manager of A&AA Basin, her dynamic efforts catalyzed several new technologies; some of the noteworthy ones are : Node Based Seismic Data Acquisition system, Passive Seismic Tomography (PST), Airborne Hydrocarbon Sensing Survey (AHSS) which are of paramount importance for geologically complex and logistically difficult terrains of Assam Arakan Fold Belt areas.

A Post-Graduate in Geology, she has an "International Certificate Program in Business Management" course at ASCI, Hyderabad and at Faculty of Economics, University of Ljubljana (FELU), Slovenia, in 2014, under the aegis of DPE.

Her visionary work on "Planning, Monitoring, Evaluation & Benchmarking of R&D Projects in an Integrated National Oil Company", presented at ASCI Hyderabad and "Process & Parameters - Driver for Furtherance of Exploration Investment" presented at FIPI R&D Conclave-2019 were widely acclaimed by the E&P fraternity.

Rohit Kumar Agrawala assumes charge as Director (Finance), CPCL

Mr. Rohit Kumar Agrawala assumed charge as Director (Finance) of Chennai Petroleum Corporation Ltd. (CPCL) on 01.03.2023.

Mr.Rohit Kumar Agrawala is a Chartered Accountant and holds a Masters Degree in Business Administration (Gold Medalist) from Xavier Institute of Management, Bhubaneswar. He started his career in Indian Oil Corporation in 1997 and has a multi-unit experience having worked in Refineries of IOCL in Guwahati, Paradip, Vadodara and Mathura. He has more than ten years of experience in Corporate Finance. He was Team Lead for multiple Change Management assignments in IOCL.

Prior to joining CPCL, he was Chief General Manager (Finance), Business Development Division, IOCL Corporate Office, New Delhi.

Sanjay Choudhuri joins as Director (Finance) of Numaligarh Refinery

Mr. Sanjay Choudhuri has joined Numaligarh Refinery Limited (NRL) as Director (Finance) on March 1, 2023.

Prior to joining the NRL Board, he was working with Oil India Limited (OIL) as Executive Director (Finance & Accounts) and holding additional charge of Executive Director (Corporate Affairs). Mr. Choudhuri is a finance professional with wide-ranging domain experience of over 30 years in the Oil and Gas Industry having headed the finance function in upstream operations, pipeline business, and green field exploration projects in India and overseas. He also has experience of heading corporate finance, budgeting, taxation, management accounts, and financial reporting.

He was Chairman and Director HPOIL Gas Private Limited, a joint venture between OIL and HPCL for CNG and city gas distribution business. He also held strategic leadership roles in OIL's overseas subsidiaries as a Director in Oil India International Pte Ltd, Singapore, Oil India International B.V., Netherland and Oil India (USA) Inc.

Mr. Sanjay Choudhuri, is a fellow member of the Institute of Cost Accountants of India and the Founder Chairman of its Duliajan Chapter

STATISTICS

INDIA: OIL & GAS

DOMESTIC OIL PRODUCTION (MILLION MT)

		2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April - Dec. 22 (P)	% of Total
Onshore	ONGC	5.9	6.0	6.1	6.1	5.9	5.8	4.5	40.1
	OIL	3.3	3.4	3.3	3.1	2.9	3.0	2.4	21.2
	Pvt./ JV (PSC)	8.4	8.2	8.0	7.0	6.2	6.3	4.3	38.7
	Sub Total	**17.6**	**17.5**	**17.3**	**16.2**	**15.1**	**15.1**	**11.2**	**100**
Offshore	ONGC	16.3	16.2	15.0	14.5	14.2	13.6	10.2	93.8
	OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pvt./ JV (PSC)	2.1	1.9	1.9	1.5	1.1	1.0	0.7	6.2
	Sub Total	**18.4**	**18.1**	**16.9**	**16.0**	**15.4**	**14.6**	**10.9**	**100.0**
Total Domestic Production		36.0	35.7	34.2	32.2	30.5	29.7	22.1	100.0
	ONGC	22.2	22.2	21.0	20.6	20.2	19.5	14.7	66.7
	OIL	3.3	3.4	3.3	3.1	2.9	3.0	2.4	10.7
	Pvt./ JV (PSC)	10.5	10.1	9.9	8.4	7.4	7.3	5.0	22.6
Total Domestic Production		**36.0**	**35.7**	**34.2**	**32.2**	**30.5**	**29.7**	**22.1**	**100.0**

