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From the Desk of the

Director General

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

Dear Members,

The year 2021 had opened on a high note with a sharp fall in the daily COVID-19 cases coupled with the Hon'ble Prime Minister's rolling out of the nationwide vaccination programme providing the much needed boost to the public sentiments and the Indian economy. The mood further turned exuberant as the Hon'ble Finance Minister presented an extremely forward looking union budget to revive the pandemic hit economy. However, the rising number of COVID-19 cases through the month of March and strengthening international oil prices have raised some concerns. Going forward, the country's economic recovery will depend, to a large extent, on how effectively we manage the pandemic. Despite the vaccination programme now being in full swing, the responsibility rests on the individual citizens to continue observing the COVID-19 restrictions and protocols.

On 1st February, as Smt. Nirmala Sitharaman, the Hon'ble Finance Minister delivered the much awaited union budget. What transpired, over the two hours, is widely being seen as the most audacious and ambitious budget in the history of independent India. The Union Budget 2021-22, that rested on the six pillars - Health and Well-being; Physical and Financial Capital; Inclusive Development for Aspirational India; Reinvigorating Human Capital; Innovation and R&D; and Minimum Government and Maximum Governance truly paves the way to achieve the projected nominal GDP growth of 14.4 per cent in the next financial year. The Federation of Indian Petroleum Industry (FIPI) unequivocally welcomed the Union Budget 2021-22 and is confident that it will infuse a new energy into the economy.

The Union Budget, placed special emphasis on increasing the penetration of natural gas in total energy mix. The expansion of CGD coverage to 100 more districts over the next three years will not only significantly improve the air quality but will also result in new employment opportunities leading to an overall better quality of living for citizens. Interventions in the pipelining segment such as setting up of an independent Transport System Operator (TSO) for regulating common carrier capacity in gas pipelines and further expansion of the gas pipeline network to the state of Jammu and Kashmir will go a long way in achieving the envisioned gas based economy.

To increase the share of natural gas in the country's Primary Energy Mix (PEM) from present 6.3 per cent to 15 per cent, the Ministry of Petroleum and Natural Gas has come out with a draft LNG policy which has set a target of increasing regasification capacity to 70 MTPA by 2030 and 100 MTPA by 2040. To boost the usage of LNG as a transport fuel, the policy aims to convert 10 per cent of long-haul heavy-duty trucks in India to LNG-compatible models. To ensure availability of the fuel to the transport sector, the policy also pitches for establishing 1,000 LNG outlets for long-haul, heavy-duty trucks and other vehicles covering major highways and commercial centers across the country. The new policy is expected to attract an investment to the tune of Rs 10,000 Crore over a period of three years.

Domestic crude oil production for the month of February stood at 2,322.32 MT, while cumulative crude production for the year until the month of February stood at 27,878.81 MT. Natural gas production for the month of February stood at 2,307.12 MMCSM and the cumulative production for the year until the month of February stood at 25,986.70 MMSCM. Recovery in economic activity has helped in the recovery of crude oil demand. As a result, crude oil benchmarks went up by around 40 per cent since December 2020. This can help in improving the profitability of domestic upstream oil producers.

A recent report by S&P Global Platts Analytics has claimed that India's domestic consumption of transportation fuels is expected to grow robustly between April 2021 and March 2022, as focus on the country's economic expansion returns to center stage, after COVID-19 fears subside.

The Union Budget also provided a renewed push to the Pradhan Mantri Ujjwala Yojana by announcing addition of 10 million beneficiaries during the year to the government's flagship scheme under which cooking gas connections are given free of cost to women of below poverty line (BPL) families. The further extension of the scheme will be vital to uplift the lives of under-privileged families and ensuring better life and empowerment for women in rural India.

During the last quarter of 2020 and in the first quarter of the year 2021, FIPI has been at the forefront advocating for key industry issues with the Government. To this end, FIPI had submitted a list of key expectations for Union budget 2021-22 from the Indian Oil and Gas industry with Ministry of Finance. FIPI has also made a representation to the revenue secretary, Ministry of Finance on the proposed amendment under Union Budget 2021-22 pertaining to the issuance of Form-C on inter-state sale or purchase of goods by dealers or manufacturers. FIPI has also advocated with Joint Secretary (Customs), Central Board of Indirect Tax and Customs (CBIC) requesting to amend notification No. 20/2019-Customs to maintain the same rate of customs duty on crude from 1 April, 2021. The Federation has also shared a representation with Joint Secretary (Marketing), Ministry of Petroleum & Natural Gas requesting for suitable interventions to resolve the issues relating to setting up of retail outlets for transportation fuels dispensation.

On 27 January, 2021, FIPI organized the FIPI Oil & Gas Awards ceremony 2020 at New Delhi. The FIPI Oil and Gas Awards are the most prestigious awards of the Indian oil and gas industry that recognize exceptional performance by companies/individuals for the contributions made by them towards the growth of Indian oil and gas industry. The awards ceremony was graced by the presence of the Hon'ble Minister for Petroleum & Natural Gas, Shri Dharmendra Pradhan ji and Shri Tarun Kapoor ji, Secretary, MoPNG. Following the COVID-19 restrictions, the ceremony was organized in a hybrid format.

On 2 February, 2021, FIPI organized its flagship post budget analysis session. Observing the pandemic related guidelines, the session was organized on a virtual platform this year. The session was organized with Deloitte India as the knowledge partner. The session witnessed fruitful deliberations on the recently announced budget and its short, medium and long term impacts on the oil and gas sector. The attraction of the FIPI Post Budget Analysis 2021 was the moderated panel discussion on the hits and misses of the budget and the future support required for an accelerated growth of the industry. The session was attended by CFOs/Finance Heads/ Directors of leading public & private sector companies among other industry leaders and participants.

The Federation of Indian Petroleum Industry firmly believes in evidence based policy advocacy. Over the last few years, FIPI has successfully completed targeted studies on key policy areas. The findings of the FIPI studies have provided meaningful inputs to key Government officials and policy makers.

The way forward

The financial year 2020-21 has been difficult for the Indian economy in general and the oil and gas sector in particular. As we close the financial year, the spirit of the country is high. The Union Budget

2020-21 has already set the tone for an accelerated growth in this new decade. The Indian oil and gas industry is well prepared to service the fuelling needs of this ever expanding economy.

Though our sector is faced with a range of challenges, but with a supportive Government having a clear long term vision for the industry in place, the Indian oil and gas sector is well placed to overcome these challenges. It is a matter of great pride for all industry participants for being associated with a sector that could successfully commercial goals to the backseat and serve the people of the nation selflessly during the toughest of times. Now, with consumption already crossing the pre-COVID levels, the oil and gas companies in the country are eagerly looking forward to the plethora of opportunities that the new financial year holds for this sector. As we embrace the new decade.

I assure you that FIPI will be at the forefront advocating the industry issues while working closely with all stakeholders including Government in scripting the growth story of Indian oil and gas industry.

Let us hope the pandemic will end soon. Meanwhile please stay safe and keep others also safe.

Wishing you the very best.

Dr. R. K. Malhotra

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 sel -sustaining, not-for-profit o ganization.

For more details kindly visit our website www.fipi.o g.in

Follow us on:

Reservoir Characterization Using RPM for Key Wells in the Carbonate Reservoir of Bombay Formation, Western Offshore Basin, India

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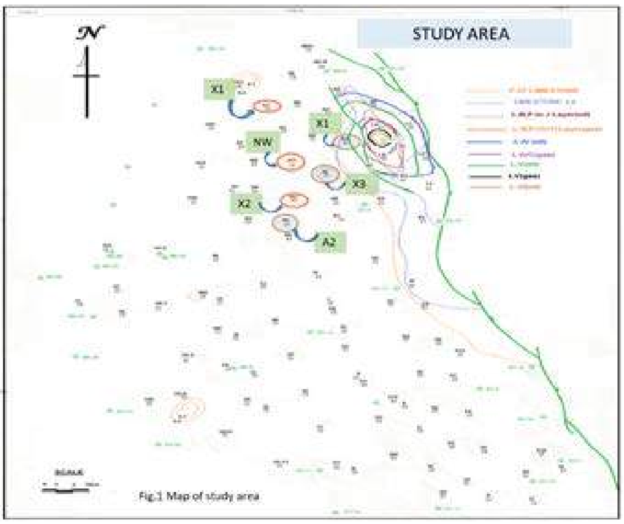
Abstract:

Rock physics Modelling makes use of the minerals and fluid volumes computed from petro-physical analysis to find out elastic properties. Rock physics models that relate velocity and impedance to porosity and mineralogy (e.g. shale content) form a critical part of acoustic analysis for porosity and lithofacies. The important input parameters required for rock-physics modelling are grain size and dry clay aspect ratio, clay and grain density, the compressional and shear velocity of clay, bulk and shear modulus of both grain and clay. Rock physics modelling was developed and carried out for 9 key wells where shear wave data was not available. The P impedance, S-impedance and Vp/Vs curves were generated for the facies and fluid identification in the study area. Various cross-plots were generated with Vp, Vs, P-impedance and S-impedance acoustic logs. The cross-plots of P-impedance modelled and Vp/Vs modelled with litho-fluid colour on Z-Axis is able to differentiate gas, water and the non-reservoir facies. Hydrocarbon-saturated reservoirs are characterized by a lower Vp/Vs ratio in the range 1.6-1.95 in carbonate reservoirs. The synthetic seismogram (SS) is prepared to understand how the lithology, porosity or fluid effects, observed at log resolution are represented at seismic scale. It is observed that boundaries are clearly seen on the seismic scale.

Introduction:

Rock physics science has been evolved during last few decades from a theoretical science to a more practical approach to address the most important subsurface problems. These developments in studying physical properties of minerals and fluids under different environmental conditions (like pressure and temperature) make it possible to find more accurate relationships for the purpose of interpreting and modelling desired scenarios within the field of geophysics, especially in seismic exploration and seismology. Between different disciplines in geophysical studies, seismic studies which work in the elastic domain are the most popular, and this is why most of rock physics studies and developments are focused on disciplines that work in elastic wave domains. This is also the main reason why rock physics models are sometimes referred to as petro-elastic models (PEM) instead of rock physics models. The goal of these petro-elastic model is to understand how lithology, porosity, confining stress and pore pressure, pore fluid type and saturation, anisotropy and degree of fracturing, temperature, and frequency influence the velocities and attenuation of compressional P- and S-waves in sedimentary rocks and vice versa (King, 2005)



Rock physics models that relate velocity and impedance to porosity and mineralogy (e.g. shale content) form a critical part of acoustic analysis for porosity and lithofacies. Rock physics diagnostic analysis of well logs, coupled to the geologic model, usually leads to more rational velocity–porosity relations. RPM is used to quantitatively relate changes in acoustic response to changes in reservoir characteristics such as porosity permeability & fluid saturation. The model used must balance simplicity with accuracy and available input data. In this work we predicted the acoustic properties of the field which are influenced by mineralogy, porosity, textures, fluid etc.

Understanding the seismic-to-reservoir relationship and discovering the best rock physics model in the studied wells are the main concerns of this study. It is known that geophysical applications in carbonate reservoirs are less mature and less abundant than those associated with clastic reservoirs. Carbonate reservoirs are notoriously more difficult to characterise than siliciclastic reservoirs. Compared with siliciclastic reservoirs, carbonate reservoirs offer unique geophysical challenges with respect to reservoir characterisation. These challenges include the following: (1) tight rock fabric, resulting in problematic rock physics models that are not widely accepted; (2) greater heterogeneity due to rapid vertical and lateral facies variation; (3) lower seismic resolution due to higher velocities; (4) physical and chemical alterations, causing fracturing and diagenesis; and (5) mostly land and shallow water seismic data, meaning relatively lower data quality over most carbonate fields (Dong et al., 2003).

The study area encompasses the vicinity of Mumbai High field and consists of Northern part of Mumbai High Area. In our study, Mumbai Formation (L-I to L-IV) is mainly focused with an embedded sandstone layer (S-1) for carrying out petro-physical analysis based on integrated model for all wells and the output of petro-physical data is being used to compute elastic properties.

Rock physics modelling was carried out with Xu and Payne (2009) model for Carbonate reservoirs. RPM enables to derive the effective elastic rock properties from fluid (water saturation Sw, and porosity) and mineral parameters (Volume of clay) as well as rock structure information. The model parameters are calibrated by comparison of the modelled p-wave and s-wave with measured elastic waves.

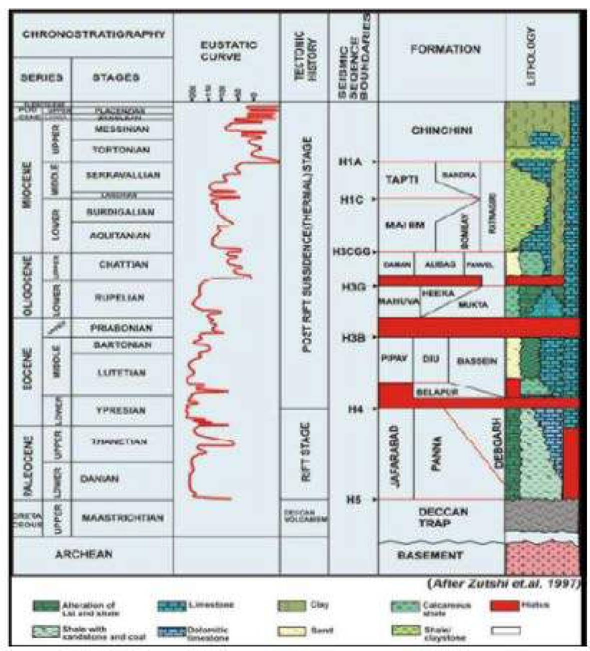


Fig.2. Generalized Stratigraphy of Mumbai Offshore Basin

Methodology: In our study of L-I, L-II, L-III, L-IV formations of Mumbai High North area; the input for Rock-physics modelling were porosity, volume of clay, water saturation and volumes of quartz, SM1 (PYRITE), limestone as an input from petro physical evaluation. Pressure, temperature curve, specific gravity of gas (0.25) and GOR (240) is used to get the dependency of individual elastic moduli and density of fluids (Batzle and Wang) (Gas, Oil and brine). Water saturation and elastic moduli of individual fluids gives bulk modulus and density of hydrocarbon.