Source : MoP&NG/PPAC

REFINING

Refining Capacity (Million MT on 1st January 2022)

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

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

JV Refineries	
HMEL	11.30
JV Total	**11.30**

Bharat Petroleum Corp. Ltd.	
Mumbai	12.00
Kochi	15.50
BORL-Bina	7.80
Total	**35.30**

Hindustan Petroleum Corp. Ltd.	
Mumbai	9.50
Visakhapattnam	8.30
Total	**17.80**
Other PSU Refineries	
NRL, Numaligarh	**3.00**
MRPL	**15.00**
ONGC, Tatipaka	**0.07**
Total PSU Refineries Capacity	**151.72**

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 251.5 (5.02 million barrels per day)
Source : PPAC

CRUDE PROCESSING (MILLION MT)

PSU Refineries	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
IOCL	65.19	69.00	71.81	69.42	62.35	67.66	53.20
BPCL	25.30	28.20	30.90	31.53	26.22	29.84	27.81
HPCL	17.80	18.20	18.44	17.18	16.42	13.97	14.13
CPCL	10.30	10.80	10.69	10.16	8.24	9.04	8.36
MRPL	15.97	16.13	16.23	13.95	11.47	14.87	12.72
ONGC (Tatipaka)	0.09	0.08	0.07	0.09	0.08	0.08	0.06
NRL	2.68	2.81	2.90	2.38	2.71	2.62	2.36
SUB TOTAL	137.33	145.22	151.04	144.71	127.50	138.08	118.64

JV Refineries	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
HMEL	10.52	8.83	12.47	12.24	10.07	13.03	9.50
BORL	6.36	6.71	5.71	7.91	6.19	7.41	--
SUB TOTAL	16.88	15.54	18.18	20.15	16.26	20.44	9.50

Pvt. Refineries	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
NEL	20.92	20.69	18.89	20.62	17.07	20.16	13.70
RIL	70.20	70.50	69.14	68.89	60.94	63.02	46.70
SUB TOTAL	91.12	91.19	88.03	89.51	78.01	83.19	60.40

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Sept. 22 (P)
All India Crude Processing	245.40	251.90	257.25	254.38	221.77	241.70	188.54

Source : MoP&NG/PPAC

CRUDE CAPACITY VS. PROCESSING

	Capacity On 01/01/2022 Million MT	% Share	Crude Processing April-Dec. 22 (P)	% Share
PSU Ref	151.7	60.4	118.60	62.9
JV. Ref	11.3	4.5	9.5	5.0
Pvt. Ref	88.2	35.1	60.4	32.0
Total	**251.2**	**100**	**188.5**	**100**

Source : MoP&NG/PPAC

POL PRODUCTION (Million MT)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
From Refineries	239.2	249.8	257.4	258.2	229.3	250.2	193.5
From Fractionators	3.5	4.6	4.9	4.8	4.2	4.1	2.7
Total	**242.7**	**254.4**	**262.4**	**262.9**	**233.5**	**254.3**	**196.2**

DISTILLATE PRODUCTION (Million MT)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
Light Distillates, MMT	71.0	74.7	75.4	76.8	71.4	76.5	56.3
Middle Distillates , MMT	122.5	127.5	130.8	130.2	110.7	120.2	95.9
Total Distillates, MMT	196.9	206.8	211.1	211.7	186.3	200.7	154.8
% Distillates Production on Crude Processing	**79.1**	**80.6**	**80.5**	**81.7**	**82.4**	**81.7**	**81.0**

PETROLEUM PRICING

OIL IMPORT - VOLUME AND VALUE

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
Quantity, Million Mt	213.9	220.4	226.5	227.0	196.5	212.0	172.5
Value, INR '000 Cr.	470.2	566.5	783.2	717.0	469.8	899.3	993.8
Value, USD Billion	70.2	87.8	111.9	101.4	62.2	120.4	125.0
Average conversion Rate, INR per USD (Calculated)	67.0	64.5	70.0	70.7	75.5	74.7	79.5

OIL IMPORT - PRICE USD / BARREL

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
Brent (Low Sulphur - LS-marker) (a)	48.7	57.5	70.0	61.0	44.3	80.7	100.9
Dubai (b)	47.0	55.8	69.3	60.3	44.6	78.1	96.5
Low sulphur-High sulphur differential (a-b)	1.7	1.6	0.7	0.6	-0.3	2.7	4.4
Indian Crude Basket (ICB)	47.56	56.43	69.88	60.47	44.82	79.18	78.10
ICB High Sulphur share %	71.03	72.38	74.77	75.50	75.62	75.62	75.62
ICB Low Sulphur share %	28.97	27.62	25.23	24.50	24.38	24.38	24.38

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

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
Gasoline	58.1	67.8	75.3	67.0	47.5	89.7	111.1
Naphtha	47.1	56.3	65.4	55.1	43.9	79.9	79.8
Kero / Jet	58.4	69.2	83.9	70.4	45.8	87.3	131.6
Gas Oil (0.05% S)	58.9	69.8	84.1	74.1	50.0	90.2	140.9
Dubai crude	47.0	55.8	69.3	60.3	44.6	78.1	96.5
Indian crude basket	47.6	56.4	69.9	60.5	44.8	79.2	78.1

CRACKS SPREADS ($/ BBL.)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
Gasoline crack							
Dubai crude based	11.1	12.0	5.9	6.7	2.9	11.7	14.7
Indian crude basket	10.6	11.4	5.4	6.5	2.6	10.5	33.0
Diesel crack							
Dubai crude based	12.0	13.9	14.8	13.8	5.5	12.2	44.4
Indian crude basket	11.4	13.4	14.2	13.6	5.2	11.0	62.8

DOMESTIC GAS PRICE ($/MMBTU)

Period	Domestic Gas Price (GCV Basis)	Price Cap for Deepwater, High temp, High Pressure Areas
October 16 - March 17	2.50	5.30
April 17- September 17	2.48	5.56
October 17 - March 18	2.89	6.30
April 18 - September 18	3.06	6.78
October 18 - March 19	3.36	7.67
April 19 - September 19	3.69	9.32
October 19 - March 20	3.23	8.43
April 20 - September 20	2.39	5.61
October 20 - March 21	1.79	4.06
April 21 - September 21	1.79	3.62
October 21 - March 22	2.90	6.13
April 22 - September 22	6.10	9.92
October 22 - March 23	8.57	12.46
April 23 - September 23	8.57	12.12

Source: MoP&NG/PPAC/OPEC

GAS PRODUCTION

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
ONGC	22088	23429	24677	23746	21872	20629	15057
Oil India	2937	2881	2722	2668	2480	2853	2295
Private/ Joint Ventures	6872	6338	5477	4770	4321	10502	8516
Total	**31897**	**32648**	**32875**	**31184**	**28672**	**33984**	**25868**

		2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
Onshore	Natural Gas	9294	9904	10046	9893	9601	10471	7805
	CBM	565	735	710	655	477	518	512
	Sub Total	**9858**	**10639**	**10756**	**10549**	**10078**	**10989**	**8317**
Offshore		22038	22011	22117	20635	18428	22869	17551
	Sub Total	22038	22011	22117	20635	18428	22869	17551
	Total	**31897**	**32649**	**32873**	**31184**	**28506**	**33858**	**25868**
	(-) Flare loss	1049	918	815	927	721	727	601
	Net Production	30848	31731	32058	30257	27785	33131	25267

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
Net Production	30848	31731	32058	30257	27785	33131	25267
Own Consumption	5857	5806	6019	6053	5736	5760	4173
Availabilty	24991	25925	26039	24204	22049	27371	21094