After defining Bulk and shear modulus of matrix limestone and quartz, computation of total volume of the minerals (Quartz, Calcite); Grain bulk modulus & Shear modulus is estimated using the average of Ruess & Voigt bounds. Clay shear modulus is calculated by clay density and shear wave velocity and clay bulk modulus is calculated from clay density and compressional and shear velocity. As aspect ratio is a crucial parameter; in our model clay aspect ratio is in range of 0.055-0.05 & grain aspect ratio is 0.095 – 0.12 as normally being taken for sandstone and carbonate reservoirs. Clay shear modulus, clay bulk modulus, grain shear modulus and grain density gives shear velocity and Clay shear modulus, clay bulk modulus, grain shear modulus, grain bulk modulus and grain density gives compressional velocity.

The data has been analyzed using the cross-plots in various lithological units considering the borehole conditions & the contrasting beds. The RPM is calibrated with recorded p-wave velocity and s-wave velocity in two wells. In the study area, the well A1 and X4 are used for calibrating Vp while well A2 is having Vs recoded used for calibrating Vs computed.

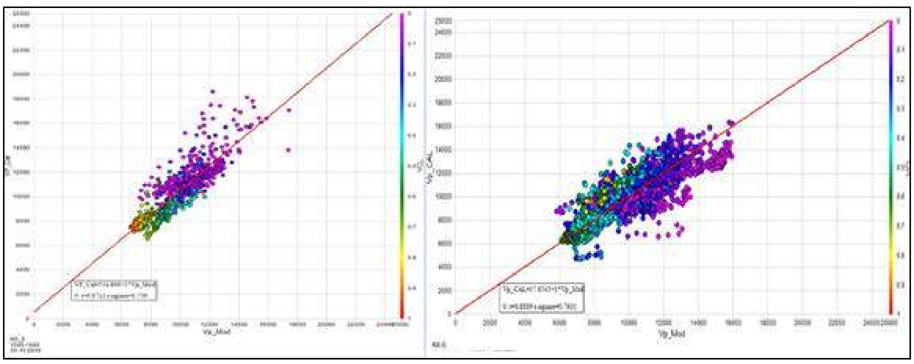


Figure-3 Calibration of Vp in well A1 and X5

Crossplot between Vp_recorded (Vp_C) & Vp modelled (Vp_mod) has been prepared to analyze the fitness between the two. In the above figures it is observed that Vp_C is reading very high value in the some intervals due to sonic data affected in bad hole conditions.

Best fit lines are **V_p_Mod=V_P_C-178 for NX-5 and V_p_Mod=V_P_C - 534 for A1** well.

The maximum variation in the modelled and the recorded Vp is noticed at the highly contrasting lithological boundaries and log data affected due to hole conditions. Hence the modelling carried out with the lithological components is appropriate in this environment & can be used in the inversion modelling within the velocity limits of the Mumbai formation to interpret the lithological & possible fluid variations.

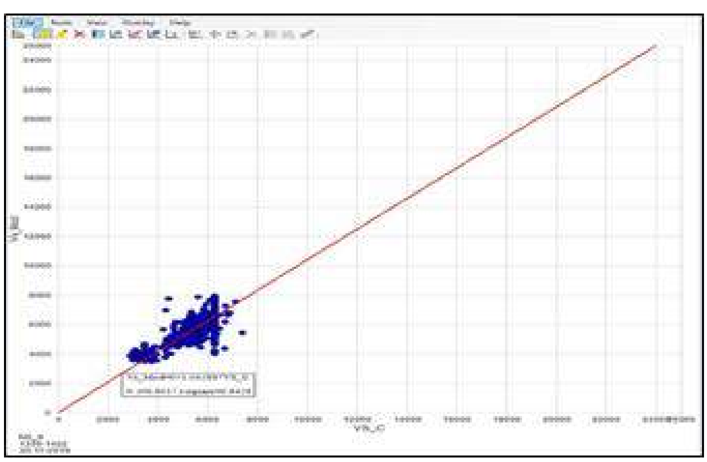


Figure-4: Vs Modelled and Vs Recorded regression in Well A2

Modelled Sonic wave velocity (V_s_Mod) and recorded Vs (V_s_C) are plotted in above figure for well A2. Best fit lines are V_S_Mod=1.04288*V_S_C for A2.

Reservoir characterization through Rock physics model:

RPM enables to derive the effective elastic rock properties from fluid (water saturation Sw, and porosity) and mineral parameters (Volume of clay) as well as rock structure information. The model parameters are calibrated by comparison of the modelled p-wave and s-wave with measures elastic waves. Rock Physics Modelling (RPM) to estimate elastic properties is carried out in sandstone (S1) and carbonate reservoirs in Mumbai formation (L-I, L-II and L-III) to achieve a reliable seismic tie and obtain elastic properties without the influence of borehole conditions, such as wash-outs within shale and alterations intervals. Cross-plots of the elastic properties after rock physics modelling colored with lithology (VCL) and water saturation (SUWI) are prepared and shown in below figures for some wells. Shale beds and gas-saturated reservoirs are characterized by lower P-impedance values. Since there is considerable overlap in P-impedance, they can only be separated by using an additional elastic parameter such as the Vp/Vs ratio.

Hydrocarbon-saturated reservoirs are characterized by a lower Vp/Vs ratio in the range 1.6-1.95 in carbonate reservoirs. The gas bearing limestone reservoirs are having Vp/Vs ratio in the range 1.75-1.85 and in oil bearing reservoir layers Vp/Vs ratio is around 1.7-1.8 in well X3. In Well X1, Vp/Vs ratios are 1.6-1.9 and 1.75-2.0 in gas and oil bearing limestone layers. The shale beds are characterized by higher Vp/Vs ratio in the range 2.0-3.5. Hence it is concluded that the cross-plots show that a reliable discrimination of the Oil, gas and non-reservoir facies clearly in the study area. The prediction of water reservoirs from cross-plot analysis is slightly difficult due to a significant overlap of its elastic properties with non-reservoirs facies. But we have identified water bearing facies based on computed water saturation from petro-physical evaluation.

Cross-plots between Vp/Vs and S-imp is prepared to find out different facies such as gas, oil, shale and water bearing. It is observed that hydrocarbon bearing reservoir having low S-impedance and low Vp/Vs ratio compared to water bearing zones.

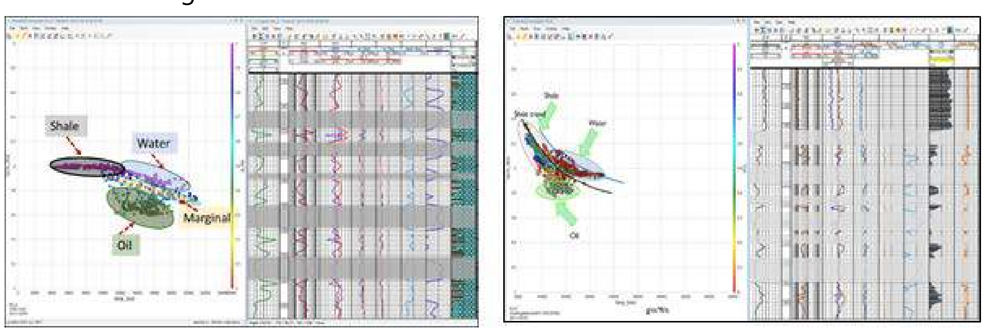
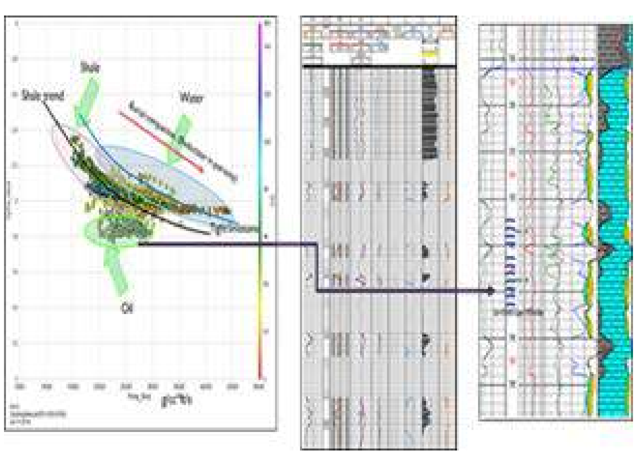


Figure-5 Cross-plot between Vp/Vs and S-imp of Well#X2 and Well#A2



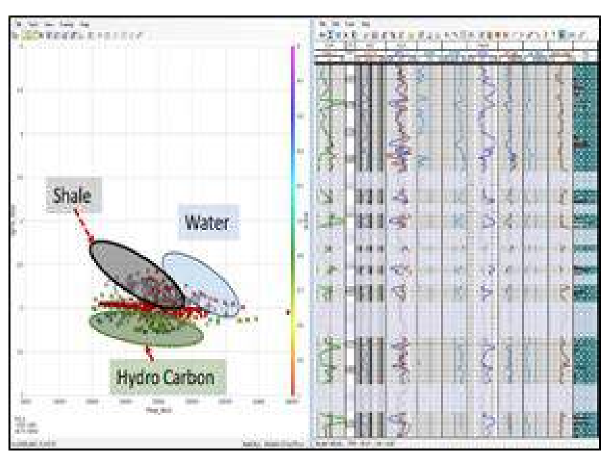


Fig 6: Cross-plot between Vp/Vs and P-Impedance of X3 Fig-7: Crossplot between Vp/Vs and Pimp of A1

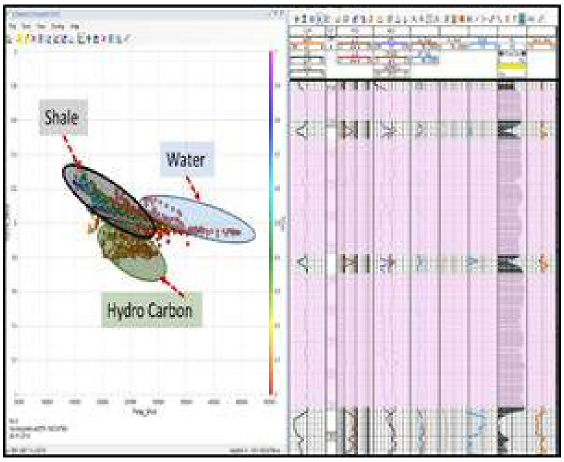


Fig-8: Crossplot between Vp/Vs and P-imp of X2

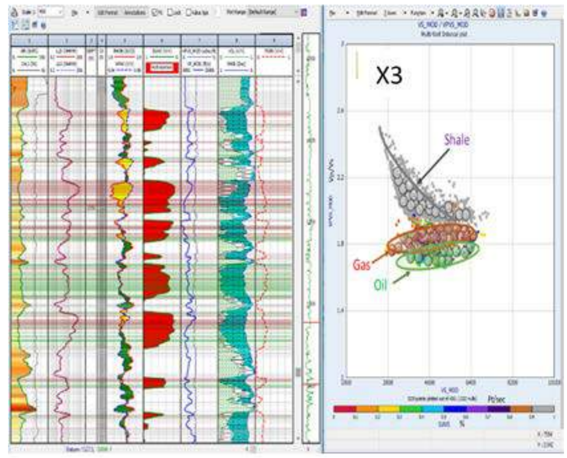


Fig-9 Cross-plot between Vp/Vs and Vs of Well X3

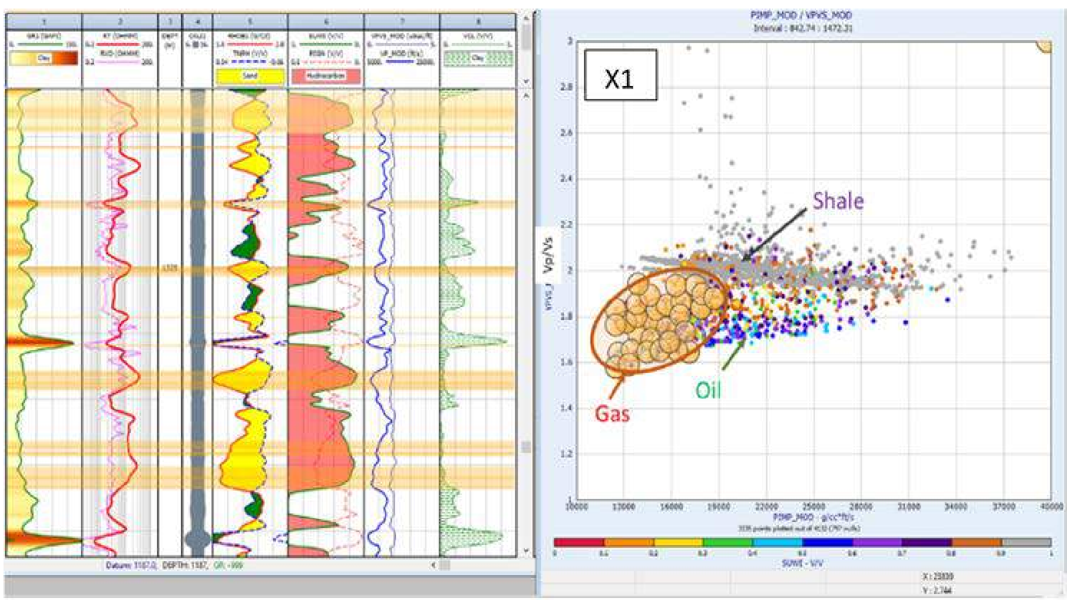


Fig-10: Cross-plot between Vp/Vs and P-Impedance of Well #X1

Various rock properties such as Vp, Vs, P-Imp and S-imp with petrophysical properties are thoroughly studied and tabulated below for Hydrocarbon bearing, shale and water bearing carbonate reservoir.