AVAILABILITY FOR SALE

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
ONGC	17059	18553	19597	18532	16972	15874	11654
Oil India	2412	2365	2207	2123	1930	2190	1728
Private/ Joint Ventures	5520	5007	4235	3549	3147	9307	7712
Total	**24991**	**25925**	**26039**	**24204**	**22049**	**27371**	**21094**

CONSUMPTION (EXCLUDING OWN CONSUMPTION

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-Dec. 22 (P)
Total Consumption	49677	53364	54779	58091	54910	59277	41488
Availabilty for sale	24991	25925	26039	24204	22049	27371	21094
LNG Import	24686	27439	28740	33887	32861	31906	20394

GAS IMPORT DEPENDENCY

	2016-17	2017-18	2018-19	2019-20	2020-21 (P)	2021-22 (P)	April-Dec. 22 (P)
Net Gas Production	30848	31731	32058	30257	27785	33131	25267
LNG Imports	24686	27439	28740	33887	32861	31906	20394
Import Dependency (%)	44.5	46.4	47.3	52.8	54.2	49.1	44.7
Total Gas Consumption*	**55534**	**59170**	**60798**	**64144**	**60646**	**65037**	**45661**

* Includes Own Consumption

Source: MoP&NG/PPAC

SECTOR WISE DEMAND AND CONSUMPTION OF NATURAL GAS

		2019-20	2020-21	2021-22 (P)	2022-23									
					Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Fertilizer	R-LNG	9556	11227	12363	1125	1247	1107	1286	1216	1181	1362	1298	1303	**11125**
	Domestic Gas	6559	6554	5716	402	475	466	427	466	493	395	398	305	**3827**
Power	R-LNG	3554	3564	2670	168	141	177	89	72	76	54	110	102	**989**
	Domestic Gas	7526	7272	6260	388	485	434	572	584	538	551	538	573	**4663**
City Gas	R-LNG	5146	4456	5238	455	428	405	454	407	301	140	138	152	**2880**
	Domestic Gas	5737	4774	6890	574	617	656	624	671	659	803	818	850	**6272**
Refinery	R-LNG	13130	12386	9725	563	696	533	601	491	401	384	456	414	**4539**
Petro-chemical Others	Domestic Gas	5285	5823	10656	818	892	866	1065	1060	1021	1013	964	1068	**8767**

Qty. in MMSCM
Source:PPAC

CGD INFRASTRUCTURE

		As on 31st March 2019	As on 31st March 2020	As on 31st March 2021	As on 31st March 2022	As on 31st Jan 2023
PNG	**Domestic**	50,43,188	60,68,415	78,20,387	93,02,667	10,562,564
	Commercial	28,046	30,622	32,339	34,854	37,031
	Industrial	8,823	10,258	11,803	13,215	14,854
CNG	**CNG Stations**	1,730	2,207	3,101	4,433	5,118
	CNG Vehicles	33.47 lakhs	37.10 lakhs	39.55 lakhs	44.09 lakhs	50.10 lakhs

Source: PPAC/Vahan

MAJOR NATURAL GAS PIPELINE NETWORK As on 31.12.2022

Nature of Pipeline		GAIL	GSPL	PIL	IOCL	AGCL	RGPL
Operational	Length	9,582	2,695	1,459	143	107	304
	Capacity	167.2	43.0	85.0	20.0	2.4	3.5
Partially commissioned#	Length	4,777			282		
	Capacity						
Total operational length		**14,360**	**2,695**	**1,459**	**425**	**107**	**304**
Under construction	Length	5,095	100		1,149		
	Capacity		3.0				
Total length		**19,455**	**2,795**	**1,459**	**1,574**	**107**	**304**

Nature of pipeline		GGL	DFPCL	ONGC	GIGL	GITL	Others*	Total
Operational	Length	73	42	24				**14,429**
	Capacity	5.1	0.7	6.0				
Partially commissioned#	Length				1,255	365		**6,680**
	Capacity							**-**
Total operational length		**73**	**42**	**24**	**1,255**	**365**	**0**	**21,129**
Under construction	Length				1,077	1,666	2,915	**12,002**
	Capacity							**-**
Total length		**73**	**42**	**24**	**2,332**	**2,031**	**2,915**	**33,131**

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

Source: PPAC/PNGRB

EXISTING LNG TERMINALS

Location	Companies	Capacity (MMTPA) As on 01st Mar. 23	Capacity Utilisation (%) April-Jan 2023
Dahej	Petronet LNG Ltd	17.5	78.2
Hazira	Shell Energy India Pvt Ltd	5.2	37.5
Dabhol*	Konkan LNG Ltd	5	34.3
Kochi	Petronet LNG Ltd	5	18.3
Ennore	Indian Oil LNG Pvt Ltd	5	13.1
Mundra	GSPC LNG Ltd	5	17.1
Total Capacity		**42.7 MMTPA**	

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

Source: PPAC

2022-23 WORLDWIDE ACTIVE RIG COUNT

REGION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
US	601	636	661	690	718	739	756	764	763	768	779	779	772
Canada	190	220	185	107	93	143	186	201	211	214	201	155	226
Latin America	158	153	160	163	155	160	163	172	180	188	185	173	170
Europe	111	102	78	81	79	87	87	104	106	107	102	115	117
Middle East	289	287	303	300	314	303	309	308	308	326	330	323	318
Africa	86	81	87	78	76	78	78	77	80	84	91	92	92
Asia Pacific(1)	120	112	111	108	115	119	119	122	128	129	124	119	126
India	77	78	76	76	78	77	77	77	77	77	78	78	78
TOTAL	**1632**	**1669**	**1661**	**1603**	**1628**	**1706**	**1775**	**1825**	**1853**	**1893**	**1890**	**1834**	**1899**

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	Axens India (P) Ltd.	Mr. Siddhartha Saha	Managing Director
3	Baker Hughes, A GE Company	Mr. Neeraj Sethi	Country Leader
4	Bharat Petroleum Corporation Ltd.	Mr. G. Krishnakumar	Chairman & Managing Director
5	BP Exploration (Alpha) Ltd	Mr. Sashi Mukundan	President, bp India & Senior Vice-President, bp Group
6	Cairn Oil & Gas, Vedanta Ltd	Mr. Sunil Duggal	Group CEO, Vedanta Ltd
7	Central U.P. Gas Ltd.	Mr. Rathish Kumar Das	Managing Director
8	Chandigarh University	Mr. Satnam Singh Sandhu	Chancellor
9	Chennai Petroleum Corp. Ltd.	Mr. Arvind Kumar	Managing Director
10	Chi Energie Pvt. Ltd.	Mr. Ajay Khandelwal	Director
11	CSIR- Indian Institute of Petroleum	Dr. Anjan Ray	Director
12	Decom North Sea	Mr. Will Rowley	Interim Managing Director
13	Dynamic Drilling & Services Pvt. Ltd.	Mr. S.M. Malhotra	President
14	Engineers India Ltd.	Ms. Vartika Shukla	Chairman & Managing Director
15	Ernst & Young LLP	Mr. Rajiv Memani	Country Manager & Partner
16	ExxonMobil Gas (India) Pvt. Ltd.	Mr. Monte Dobson	Chief Executive Officer
17	FMC Technologies India Pvt. Ltd.	Mr. Housila Tiwari	Managing Director
18	GAIL (India) Ltd.	Mr. Sandeep Kumar Gupta	Chairman & Managing Director
19	GSPC LNG Ltd.	Mr. Anil K. Joshi	Chief Executive Officer
20	h2e Power Systems Pvt Ltd.	Mr. Siddharth R. Mayur	MD &CEO
21	Haldor Topsoe India Pvt. Ltd.	Mr. Alok Verma	Managing Director
22	Hindustan Petroleum Corporation Ltd.	Dr. Pushp Kumar Joshi	Chairman & Managing Director
23	HPCL Mittal Energy Ltd.	Mr. Prabh Das	Managing Director & CEO
24	HPOIL Gas Pvt. Ltd.	Mr. Arun Kumar Mishra	Chief Executive Officer
25	IHS Markit	Mr. James Burkhard	Managing Director
26	IIT (ISM) Dhanbad	Prof. Rajiv Shekhar	Director
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 Oiltanking Ltd.	Mr. Rajesh Ganesh	Managing Director
31	Indian Strategic Petroleum Reserves Ltd.	Mr. L.R. Jain	CEO & MD
32	Indraprastha Gas Ltd.	Mr. Sanjay Kumar	Managing Director
33	International Gas Union	Mr. Milton Catelin	Secretary General