Table1.1: Rock physics properties for HC bearing Carbonate

	Hydrocarbon bearing			
Well No	Vp/Vs Ratio	P-Imp (g/cc*m/s)	S-imp (g/cc*m/s)	PIGN (%)
X2	1.74-1.85	6000-9000	3000-5000	20-25
A2	1.6-1.8	-	3000-5500	20-25
X4	1.7-1.85	5000-10000	NA	25-28
A1	1.7-1.85	5000-11000	NA	22-25

Table1.2: Rock physics properties for shale beds

	Shale beds			
Well No	Vp/Vs Ratio	P-Imp (g/cc*m/s)	S-imp (g/cc*m/s)	PIGN(%)
X2	1.9-2.4	4500-8500	1500-4500	2-5
A2	2-2.2		1300-3500	2-5
X4	2-2.4	4500-8000	NA	2-7
A1	2-2.5	4500-9000	NA	5-7

Table1.3: Rock physics properties for water bearing Limestone

	Water bearing			
Well No	Vp/Vs Ratio	P-Imp (g/cc*m/s)	S-imp (g/cc*m/s)	PIGN (%)
X2	1.9-2.2	7500-13000	3000-7000	20-22
A2	1.8-2.0		3600-6200	20-25
X4	1.9-2.0	8500-1100	NA	25-30
A1	2-2.5	8000-11000	NA	25-30

Various cross-plots are prepared between Vp and Vs with Saturation on z-axis in some wells. It is observed that separate clusters are seen for shale facies, water bearing reservoir, hydrocarbon saturated limestone reservoirs and sandstone reservoir. The same is shown in below figures.

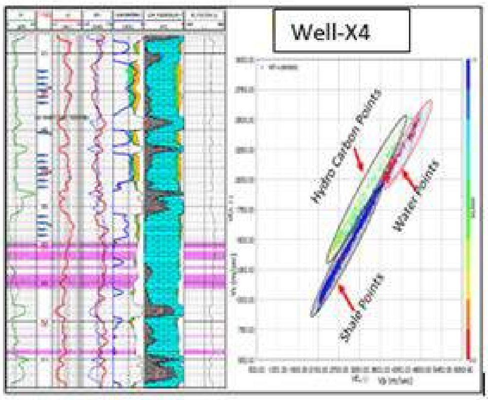


Fig.11 P-wave and S-wave velocities in Well#X4

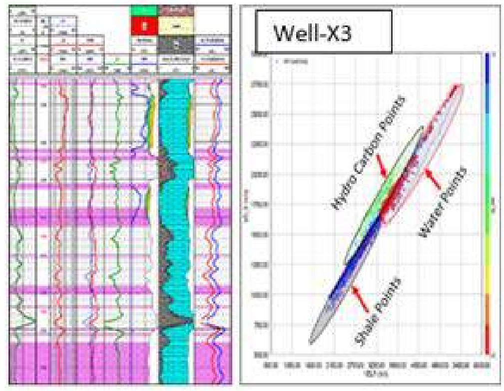


Fig.12: P-wave and S-wave velocities in Well#X3

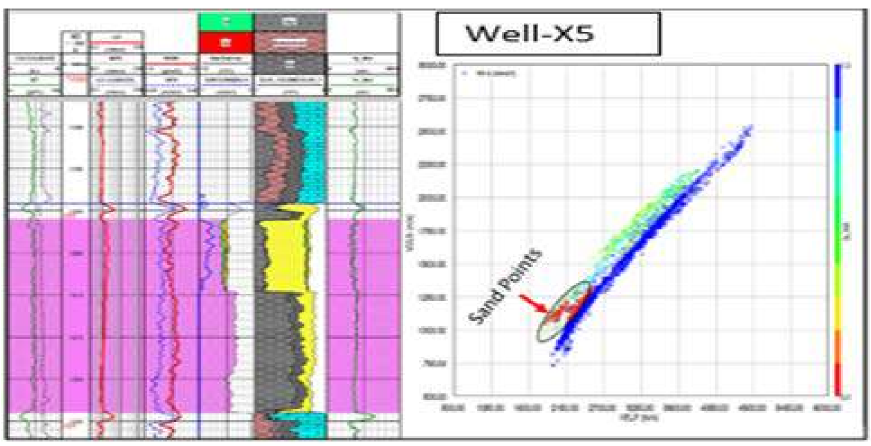


Fig. 13: P-wave and S-wave velocities in Well#X5

Finding out Regression equations where s-wave is not available:

Rock Physics is currently playing an important role in optimizing reservoir performance as well as management, due to its ability to give explicit information when compared to petrophysical analysis results, thereby giving strategic advantage for evaluating rock properties and there changes under reservoir conditions from in situ measured data.

Furthermore, it establishes a relationship between material properties and seismic response so that properties can be observed seismically, and its key advantage is its ability to translate basic rock properties into elastic properties (forward modeling) and otherwise (inversion/backward modeling), for the purpose of exploration, exploitation and management of petroleum and gas reservoirs. Various crossplots are prepared and studied thoroughly for reservoir characterization in Mumbai High North under study area.

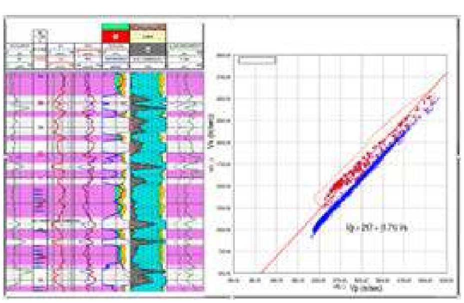


Fig. 14 Regression equation for hydrocarbon bearing section

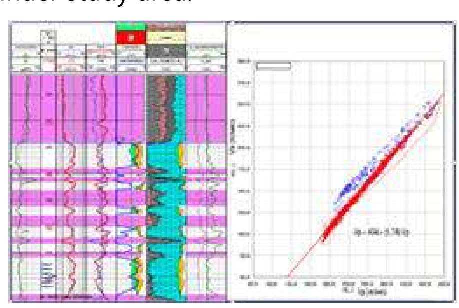


Fig. 15 Regression equation for non-hydrocarbon bearing section

Various Cross-plots between elastic properties (Vp and Vs) are interacted with processed petro-physical data and find trend showing hydrocarbon bearing and non-hydrocarbon bearing limestone layers clearly. It is observed that broadly two trends are seen; one showing hydrocarbon bearing and another non-hydrocarbon bearing limestone layers clearly. For well NW-6, below figure shows interaction between Vp and Vs with log data.

Vp formula is find out using regression line for hydrocarbon bearing zones.

Vp = 217 + (1.71)Vs for hydrocarbon zones

Another trend line clearly shows the shale section and water bearing layers for X4. The shaded part on composite log and highlighted section with red colour on Vp-Vs crossplot shows shale section and water bearing limestone. Vp = 434 + (1.74)Vs for Shale and non-hydrocarbon zones. Another well X2, Regression equation is find out for hydrocarbon bearing layers.

Vp = 201 + (1.75)Vs For HC Bearing limestone section

Table: 1.4 First order Regression equations for different facies

Well No.	*Hydrocarbon bearing facies*	*Shale beds/ Water bearing limestone*	*For all facies*
X5	*Vp = 138.14 + 1.9Vs*	*Vp = 358.2 + 1.7Vs*	*Vp = 424.64 + 1.67Vs*
X3	*Vp = 125 + (1.74)Vs*	*Vp = 320 + (1.80)Vs*	*Vp = 407 + (1.69)Vs*
X2	*Vp = 201 + (1.75)Vs*	*Vp = 198 + (1.89)Vs*	*Vp = 272 + (1.82)Vs*
X4	*Vp = 217 + (1.71)Vs*	*Vp = 434 + (1.74)Vs*	-

Synthetic seismogram: A synthetic seismogram represents the seismic response that would be observed if a wave to travel through a known earth model, in our case defined in terms of the petrophysical properties (porosity, lithology, fluids, etc). A change in the petrophysical properties would produce changes in the velocity of propagation of P and S seismic waves and therefore would produce changes in the seismic amplitudes and travel times.· The synthetic seismogram is computed using P-wave, S-wave and Density logs, which represent the variation of the earth impedance (resistance of the medium to wave propagation). The seismic energy transmitted to the subsurface is represented by a wavelet.

As the wave travels through the earth, at each impedance contrast found (mathematically defined as reflection coefficient), the source wavelet will be reproduced with a resultant amplitude proportional to the magnitude of the impedance contrast. The combination of all reflection coefficients from surface to the maximum propagation time is called Reflectivity Series. The resultant synthetic seismogram is the summation of all the wavelets repeated in the reflectivity series. Mathematically, this process is called Convolution.

The magnitude of the reflection coefficients also depends on the angle of incidence of the seismic wave. Zoeppritz equations provide a way to estimate the reflection coefficients at a given angle of incidence, these equations account for the energy that is transmitted, reflected and converted from P to S as the wave travels through the earth.

In the Software, Synthetic Seismogram module a one-way and/or two-way time curve is created by integrating the data in a sonic or velocity log over true vertical depth, and then calibrating using either a replacement velocity, or a known set of depth/time pairs. Time curve generation requires a sonic or velocity log and a reference depth curve for integration over depth.

The Synthetic Seismogram allows modeling the seismic response from DT (compressional sonic), DTS (shear sonic) and RHOB (density) logs using the first order linear form of Zoeppritz Equations (Aki & Richards, 1980). The synthetic seismogram is prepared from log data in well NI-5 in the study area. The synthetic seismogram (SS) can be used to understand how the lithology, porosity or fluid effects, observed at log resolution, are represented at seismic scale. In well NI-5, rock properties (Vp, Vs and RHOB) are computed using RPM. It is observed that boundaries are clearly seen on the seismic scale. The tops of the formation also marked on the log and beds clearly identified on synthetic seismogram. This is validate the log data processing and modelling of rock properties using RPM.

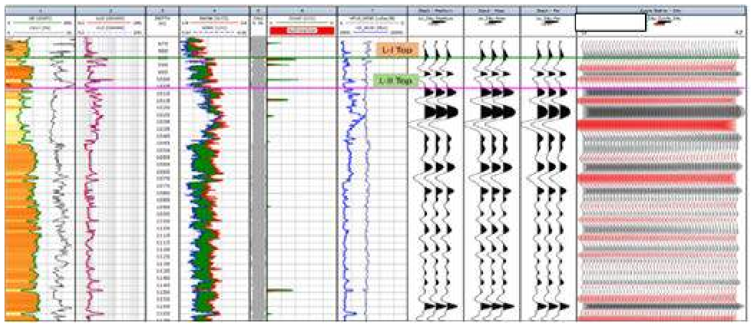


Fig: 17 Synthetic seismogram of X3 (Depth (MD) 970-1170m) for L-I and L-II Formation

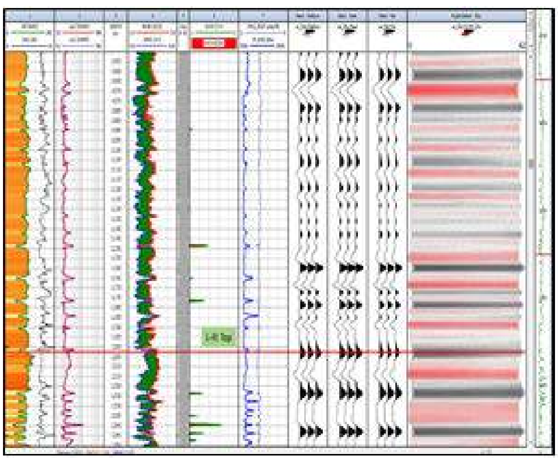


Figure: 18 Synthetic seismogram of well X3 for L-III Formation

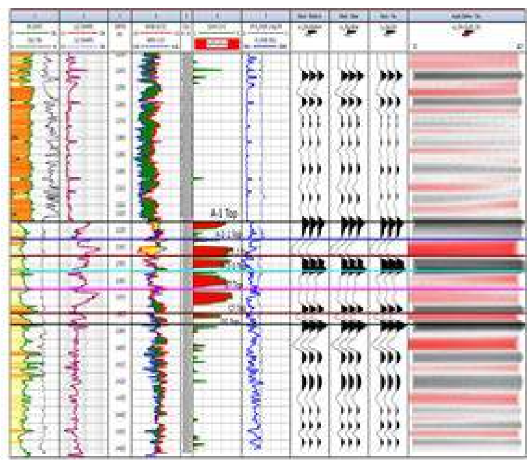


Figure: 19 Synthetic seismogram of well X3 L-III Formation

Conclusions

• Comprehensive petro-physical model has been firmed up using various crossplots & core study available in this area for computation of volume of clay, effective porosity and water saturation. Kaolinite, Montmorillonite, Quartz, and Calcite has been considered as minerals for petro-physical evaluation.
• Pickett plots have been generated to estimate formation water salinity. The estimated formation water salinity from Pickett plot for L-III formation is around 21-25 gpl.
• Rock physics modeling was developed and carried out for 9 key where shear wave data was not available. The P impedance, S-impedance and Vp/Vs curves were generated for the facies and fluid identification in the study area.
• Rock physics Modeling makes use of the mineral and fluid volumes from petro-physics processed output to compute elastic properties. The other important input parameters required for rock-physics modeling are grain size and dry clay aspect ratio, clay and grain density, the compressional and shear velocity of clay, bulk and shear modulus of both grain and clay.
• Various cross-plots were generated with Vp, Vs, P-imp and S-imp acoustic logs. The cross-plots of P-impedance modeled and Vp/Vs modeled with litho-fluid color on Z-Axis is able to differentiate gas, water and the non-reservoir.
• Hydrocarbon-saturated reservoirs are characterized by a lower Vp/Vs ratio in the range 1.6-1.95 in carbonate reservoirs.

• The gas bearing limestone reservoirs are characterized by having Vp/Vs ratio in the range 1.75-1.85 and in oil bearing reservoir layers Vp/Vs ratio is around 1.7-1.8 in well X3. In Well X1, Vp/Vs ratios are 1.6-1.9 and 1.75-2.0 in gas and oil bearing limestone layers. The shale beds are characterized by higher Vp/Vs ratio in the range 2.0-3.5.

• Vp/Vs ratio is a good approach to identify fluid nature in the same formation where other logs are non-conclusive.

• Regression equations have been find out for calculating s-wave from p-wave for different wells where s-wave is not recorded.

• The synthetic seismogram (SS) is prepared to understand how the lithology, porosity or fluid effects, observed at log resolution are represented at seismic scale. It is observed that boundaries are clearly seen on the seismic scale.

Acknowledgements

The authors express their sincere thanks to ONGC management for allowing to publish this paper.

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CO_2-EOR as CCUS: Opportunities and Challenges



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Introduction

Atmospheric CO_2 concentration has witnessed significant increase vis-à-vis pre-industrial era and currently has reached an alarming level of around 410 ppm. Its adverse impact is manifested as global warming & climate change. Owing to which, concerted efforts are being undertaken globally to reduce CO_2 emissions. While adoption of renewables in the energy-mix and improvement in energy usage efficiencies have been thrust areas but climate scientists and agencies consider injection of anthropogenic CO_2 into the sub-surface to be indispensible if global warming targets are to be met. According to the two degree scenario (2DS) released by International Energy Agency (IEA), to curtail global warming within 2°C, CCS accounts for 14% of the overall reduction in emission.

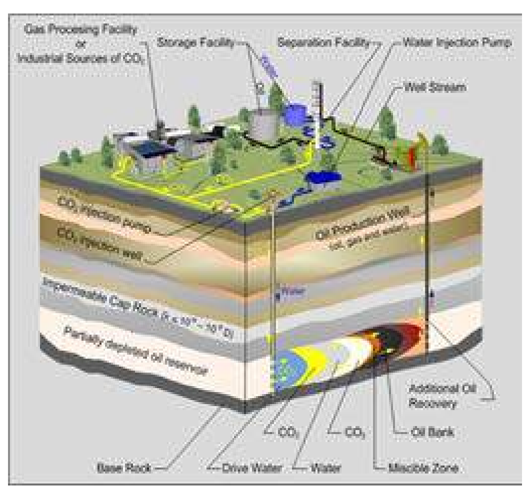
Coming to Indian context, with over 1.3 billion population, India needs sustained sources of energy to fuel its growth and cater to the aspirations of its huge population. Envisioned by our Prime Minister, 10% oil import reduction by 2022, warrants adoption of groundbreaking ideas to ramp up domestic oil production corroborating the import reduction vision. On the other hand looking at the emission front, India, albeit with very less per capita emission, is the third largest CO2 emitter in the world. As per the Intended Nationally Determined Contributions (INDC) of Paris Agreement, India has ratified to decrease its emission intensity of GDP by 33- 35 percent by 2030 from 2005 level. In this regards, Carbon Capture Utilization & Storage (CCUS) offers win-win proposition by curtailing atmospheric emissions as well as may potentially be utilized for enhanced oil recovery from mature oil fields or for production of chemicals & fuels.

Overview of CCUS

As per AIChE, CCUS encompasses methods and technologies to remove CO_2 from the flue gas and from the atmosphere, followed by recycling the CO_2 for utilization and determining safe and permanent storage options.

Fundamental steps of CCUS process are:-

- CO2 Capture
- Compression
- Transportation
- Utilization



Carbon Capture technologies can be broadly classified on the basis of stage of occurrence of Carbon Capture step into three categories namely post- combustion, pre- combustion, and oxy-combustion. Out of these, post-combustion carbon capture is most amenable to retrofitting and hence is most common mode of carbon capture from existing plants. Owing to high energy penalty and consequent cost of capturing CO_2, Capture technologies have traditionally been restricted to concentrated CO_2 sources.

Why CO_2 EOR as CCUS?

Any emission curtailment measure should have potential to be scaled to Gigatonne level to have a meaningful impact as a climate change initiative. CO_2-EOR is clearly the most preferred choice as CCUS project on multiple accounts (a) It can be scaled to a level required to have a significant impact on global emission level (b) Technology has matured with numerous successful examples globally (c) Can generate revenue stream offsetting a part of high cost incurred on CCUS project (d) Precursor to pure sequestration projects.

Carbon dioxide displaces oil through a combination of different mechanisms viz. solution gas drive, swelling of the oil, reduction of its viscosity and the miscible effects resulting from the extraction of hydrocarbon from the oil. CO_2 is preferred over other gases for gas injection projects due to its tendency to remain in super critical state at typical reservoir condition at which CO_2 gas and liquid are indistinguishable.

It exhibits higher viscosity & density resulting in a stable displacement front. Secondly, at miscibility condition (dependent on reservoir pressure, temperature & composition of oil), the interfacial tension becomes negligible and there is no oil trapped by capillary forces. This implies that the remaining oil saturation can be ideally reduced down to zero during miscible CO_2 flooding. In addition to this CO_2 can extract hydrocarbon components from oil more easily than gaseous CO_2. Hence, worldwide majority of CO_2 based processes are operated in miscible condition.

Entrapment & storage of injected gas is result of a combination of different mechanisms namely a)Structural Trapping b)Dissolution Trapping c)Residual Trapping d)Mineral Trapping, in order of their prominence with time since injection.

Injecting CO_2 into oil reservoirs for Enhanced Oil Recovery has been commercially used for several decades in the petroleum sector. USA has been at the forefront of harnessing CO_2-EOR, producing more than 300,000 bbl/d of oil by injecting 3.5 bcf/d of CO_2 in 136 EOR projects. The success of CO_2-EOR in the USA can be attributed primarily to availability of natural sources of CO_2 and more than 7000 km of dedicated pipeline infrastructure. However, in order to curtail CO_2 emissions to combat climate change, usage of anthropogenic CO_2 captured from industrial large point sources is increasingly being adopted globally for CO_2-EOR.

India has a vast port-folio of reservoirs operating at their advance stage of production life which are potentially amenable to CO_2-EOR. In view of lack of natural CO_2 sources, as in USA, CCUS offers a great opportunity to rejuvenate production from matured reservoirs & extend their productive life, with concomitant CO_2 sequestration.

Efforts of ONGC in planning CO_2-EOR as CCUS

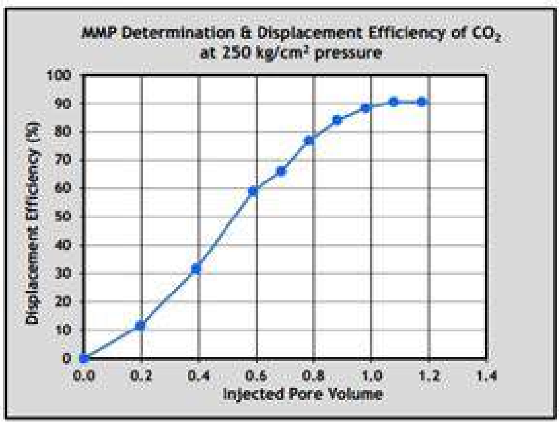
ONGC was a part of a Taskforce constituted by Ministry of Coal under the aegis of TIFAC to prepare a roadmap of Carbon Capture Utilization and Storage (CCUS) for India. As per the taskforce, $CO2$-EOR as considered as the top priority area for utilization of anthropogenic $CO2$.

Feasibility studies of $CO2$-EOR as CCUS project typically comprise of following broad steps:

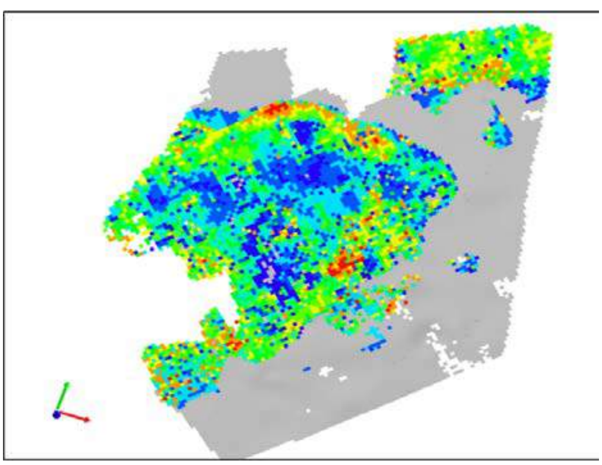
- Source-Sink Matching
- Preliminary Screening of Reservoirs
- Laboratory Studies
- Compositional Numerical Simulation
- Techno-economical Evaluation

TIFAC study, with consideration of both increasing domestic oil production & emission curtailment, bought $CO2$-EOR to the fore. Accordingly, IRS undertook projects to study the suitability of $CO2$-EOR for fields of ONGC. Identification of reliable source of uninterrupted supply of $CO2$ is pre-requisite for $CO2$-EOR project. In this regard, ONGC signed MoU with IOCL for $CO2$ based Enhanced Oil Recovery in Gandhar Field by injecting $CO2$ captured from IOCL's Koyali refinery. Taking into account the current reservoir pressure, fluid properties and Ankleshwar Asset's experience in handing gas based EOR process, Gandhar field was identified as a candidate for $CO2$-EOR.

Laboratory studies and compositional numerical simulation for multiple layers of Gandhar field was carried out at IRS,ONGC. The results are indicative of an incremental oil recovery of ~ 10% from GS-9 and GS-11 sands of Gandhar Field with concomitant sequestration of ~6 MMT of CO_2.



The CO_2 requirement for GS-9 and GS-11 sands was found to be 1400 tpd. Currently, ONGC is carrying out feasibility study of surface facilities aspects of the CO_2-EOR project including pipeline transportation of CO_2 from Koyali Refinery to CPF Gandhar.



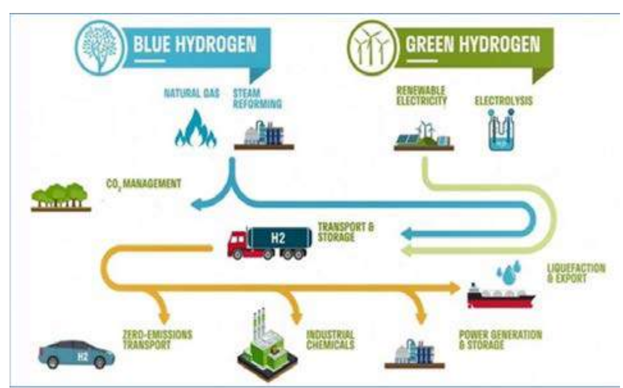
Opportunity

India is the world's third largest oil importing country, with a significant oil import bill. Unfavorable exchange rate coupled with geo-political uncertainties further exacerbates the looming burden on current account deficit. In view of this, it is imperative to significantly boost domestic oil production. However, the existing hydrocarbon endowment where significant discoveries are getting fewer & far between and major production comes from aging oil fields functioning at advanced stage of their production life. In this prevailing scenario, CO2-EOR being a versatile Enhanced Oil Recovery method offers opportunity to rejuvenate many mature oilfields of India, expending their commercial production life. Also, with its rapidly growing and concomitant industrialization & emissions increase, India assumes a critical role in global fight for climate change. CCUS offers the only means to decarbonize Industrial sector as we embrace ourselves for Carbon constrained World. CCUS when scaled proportionately can reduce the carbon footprint of industries as well as power generation using fossil fuels which is likely to be mainstay in India for foreseeable future balancing both energy justice and emission curtailment obligation.

CCUS Dovetails with novel Technologies in pathways towards Sustainable Development

Hydrogen economy:

Hydrogen with its versatility and offerings as a clean energy solution is increasingly gaining momentum. Almost all major economies have factored in adoption of greater proportions of Hydrogen in their energy mix going forward in future. Although, green hydrogen is the ultimate vision, but currently industrial scale Hydrogen is mostly produced from fossil fuels with significant CO_2 generation during the production process.



One the popular ways of reducing carbon footprint of Hydrogen production thereby reducing Carbon footprint significantly is, CCUS. Many counties like Japan and Norway have taken significant strides in this direction. For a country like India, having large coal reserve, Hydrogen production with CCUS can play a significant role in its pathway towards sustainable development.

Waste to Energy with CCUS (BECCS):

IPCC SR15 report acknowledges that Carbon Dioxide Removal (CDR), including BECCS, being a negative emission technology is necessary to limit warming to 1.5°C. In view of this, many countries have undertaken Waste to Energy with CCUS projects and have planned to further increase the number of such projects in future.

Challenges & Required support

Challenges of CO_2-EOR as CCUS include:

- Investment at Source end to capture high purity CO_2
- High Upfront capital cost
- Require CO_2 compatible metallurgy for tubulars, pipelines and processing facilities
- Separation and handling of CO_2 produced along with reservoir fluids requiring dedicated additional surface facilities
- Increased OPEX
- Robust monitoring system

During a CO_2-EOR process, injected CO_2 becomes miscible with oil and little CO_2 produced in the beginning. However, in due course of time, there is a steep increase of CO_2 fraction in produced stream. Since, this shall be a CCUS project, hence CO_2 from the produced stream of oil wells has to be separated, compressed and re-injected into the reservoir thereby avoiding escaping of CO_2 into the atmosphere resulting in closed-loop operation.

Establishing robust measurement and monitoring frameworks is a key requirement of CCUS projects. These monitoring frameworks are needed to provide confidence and certainty regarding the use of this technology as an atmospheric CO_2 emission reduction tool. It is the inclusion of dedicated Monitoring Verification & Accounting (MVA) or Measurement, Monitoring and Verification (MMV) program which is one of the key distinctions between a pure CO_2-EOR project and a CCUS project. A number of surface, near surface and sub-surface technologies under the umbrella of MMV/ MVA are required to be employed to generate baseline data, during injection and post injection monitoring & surveillance.

Economic analysis of a CO_2-EOR as a mode of CCUS entails integration of Cost to be incurred in the entire life cycle of the project.

Cost of capture, compression, transportation and injection is the first part of the operation. Second part is the cost of drilling of wells and building surface facilities for treating the produced fluid and separates the produced CO_2 from the stream and re-injection back to the surface. Third part is the operating cost (OPEX) of the capture to treatment recycling and monitoring. In absence of firm business model of CO_2 delivery at the sink end and modalities of risk and reward sharing between various stakeholders in the entire value chain of CCUS operation, economic analysis at this stage has a high degree of uncertainty.

Support required to accelerate the deployment of CCUS projects in India :

- Policy & Regulatory framework for CCUS
- Fiscal Incentives
- Support in terms of VGF for first demonstration project
- Industrial Hubs/Clusters with collective carbon capture facilities
- Collaboration with other Countries & global agencies

Conclusion

CCUS is vital for combating adverse effects of climate change globally and for India in particular. Success of CCUS in India will not only increase domestic oil production but also cater to address the National INDC of reducing emission intensity of GDP as per Paris agreement. With the aforementioned efforts, ONGC is on path bringing the dream of India's first CO2-EOR as CCUS to its fruition. The learning curve from ONGC's endeavor shall create knowledge base to further expand deployment of CCUS in India, bringing a large port-folio of reservoirs under the ambit of CO2-EOR.

Acknowledgement

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Waste 2 Wealth – a Transformative Paradigm in Upstream Sustainability
(A perspective on the new 3Ps – People, Planet and Profit of O&G Balance Sheet)

Subha Sen
CEO & Managing Director
SurasOl Inc.

In Quest of New Ideas in Oil & Gas Paradigms

Etymologically the word 'waste' originates from Latin 'vastus' translates literally as "uncultivated" or "unoccupied", which, by Dictionary.com means "to consume, spend, or employ uselessly or without adequate return; use to no avail or profit"; while, the legal use of the term, somewhat more interestingly, refers to "damage caused to an entity by an act of neglect especially by a tenant". As much as this etymological introduction aims at establishing the perspective of the following discussion, the author hopes that the subjective as well as technological insights get illustrated to its audience to enable a suitable purview of the enormous potential of unrecovered left-overs that are usually both uncultivated and consumed without adequate return that lie invisible in the veracity of hydrocarbon sources. Mostly unrecovered due to unmitigated loss or spoilt by negligence, such losses are often extremely valuable resources and assets that are quantifiable suitably in considerable monetary terms. Unfortunately, as industrialisation started to synonym more and more to modernisation and development, the negative consequences of wastefulness got devalued consequently ever more to an almost permanent factor of a loss in transition or to a mere financial percentage conveniently termed as "NBV (net book value)".

> "We usually find gas in new places with old ideas. Sometimes, also, we find gas in an old place with a new idea, but we seldom find much gas in an old place with an old idea. Several times in the past we have thought that we were running out of gas, whereas actually we were only running out of ideas."
>
> Parke Dickey, geologist (1909–95), quoted in *Encyclopedia of Petroleum Science and Engineering*

The whole purpose of drawing the etymological parallel is to associate the critical considerations of the real value or more accurately, the real-loss value, of industrial waste that help determine the all new concept of 3Ps - the Planet, the People and the Profit in Balance Sheet by deriving the imminent circular dynamics by assessing:

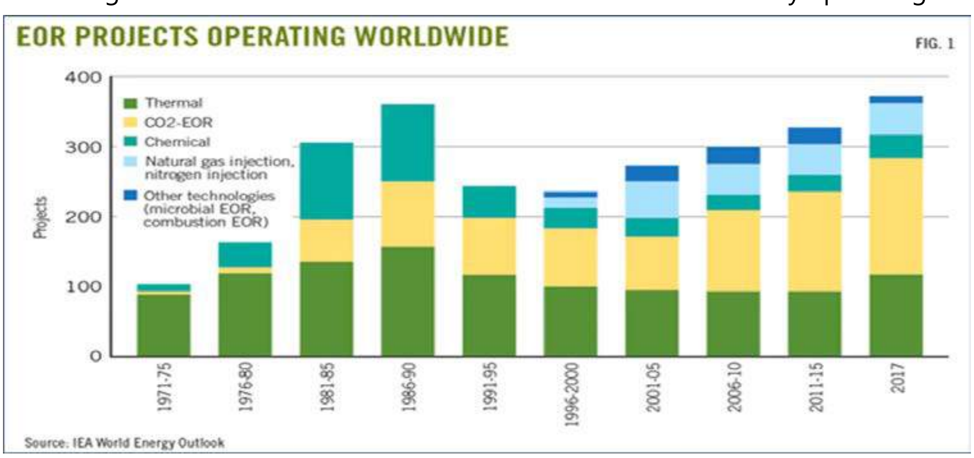
1. The possible ways of identifying and recovering such a waste of energy component by assessing, analysing, sorting, processing, converting and supply chaining to the reusable or renewable value chain. (Planet)
2. Practicable and viable digital transformation by incorporating new and advanced machines and technology like smart instrumentation sensors (IoT), Robotics, Digital Twins, Mobile assets (Drones) Visual identifiers and monitoring (RFID) and the world of smartness that's absolutely feasible and adoptable by suitability to ensure zero waste, prevention in hazards and proactive safety (People)
3. Applying cognitive data analytics and spatial ICT to process convert and connect supply chain of buyers and sellers and derive alternative profitability (Profit)

Distinguishing the Polished From The Crude

In order to understand the crudity in the liquid jewel, it is important to review the involved operations and production life cycle. Especially in current economic and political conditions, the industry has significant challenges both with alternative players in shale and renewables and inevitably for being in its historical lowest prices. If it is to achieve its stated goals of delivering higher and more predictable returns for shareholders, along with its reputation, it must strengthen how it redefines its operating procedures by delivering the most competitive projects at the most optimum quality, driving down operating costs and improving its performance in managing assets, people and environment.

As much as mid and down stream activities are generating addressable comprehensible wastes, upstream operations have remained somewhat busy within their conventional practices and in maximising production rather than taking a step back to ask themselves if something could be done differently in order to be more sustainable in operating practices. In this current context a suitable analogy could be assessed on EOR (Enhanced Oil Recovery), which most certainly is most critical in my opinion and my favourite in the discussion of "waste to wealth" since the concept of wealth is verily embedded in the word "enhanced". Consider this report as published on Oil & Gas journal dated May 4, 2019 stating, "IEA (International Energy Agency) estimated about 375 enhanced oil recovery projects worldwide produced slightly more than 2 million b/d in 2018. They forecast this could grow to 4.5 million b/d, or around 4% of world production, by 2040".

As I attach the visual graph they published, I hope at the end of our discussion we may poise to ponder as to if 81% of hydrocarbon liquid is expected from newer efforts which are in any case yet non-compliant with climate policies and already causing serious concerns for flooding out excessive sludgy water with about 24% of global active wells deep inside the difficult hazardous terrain offshore and most importantly, given the enormous possibilities with advanced technology intervention, why only 4% after 20 years and why not more? There is no redemption for the industry unless we give a sincere effort to minimize our waste and find alternative profit sources from converting these wastes to viable wealth - the basic reference for my upcoming deliberation.



(This report has not yet been re-assessed and updated on EOR statistics post 2019)

Two key points show up:

A. As per IEA report "Factors such as increasing demand for oil and gas is expected to increase by 1.4% per year, till 2040". The world energy market is slated to be led by Oil & Gas for at least another 25 to 30 years and shall remain an essential part of energy management until an alternative energy source becomes more economical.

B. While 61% of hydrocarbon produce comes from fields and wells that age more than 20 years underlining the fact that asset recovery from EOR plays an extremely prominent role, its quite evident from trend analysis (sources: IEA, Morgan Stanley, Mordor Intelligence) that more than 81% of the global Oil & Gas production have seen a sharp decline in BOPD due to high investments for new discoveries and cost of upstream activities. Additionally EOR not only has a contribution to carbon sink, it evidently discusses the moot points of lost assets and abandoned wells turning them into suitable useful values.

Attached I have drawn a visual architecture of complex operation flow-chart mentioning the critical practices.

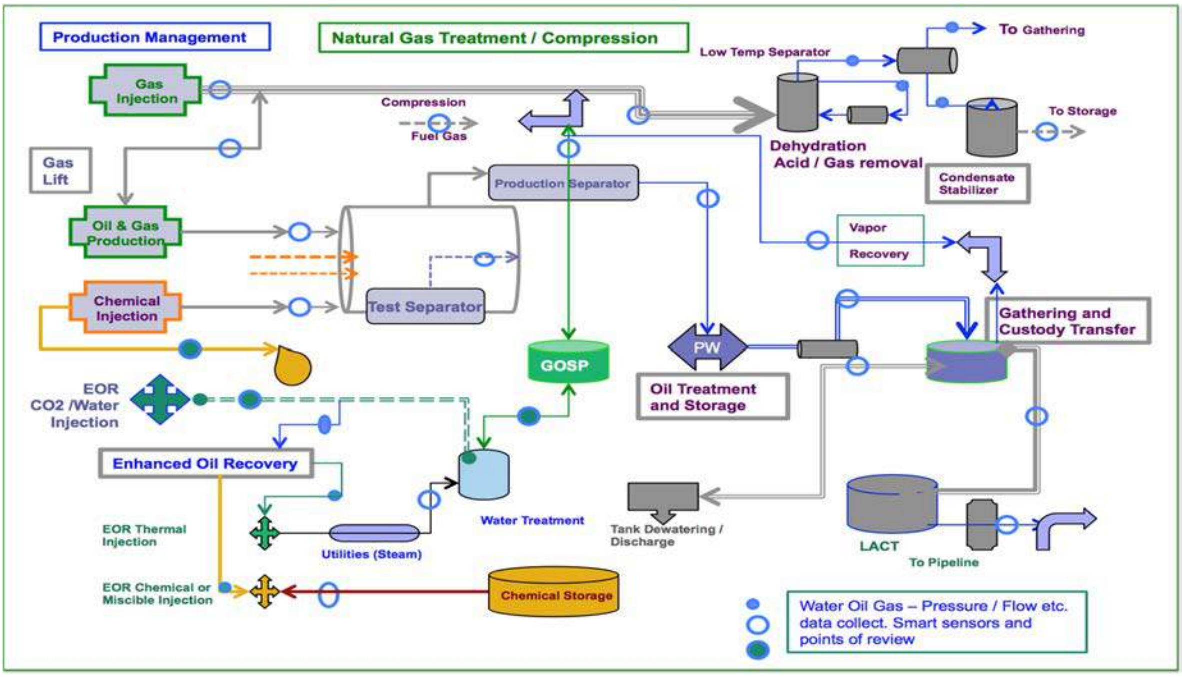


Fig.1 An illustration of O&G complex Production Life Cycle flowchart

"A barrel of oil has 4.5 years of human labour" - an often-referred line from Oil & Gas bible has a serious implication in the enormity of the value for effort. In consideration of the above complex flow-chart reiterating that huge amounts of efforts and energy is consumed in exploration and production of hydrocarbon liquids evidently incurring huge financial as well as human and environmental impacts. In the above illustration every bullet dot on the connectivity presents a conventionally manual or analogue process with or without an alarm without real-time event tracking – hence with possibilities of negligence or value-loss. The point is that what ever the challenges may be, reduced pressure, clogging porosity, sludge condensation in GOSP, rusting SS wall of the treatment / storage or gathering tank or even cheaper prospects of easier newer wells, the implicit question must be that after so much of effort any unrecovered asset left behind under ground or untreated sludgy discharges to the environment in effect amounts to serious loss of wealth to upstream profitability, people and planet. Moreover Gas, Chemical or Microbial injection technique for EOR has some effective CO2 sequestration. For instance, the injection CO2 derived from anthropogenic sources like industrial facilities and power plants uses a technique to separates CO2 from other exhaust particles and similar industrial emissions like H2S etc. Without EOR, these anthropogenic CO2 emissions get released into the atmosphere. By capturing, transporting, and storing the CO2 from an anthropogenic source to an EOR field uses energy that emits less CO2 into the atmosphere than utilised by EOR processes resulting a net negative source of emissions.

- Minimum well intervention
- Reduce production short fall
- Maximize production

Unfortunately, we are yet working with such challenged processes across wells like, providing lab-tested pre-decided chemical injection and manual or at most hydraulic stop triggers without considering the probable variation in required injection amount, with sensor driven processes, which could be actualised real-time and therefore extra dollar, excess chemical and a probable un-assessed idle hours with stop trigger. Attached is an example of embedding of smart sensors on the Christmas tree with remote data read capabilities – a technique EOR fields must employ not only to save unrequired down-time, un-estimated chemical for injection, cost on losses but, also on severity of possible incidents saving huge values of assets and more importantly human lives. These embedded sensors can measure flow rate, density, OWR, LGS, HGS at the suction line and effluent of the centrifuge. Such data collect can create full API-13B calculations to run all possible calculations including injections and discharges to measure a possible Barite recovery process.

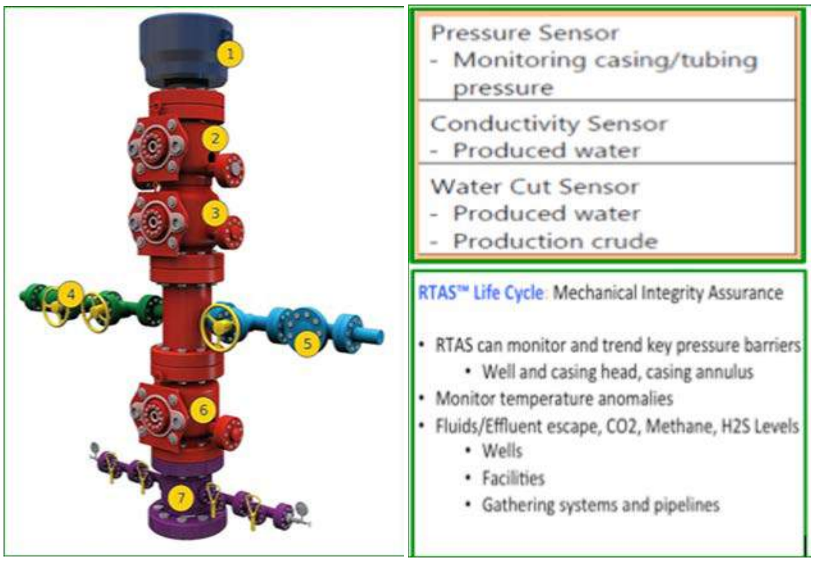
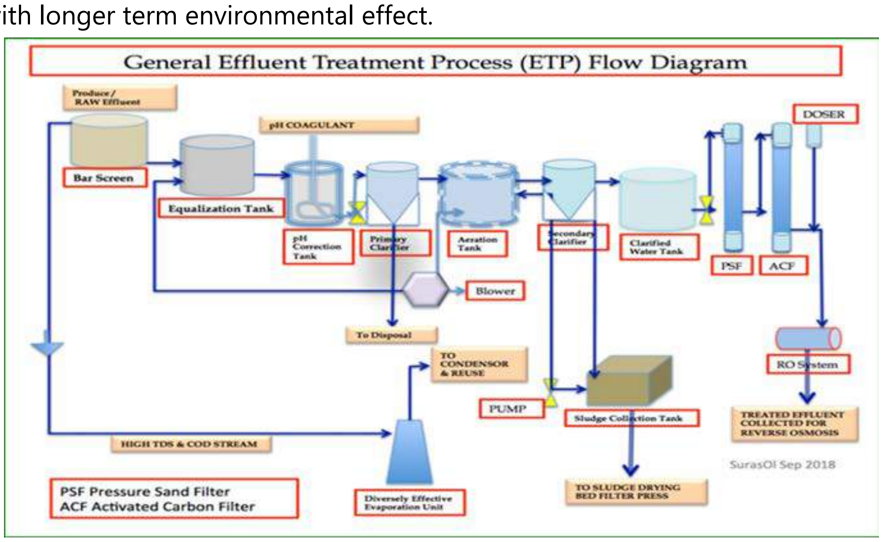


Fig. 3 Christmas Tree Embedded IoT Sensors from ABSMART enabling Realtime data advisory

Additionally, industry has so far been only doing "pre-treatment" of PW for reinjection rather than comprehensive thorough water treatment by testing at every juncture of injection as well as discharge. Often tests have shown that especially in EOR wells, the pre-treatment at the GOSP for reinjection, due to high centrifugal force and pressure the recovered fluid post injection delivers optimal GOR / OWR. However at the storage tank or while testing at gathering chambers or at LACT the ratio deteriorates almost always by 33 – 45%. Additionally sludgy water injection with excessive chemicals without an adequate well health analysis potentially clogs and layers the pores on the well walls reducing the pressure considerably. The outcomes have serious GWR / OWR, asset recovery fallouts additionally causing high violation payment for wrongful discharges, the impending perils to the agricultural fields including hazardous emissions for slow releasing methane vapour with longer term environmental effect.



In implementing all round upstream down-hole waste and water treatment, filtration of these fluids require sophisticated technological solutions both in treatment and filtration such as:

- Pretreatment
- Ion exchange
- Membrane processes
- Electrodeionisation
- Wastewater recycles / reuse
- Desalination
- Zero Liquid Discharge (ZLD)
- Evaporative processes

Rig Up Rig Down – ROBOT On It

"Today's rig floor operations can be remotely controlled, removing rig personnel from the danger zone". Offshore drilling rigs operating in immense water depth in highly dangerous situations requires Oil & Gas industry to consider removal of humans from offshore and instead use BOTs and ROVs to operate on site being managed by highly skilled operators at a remote and safer physical location. Offshore wells and pipeline systems have started to be operated by unmanned underwater vehicles (ROVs) performing installations, inspections including repair and maintenance. To transport these unmanned vehicles to the offshore site, which can be 100 or more miles out to sea, mobile assets or drone driven tethers could be used to transport and install being remotely managed. In effect the total cost is estimated to reduce by 25 – 40% in offshore operations.

"We believe subsea operations are inefficient because of the reliance on large surface platforms like a boat," says Sean Halpin, HMI's Senior Vice President of Products and Services. "If we can remove the boat from the operation, we are removing an enormous cost". Robotics could be used for Subsea Services for Offshore Asset Inspection, correction and maintenance.

Therefore tasks that are repeated, dirty, and dangerous and require high degree of accuracy are prolific in Oil & Gas industry. These tasks automated with remote control BOTs not only saves human lives, every drilling and production operations has the promise to be pre-emptive with detailed knowledge of costs, BOMs, process-flow, skill requirement and also the end total value of asset recovery.

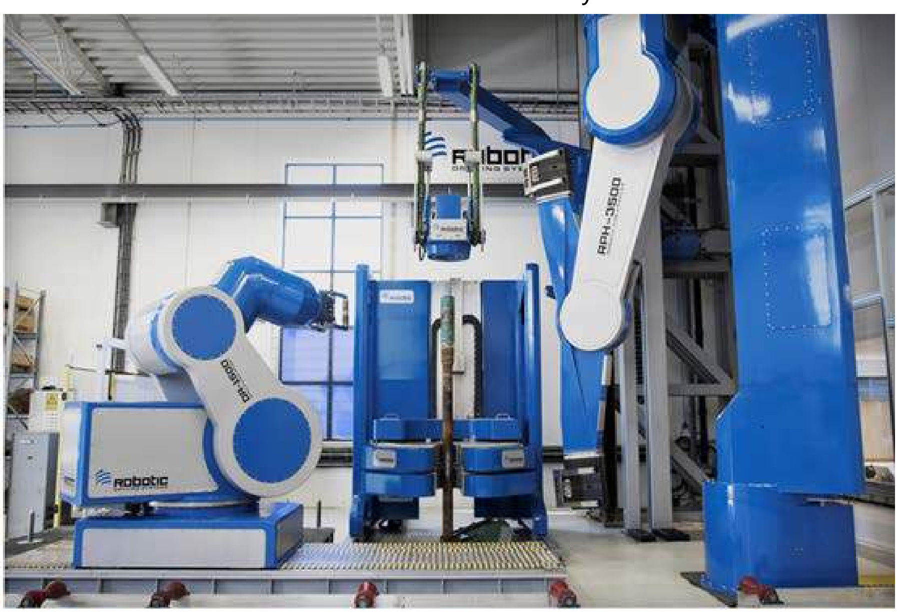
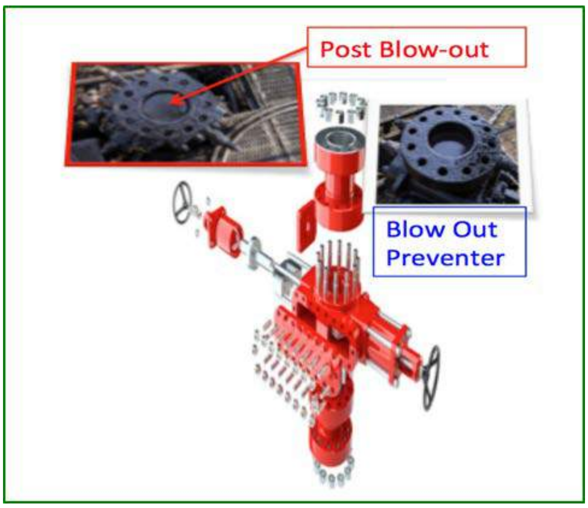


Fig.1-The Robotic System from RDS

The system can be used on new-builds or retrofitted to existing rigs. In order to achieve a seamless system with good motion control, RDS has replaced the conventional hydraulic drill floor machines with a new generation of electrical machines or robots. In addition to avoiding an HPU, the electric system is easier to install and integrate on the rig. As standard electric motors and gear are used, potentially the reliability will be higher and the energy consumption will be significantly lower for electric robots. Early studies indicate a potential saving of up to 40 rig days per year for a rig (depending on how much of operation time is considered critical), including non-productive time. Several thousands of manual operations will be avoided. In addition to saved rig time, improved HSE and reduced OPEX, a full robotic system will give other benefits, such as less downtime, faster installation, lower noise, less energy consumption and less CO_2 emission. RDS is in the process of workshop testing the robotic drill floor system including the seamless co-operation between the machines/robots.

"Do the Right Things Get Things Right First (After Several Attempts)"
Peter Aird, Complex Well Drilling Operations

Besides often losing huge values and hydrocarbon assets our industry has been losing more significant assets like people and the planet often due to negligence and almost always due to their focus on maximizing production often undermining the alerts and alarms of upcoming hazards. Statistics has shown that between 2019 and 2020 at least 12 big and not so big incidents mostly of hydrocarbon spills, leaks or blow outs, occurred in Oil & Gas industry alone, most of which have had fatal hazards causing huge impacts to economics, people and environment alike. Investigations have proven that one of the main reasons is that drilling activities are not focused on adequate best practice in optimising technology or total safety and instead insist on maximising production trying to eliminate the loss of hydrocarbon often ignoring the life-risk factors as well as environment. As defined by The Society of Petroleum Engineers (SPE), an oil spill is the release of a liquid petroleum hydrocarbon into the environmental eco-system due to human activity, and is a form of pollution. My motivation for this specific article comes from the italics phrases in the previous sentence – "human activity" causing "pollution" and in our endeavor to alter the Oil & Gas industry from its downward reputation



To enable a validity of the circular 3P based economics allow me to showcase one of the most recent investigated incidents from the industry. I urge the readers to view the CSB video report on the YouTube link at https://youtu.be/1zDcsjHyxr8

Case Study

Investigation authority and report from the US Chemical Safety and Hazard Investigation Board (CSB)
Incident Description: Pryor Trust Fatal Gas Well Blowout and Fire
Location: Pittsburgh County, Oklahoma, USA
Accident Occurred On: 22nd January 2018
Final Report Released On: 12th June 2019
Accident Type: Explosion and Fire
Investigation Status: The CSB's (U.S. Chemical Safety and Hazard Investigation Board) final report was released at a news conference in Oklahoma City, Oklahoma, USA, on 12th June 2019

Details

During drilling operations at a gas well in Pittsburg County in Oklahoma, a large explosion fatally injured five workers. From 20 barrels of leaking gas at hour 1, an estimated 207 barrels of gas leaked inside the well over 14 hours despite crewmembers on board receiving cautionary indication, choosing to turn-off the alerts and trying to maximise production.

At the final hour of the incident, a crewmember found mud flowing off the open BOP stack steadily in big bubbles closer to the rig floor. The crewmember told the driller who responded that he is going to close the blind rams but he never made it. Seconds later muds blew upwards out of the well and what is known as blowout. Two crewmembers ran into the Drillers cabin where three others were located. While mud and gas exploded causing a massive fire all five crewmembers died.

The CSV team analysed the data to find that the night crewmember had turned off the alarm system. Even the day crewmember had turned on the alarm system for a short while and then turned it off once again. So, the alarm system was turned off for 14 hours causing the blowout.

As described by CSB Investigator Lauren Grimm "We are not able to conclusively determine why the drillers turned the alarm system off. Most probably, Alarms were perceived as a nuisance or an annoyance In fact we found that had the alarm systems been on, most of the alarms that would have activated during the 14 hours leading up to the incident likely would have been irrelevant to detecting the problems in the well".

Following are CSB's conclusive analysis on their report:

Key issues:

- Poor Barrier Management
- Underbalanced Operations Performed Without Proper Planning, Procedures, or Needed Equipment
- Signs of Influx Either Not Identified or Inadequately Responded To
- Alarm System Off
- Flow Checks Not Conducted
- Gaps in Safety Management System
- Driller's Cabin Design
- BOP Could Not Close Due to Burned Hydraulic Hoses
- Lack of Safety Requirements by Regulation

Incident Analysis

This section discusses the areas causal to this incident, including:

- Failure of Barriers – Both the primary barrier, hydrostatic pressure produced by mud to keep the well overbalanced, and the secondary barrier, the human detection of the influx and closure of the blowout preventer failed.
- Underbalanced Operations Proceeded without Needed Planning, Equipment, Skills, or Procedure
- Driller Had Difficulties with Electronic Trip Sheet – These difficulties impeded the driller from identifying the amount of gas that entered the well during the tripping operation out of the lateral section
- Incorrect Determination That There Was No Surface Pressure Before Opening BOP – Both times that no pressure was observed in the annulus before opening the BOP, the data indicates mud flowed from the well once the BOP was opened, indicating there actually was unobserved pressure at the surface
- Weighted Pill Did Not Overbalance the Well – The weighted pill placed at the top of the curve was not of sufficient volume or density to overbalance the lateral section of the well
- Lack of Detail in Procedures – The Patterson tripping procedure was overly vague such that both the "Calculated Fill" and "Continuous Fill" tripping methods technically complied with the procedure. The procedure did not detail the methods to monitor that the well was taking proper fill.
- Alarm System Was Deactivated – Both the day and night driller elected to turn off the alarm system, which likely contributed to the crew missing key indications of the well control event. The alarm system also was not effectively designed to alert personnel to hazardous conditions during different operating states (e.g., drilling, tripping, circulating, and surface operations) and would have sounded excessive non-critical alarms during the 14 hours leading to the blowout, which likely led to the drillers choosing to turn off the alarm system
- Deficient Policies for Controlling Abnormal / Unexpected Conditions – The Management of Change (MOC) program was not used—and was not expected to be used by Patterson management—during the unexpected and abnormal operation conditions preceding the incident to control or correct the hazards. The Time Out for Safety (Stop Work) program also was not successful in halting operations when crewmembers raised concerns

• Drills Did Not Test Driller Influx Detection Skills – Both the day and night tour drillers missed or did not respond to pit gains leading to the incident. Patterson did not regularly test whether drillers would quickly identify and respond to simulated pit gains, as recommended by API RP 59.

• Flow Checks Not Conducted Per Patterson Policy Crewmembers on Patterson Rig 219 did not perform flow checks as required by Patterson policy, performing only two out of a required 27 flow checks on well 2H-16 and well 1H-9.

• Patterson Did Not Effectively Monitor the Implementation of its Policies – The deficient or lack of implementation of several Patterson corporate safety policies contributed to the incident.

• Victims Had No Safe Escape Option from Driller's Cabin (Dog House) – While it is unknown how long the victims remained alive in the driller's cabin they were effectively trapped inside of the driller's cabin when the mud and gas ignited. The two exit doors got blocked by flames.

• Blowout Preventer Did Not Close – The hydraulic lines that supplied hydraulic fluid to the blowout preventer likely burned early in the incident, preventing the BOP from closing when workers attempted to function it

Report Name:

Gas Well Blowout and Fire at Pryor Trust Well 1H-9 Pittsburg County, Oklahoma | Incident Date: January 22, 2018 | No. 2018-01-I-OK U.S. Chemical Safety and Hazard Investigation Board

Inferences – Circular Dynamics in Oil & Gas Balance Sheet mandates the 3 Ps of PLM

Unfortunately, despite its thoroughness in operating procedures and domain expertise, in the midst of extreme proficient production mindedness with prominent oversee of QHSE, somewhere down the line our industry got misled in actualising its "write-offs", "Profit & Loss" and "Capex /Asset /Cash Flow" entries on its financial statements. Instead of deriving the true value of what conventionally is considered as "waste" (of time, effort / production and profit) if we rather see the vantage points of visualising the bottom line in the above considerations in Oil & Gas PLM (Production Lifecycle Management), we shall in effect tackle both economics and environment.

A suitable integrated perspective in sustainable Oil & Gas business mandates managing waste to derive optimum value out of it. We must use solids control data to optimize the dilution process and to manage the volume of waste we leave back in side the wells or discharge. "To do things properly, the entire back yard process needs to fall under one umbrella.... not three different services with three different objectives. This has gone on long enough" – as Jason Norman of ABSMART, says.

Hence, the consideration is that oil and gas shall remain key to energy management until a more viable renewable alternative is made available. At such a transition juncture, the industry has a sincere responsibility in managing the entire PLM from exploration, drilling to production in applying best practice and intensive digital transformation to enable QHSE to reduce emissions, discharges, and the ecological impact while providing energy at a reasonable cost. In addition, organisations have critical challenges in financial exposures in terms of insurance and risk assurance due a cruel operational environment of exploration and production activities with explicit regulations and focus in assuring a safe and secure working environment in consideration that the involved components, whether the plant, the people or the planet, are significant assets and the focus shall be to eliminate maximum hazards or assurance of prevention of the same.

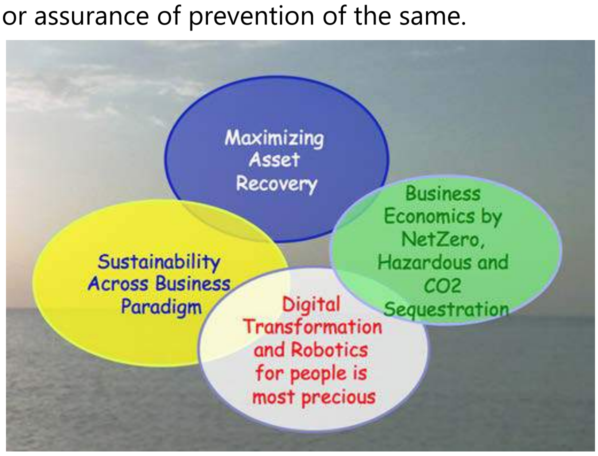


Fig: 2. SurasOl Sustainability Pledge

Building Strategic Storage for Natural Gas: Enhancing India's Energy Security

Sujay Sarkar
Senior Assistant Director (Gas)
Federation of Indian Petroleum Industry (FIPI)

The clarion call given by Hon'ble Prime Minister Shri Narendra Modi for an 'Atmanirbhar Bharat' will drive in evolving a comprehensive energy security architecture as the nation's energy consumption growth is expected to be the fastest among large economies in coming decades. India's quest for energy security could be seen under the framework of four 'A's: availability, accessibility, affordability, and acceptability, which is to make energy accessible to all the sections and sectors at an affordable price in a socially and politically acceptable carbon-controlled environment.

The creation of Strategic Petroleum Reserves (SPRs) is one of the contingency measures adopted by the Government of India to meet the energy security mandate. SPRs are oil stocks stored in large underground storage facilities with intrinsic advantages on economic, environmental, and strategic safety considerations. The inventories are used to mitigate economic supply disruptions. The crude oil storage alternatives include Salt and Rock caverns, while natural gas may be stored underground primarily in three reservoir types: depleted oil and gas fields, depleted aquifers, and in salt beds and salt caverns. Natural gas may also be stored above ground in refrigerated tanks, as liquefied natural gas (LNG). Though salt caverns are the cheapest storage alternative, adoption of storage technology involves the availability of suitable geological setting viz. salt formations or competent rock formations with supplementing groundwater regime.

India's Crude Oil Strategic Reserves

As the global oil pricing benchmarks are susceptible to the security of demand and supply and/or geopolitics, India has constructed three underground rock caverns for SPR with a total crude oil storage capacity of 5.33 MMT[1] at Vishakhapatnam (1.33 MMT), Mangalore (1.50 MMT), and Padur (2.5 MMT) under the Phase-I Storage program to improve energy security in the hydrocarbons sector. Taking advantage of low crude oil prices in April and May 2020, India has filled these existing SPR with 16 million barrels of crude oil, resulting in saving over INR 5000 crore[1] for the Government. As per the consumption pattern of 2019-20, 5.33 MMT SPR capacity is estimated to provide for about 9.5 days[1] of crude oil requirement. In addition, Oil Marketing Companies (OMCs) in the country have storage facilities for crude oil and petroleum products for 64.5 days[1], thus the current total national capacity for storage of crude oil and petroleum products currently is 74 days[1].

The Government has also given 'in principle' approval for the establishment of two additional SPR facilities at (i) Chandikhol (4 MMT) in Odisha and (ii) Padur (2.5 MMT) in Karnataka with a total capacity of 6.5 MMT[1]. As per the consumption pattern of 2019-20, 6.5 MMT SPR capacity is estimated to provide for about additional 12 days[1] of crude oil requirement, which will further augment India's preparedness during an emergency oil shortage situation.

Further, to attract private investment in its SPRs, India has allowed Abu Dhabi National Oil Co (ADNOC) to re-export some of its oil stored in Mangalore SPR, mirroring a model adopted by South Korea and Japan. India has invited global energy firms to invest in these upcoming projects and is also exploring overseas crude storage facilities in the US and other commercially viable locations.

India's move towards a Gas-based economy

Globally, natural gas has been gaining traction as a key alternative and an ideal fuel to support the energy shift in favour of cleaner and greener energy sources. India, too is on its path to becoming a sustainable economy and has set a vision to become a gas-based economy. Increasing the share of gas in the energy mix from 6% to about 15% by 2030 will raise the gas consumption from 150 MMSCMD, 2018-2019 level to over 500 MMSCMD in 2029-2030.

To achieve this, India has bolstered its efforts to make the environment favourable to ensure such an increase. Companies along the value chain are investing over $60 billion in creating oil and gas infrastructure through 2024, which includes building gas import terminals and expanding gas pipeline networks to provide last-mile connectivity to households and industries.

With such sustainable and enabling policy in favour of gas, India could become one of the world's largest gas consumers, as its consumption is driven by a growing population, a thriving economy and the need to reach ambitious climate change targets aimed at reducing its carbon footprint.

Underground gas storage (UGS): a vital segment of the gas chain

Underground gas storage (UGS) is one of the most critical components of the natural gas market and for the nation's energy system. Along with other forms of temporary storage such as line pack (although limited), LNG ships, or storage at LNG receiving terminals, UGS provides a range of functions needed for the gas market's proper functioning.

The gas demand varies as a function of weather, economic activity, gas prices (and the costs of alternatives) and does so continuously, daily, seasonally, and annually. With adequate levels of storage, the security of supply is enhanced with respect to either demand surges or unanticipated supply interruptions. Thus, UGS plays a vital role in smoothing out fluctuations in seasonal and peak demand throughout the year with reliable service and prices and also plays a vital role in the security of gas supply and optimizing the whole gas value chain. In liberalized markets, storage is also used as a financial tool to arbitrage price differentials between different time points.

Seasonal gas storage allows to inject gas during the summer, when demand is low, and to withdraw it during the winter when demand increases. Given this pattern, storage capacity is usually measured by the amount of working gas that can be used throughout the year. In countries along the temperate zones, particularly US or Europe, where natural gas remains the quintessential heating fuel in winters, gas storage hubs have become an integral part of energy policy. However, in India, the summer-winter price spread is not much significant as we see in these countries. So, from a commercial point of view, companies may not have a considerable interest in building gas storage in India.

Precautionary gas storage is used instead to manage the risk of supply disruptions due to accidents or geopolitical reasons. The amount of storage devoted to the last purpose is also known as strategic storage, and consists of gas stocks often managed under specific Government rules.

In India, the share of domestic gas and imported LNG was about 47% & 53%, respectively in 2019-20, indicating that LNG forms an integral part of the country's natural gas mix. LNG is being procured on spot, short-term, medium-term, and long-term basis, and there is a continuous increase in the volume of LNG in overall gas consumption. India's domestic production of natural gas can only partially fulfil the expected increase in demand in the coming years, and the country will have to increase its imports to expand the share of natural gas in the primary energy mix to 15% by 2030. Such reliance on external sources makes the country's energy security susceptible to regional and global events. Hence, natural gas storage becomes a strategic issue to ensure the country's energy market security and to shield itself from supply disruptions.

Types of Natural Gas Underground Storage

Storage, such as UGS in depleted oil and gas fields, aquifers, salt caverns, built near market centers, and LNG Tanks are the most common ways in the developed consuming countries to ensure reliable and secure gas supplies. Each type of UGS has its own physical characteristics and economics (costs, deliverability rates, and cycling capability) which govern its suitability for particular applications.

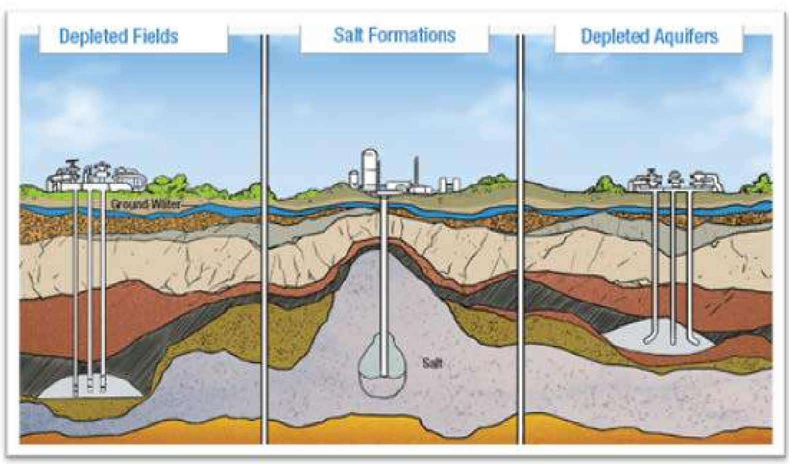
(i) Depleted Natural Gas or Oil Fields: Conversion of an oil or gas field from production to storage takes advantage of existing infrastructure such as wells, gathering systems, and pipeline connections. Depleted oil and gas reservoirs are the most commonly used underground storage sites because of their relatively wide availability.

(ii) Salt Formations: Salt formation storage facilities (also known as salt caverns or salt beds) make up about 10 percent of all facilities. These subsurface salt formations are primarily located in the Gulf Coast states. Salt formations provide very high withdrawal and injection rates. The installations built-in salt caverns are designed to satisfy peak demand and trading purposes. Their advantage is their high deliverability and their ability to be cycled several times during the year.

(iii) Depleted Aquifers: Natural aquifers may be suitable for gas storage if the water-bearing sedimentary rock formation is overlaid with an impermeable cap rock. They are not part of drinking water aquifers and makeup only about 10 percent of storage facilities.

UGS facilities in aquifers and depleted oil and gas fields are better suited to meet seasonal adjustment needs and constitute strategic reserves because they can store a larger working volume than salt caverns.

Fig 1: Types of Natural Gas Underground Storage[2]



Source: American Gas Association (AGA)

While the most common and economical way to develop gas storage is UGS due to geological and other considerations, **some countries rely on storage capacity built at LNG receiving terminals** to ensure reliable and secure gas supply. The capacity of LNG receiving and regasification terminals worldwide offers a large spare capacity to allow flexible operation of these facilities. Flexible LNG (spot cargoes and short-term LNG supplies) and ample regasification capacity play a significant role in balancing supply and demand in several LNG importing countries. While this policy was first developed in Japan for geological and geographic considerations, the advent of the Floating Storage Regasification Unit (FSRU) technology since the middle of the 2000s, as well as growing volumes of flexible LNG on the international market, have driven several countries to build FSRUs.

LNG, therefore, competes with UGS in the provision of short term flexibility. The issues with LNG flexibility are the timing of the availability of supplies, prices, and uncertainty on the future availability of flexible spot cargoes. LNG is a global commodity competing on the international market. While additional supplies may be available at LNG export terminals, they will go to the highest-price market. Obviously, UGS and LNG import terminals (onshore or FSRUs) do not serve the same functions. UGS's main purpose is to shift supply & demand from one period to another and to provide security during supply disruption events while LNG import terminals are built to access and/or diversify gas supplies. Their primary purpose is not to store LNG but to inject gas into the transmission system.

Zooming out: Global Gas Storage Scenario

The first commercial natural gas storage facility in the world commenced operations at the Zoar field near Buffalo, New York, United States, in 1916. At the end of 2019, there were 661 UGS facilities in operation globally with a global working gas capacity of 422 billion cubic meters (bcm). UGS has been developed in five regions: North America, Europe, the CIS, Asia-Oceania, and the Middle East (mostly Iran). North America concentrates two-thirds of the sites (441 facilities) and accounts for almost 40% of global working gas capacity (163 bcm) and more than half of global deliverability (3,726 mcm/d). There are 141 facilities in Europe (108.6 bcm, 2,082 mcm/d), 47 in the CIS (121 bcm, 1,242 mcm/d), 28 in Asia-Oceania (22.4 bcm, 200 mcm/d), and 3 in the Middle East (6.9 bcm, 34 mcm/d). There is also one small UGS in Argentina.

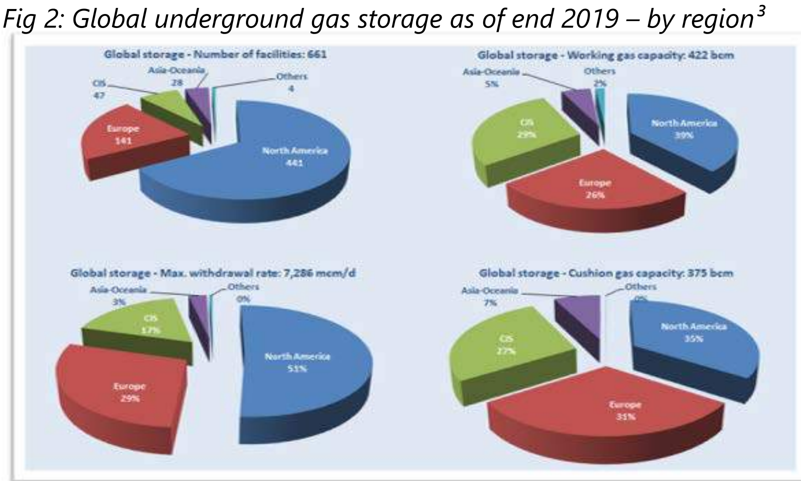
UGS's breakdown by type of storage shows the dominance of depleted fields, representing 73% of the total number of sites and 80% of global working gas volume. However, market liberalization has brought some important changes in the gas storage market. Today, flexibility is a key asset in liberalized markets. This trend can be seen in the growing importance of salt cavern storage. This type of storage allows high injection and withdrawal rates, and the working gas can be cycled several times per year. At the end of 2019, 99 salt caverns facilities were in operation globally, representing 15% of the total number of sites.

At the end of 2019, there were 58 storage projects under construction (new facilities and expansion of existing facilities), adding 41 bcm of working gas capacity. All regions, but Central and South America, participate in the construction activity, but there is a shift of storage investment towards new emerging and growing gas consuming countries. China alone accounts for 41% of the global capacity under construction.

At the end of 2019, there were 97 identified projects at different stages of planning (81 planned and 16 potential projects). If all built, these projects would add 82 bcm of working gas capacity.

The UGS trends in four key markets (Europe, Ukraine, Russia, and China) highlight UGS's essential role in rebalancing the market in an oversupplied market. It also highlights UGS's crucial role in the security of gas supply in the context of rising geopolitical risks and trade tensions.

Fig 2: Global underground gas storage as of end 2019 – by region[3]



Source: CEDIGAZ

Conclusion:

Natural gas storage is becoming more important in the gas business value chain and India's plans to develop a gas-based economy with cleaner fuel gradually becoming the mainstay of the country's energy security needs. The gas storage not only used for smoothing out variations in gas demand but can also play an essential role in the security of gas supply and optimizing the whole gas value chain while benefiting all the market participants along the gas value chain.

As India is in the spotlight as a potential future growth market for gas, therefore, it is of vital importance for both government and the companies working in the gas value chain to undertake an assessment of the underground gas storage and accordingly adjust their strategic, operational, and investment decisions in a well-planned manner for building underground gas storage against future price volatility and demand/ supply shocks.

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Assessing the Carbon Intensities of Alternative Electricity Pathways in India

Ian Laurenzi

ExxonMobil Research & Engineering Company

As the world progresses to a lower carbon future, both conventional and emerging energy resources will be required to meet energy needs. As different energy options are considered, it will be increasingly important to consider their comprehensive environmental impacts. Life cycle assessment (LCA) is a well-established methodology that can provide key insights for comparing alternative business investments as well as highlighting opportunities for reducing environmental impacts of particular energy pathways.

LCA estimates a "complete" environmental impact of a product or process, i.e. "cradle to grave". The general procedure is codified by ISO ( ), however, there exists considerable flexibility in the guidelines, allowing for the environmental characterization of a wide range of products including emerging energy resources. Key steps in the procedure include:

1. Definition of the environmental impact to be assessed.

In the context of energy systems, this is often the greenhouse gas emissions associated with a particular energy source. However, impacts to fresh water (including freshwater consumption), land use, and other impacts are of increasing interest.

2. Definition of the "system boundary" for the energy system.

For fossil energy, this includes all operations from resource extraction to generation of electricity or fuels. For coal power, the boundary includes mining, transportation of coal by rail and ship, and combustion of the coal at a power plant. For natural gas, it includes drilling and completion of wells, gathering, treatment and processing of the natural gas, transportation of the gas via ship (e.g. for LNG) or pipeline, and combustion of the gas at a power plant.

3. Definition of the "functional unit".

When comparing alternative power generation technologies such as coal, natural gas and renewables, LCA practitioners use a common basis of "MWh of power generated". When comparing alternative light duty transportation technologies such as battery electric, gasoline, diesel and other vehicles, the functional unit should be "km of transport". These bases implicitly acknowledge the differences in efficiencies of alternative power generation or transportation technologies. Alternative energy sources should be compared in terms of their ultimate functional uses.

In LCAs of fossil energy, one typically accounts for an amount of a resource throughout its life cycle, attributing emissions to that mass or volume through its ultimate use. An example is illustrated in Figure 1. Energy and mass are conserved to ensure a complete accounting of fugitive losses, venting, flaring, and "internal" consumption of the resource (e.g. combustion of some of the gross natural gas produced as fuel for turbines used in the liquefaction process), and the associated environmental impacts. This guarantees a full accounting of the environmental footprint upstream of power generation.

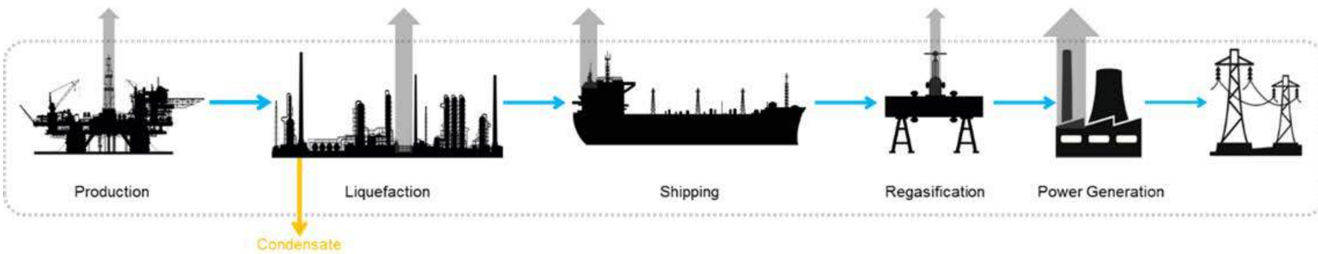

Figure 1: System boundary for an LCA of electricity generated at a power plant that uses liquefied natural gas (LNG) as a fuel. The blue arrows represent mass flowrates of natural gas, and the gray arrows represent emissions (not to scale). Environmental impacts associated with the production of crude oil and natural gas liquids (condensate) are excluded from the LCA of LNG, but should be employed in LCAs of fuels or chemicals produced from those liquids.

LCA of renewable power sources such as solar and wind often focus on the quantification of environmental impacts associated with the manufacture of the power plants, materials utilized in mining and processing of materials used for solar panels or wind turbine blades, etc., and then amortize those emissions over a characteristic amount of energy delivered over a characteristic timescale. ISO does not specify which operations should be included in LCAs, but it does require transparency regarding the definition of the system boundary and how the life cycle is modeled. There is consensus in the international LCA research and practitioner communities on how system boundaries for fossil power systems should be modeled.

Another important consideration in LCA is the accounting of environmental impacts associated with co-products, especially when these products have different dispositions. For example, LCA of natural gas power must explicitly quantify the relative environmental impacts of hydrocarbon condensate (natural gas liquids and crude) and generated electricity (Figure 1). ISO 14040 provides guidelines for allocating GHG emissions and other environmental impacts to co-products, but the implementation will ultimately depend on the nature of the energy resource, its supply chain, and the disposition and function of each co-product.

Once the previously mentioned steps have been completed and a co-product allocation method is selected in accordance with the rubrics of ISO 14040, process data is gathered. Material and energy balances are then conducted, often using specialized software for LCA, and integrated to obtain life cycle estimates of impacts associated with the energy product.

For coal and natural gas based power, life cycle "carbon intensities" are often reported in units of kg CO_2eq/ MWh power generated, with "CO_2 equivalency" defined by global warming potentials (GWPs) reported by the IPCC. GWPs are factors employed to quantify the relative impacts of different GHGs: By definition, the GWP of CO_2 is 1 kg CO_2eq/kg CO_2, but other GHGs such as methane (CH_4) and nitrous oxide (N_2O) have higher values. The Kyoto protocol recommends the use of "100-year" GWPs for industries such as power generation (2). Presently, many nations employ "100-year" GWPs from the 4th Assessment Report (AR4) of the IPCC for regulatory purposes. For methane and N_2O, these are 25 kg CO_2eq/kg CH_4, and 298 kg CO_2eq/kg N_2O respectively. However, since the release of the 5th Assessment Report (AR5) of the IPCC in 2013, researchers should employ the updated GWPs, which are found in Table 8.A.1 of the AR5: 30 kg CO_2eq/kg CH_4 and 298 kg CO_2eq/kg N_2O (3). We use GWPs from the AR5 in the forthcoming discussion.

LCA has played a key role in the scientific dialogue regarding the GHG emissions associated with natural gas and hydraulic fracturing. In Figure 2, we illustrate the results of a recently published peer-reviewed LCA of LNG sourced from Marcellus shale gas (4), terminating at two different classes of combined cycle gas turbines (CCGTs) hypothetically located in Mumbai. The functional unit of the LCA is, as previously discussed, "MWh of generated electricity". New F-class CCGTs have a typical efficiency of 50% (gross calorific value basis), whereas we have modeled the H-class CCGT as having an efficiency of 53%; H-class CCGTs with even higher efficiencies have been reported (5). The intensity of fossil power decreases with increasing efficiency because less natural gas is required to generate the same amount of electricity.

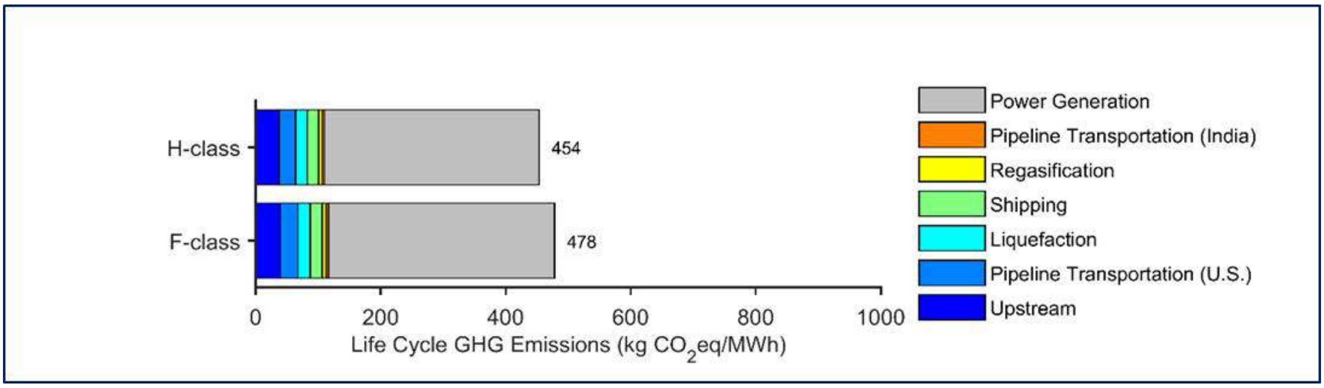

Figure 2: Life cycle GHG emissions associated with electricity generated by combined cycle gas turbines using regasified LNG. In this analysis, LNG is sourced from the Marcellus shale in the U.S. and transported to Mumbai.

In Figure 3 we present analogous life cycle GHG emissions intensities of power generated via the combustion of Indian coal, also adopted from the recent peer-reviewed literature (6). We report life cycle GHG emissions for a "typical" supercritical power plant and the lowest-GHG-emitting coal-fired power plant in India. Emissions data for both plants are from 2015, taken from Central Electricity Authority (CEA) "CO2 Baseline Database for the Indian Power Sector" (7).

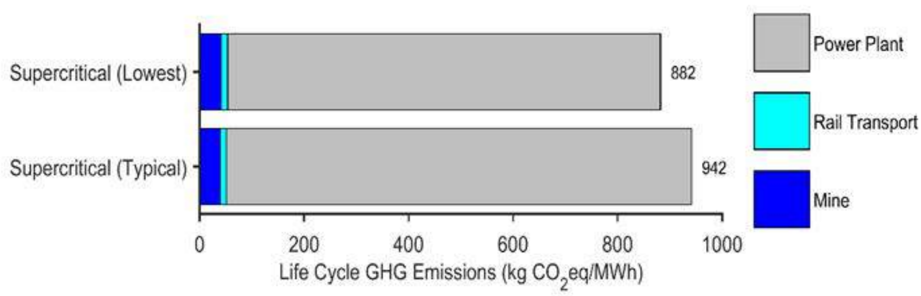

Figure 3: Life cycle GHG emissions associated with electricity generated from Indian coal. Results are shown for two Indian "supercritical" power plants, using CEA data from 2015.

The results in Figure 2 and Figure 3 clearly illustrate that the GHG emissions intensity of Indian coal power is approximately twice that natural gas power. This observation may be expected to hold for future developments in steam cycles. For example, development of technology facilitating ultra-supercritical steam cycles may increase the efficiencies of the steam cycles of both coal-fired and combined cycle natural gas power plants.

The LCA of natural gas power whose results are illustrated in Figure 2 was specifically focused on an investigation of LNG sourced from the United States, and more specifically, the gas originating from the Marcellus shale. Like most shale gases to be liquefied, Marcellus shale gas requires transportation to the coast. Operation of the pipeline has associated GHG emissions. By contrast, other international LNG projects may not feature large scale pipelines. On the other hand, Marcellus shale gas does not have appreciable amounts of CO_2, which must be rejected prior