S.No	Organization	Name	Designation
34	Invenire Petrodyne Ltd.	Mr. Manish Maheshwari	Managing Director
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	Maharashtra Institute of Technology (MIT) Pune	Mr. Rahul V. Karad	Executive President
41	Mangalore Refinery & Petrochemicals Ltd.	Mr. M. Venkatesh	Managing Director
42	Megha Engineering & Infrastructures Ltd.	Mr. P. Doraiah	Director
43	Nayara Energy Ltd.	Mr. Prasad K. Panicker	Chairman & Head of Refinery
44	Numaligarh Refinery Ltd.	Mr. Bhaskar Jyoti Phukan	Managing Director
45	Oil and Natural Gas Corporation Ltd.	Mr. Arun Kumar Singh	Chairman & CEO
46	Oil India Ltd.	Dr. Ranjit Rath	Chairman & Managing Director
47	Petronet LNG Ltd.	Mr. Akshay Kumar Singh	Managing Director & CEO
48	Pipeline Infrastructure Ltd.	Mr. Akhil Mehrotra	Chief Executive Officer
49	Rajiv Gandhi Institute of Petroleum Technology	Prof. A.S.K. Sinha	Director
50	Reliance BP Mobility Ltd.	Mr. Harish C Mehta	Chief Executive Officer
51	Reliance Industries Ltd.	Mr. Mukesh Ambani	Chairman & Managing Director
52	SAS Institute (India) Pvt Ltd.	Mr. Noshin Kagalwalla	CEO & Managing Director-India
53	Schlumberger Asia Services Ltd.	Mr. Vinay Malhotra	Manging Director
54	Scottish Development International	Mr. Kevin Liu	Head of Energy Trade, Asia Pacific
55	Secure Meters Ltd.	Mr. Sunil Singhvi	CEO-Energy
56	Shell Companies in India	Mr. Nitin Prasad	Chairman
57	Siemens Ltd.	Mr. Guilherme Vieira De Mendonca	CEO (Siemens Energy - India)
58	SNF Flopam India Pvt. Ltd.	Mr. Shital Khot	Managing Director
59	South Asia Gas Enterprise Pvt. Ltd.	Mr. Subodh Kumar Jain	Director
60	Sun Petrochemicals Pvt. Ltd.	Mr. Padam Singh	President
61	THINK Gas Distribution Pvt. Ltd.	Mr. Hardip Singh Rai	Chief Executive Officer
62	TotalEnergies Marketing India Pvt. Ltd.	Ms. Ahlem FRIGA-NOY	Country Chair
63	University of Petroleum & Energy Studies	Dr. Sunil Rai	Chancellor
64	UOP India Pvt. Ltd.	Mr. Mike Banach	Managing Director
65	VCS Quality Services Pvt. Ltd.	Mr. Shaker Vayuvegula	Director
66	World LP Gas Association	Mr. James Rockall	CEO & Managing Director

FEDERATION OF INDIAN PETROLEUM INDUSTRY

CORE PURPOSE STATEMENT

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

SHARED VISION

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

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

Follow us on:

FIPI

Federation of Indian Petroleum Industry

3rd Floor, PHD House, 4/2, Siri Institutional Area,
August Kranti Marg, New Delhi-110016

Follow us on: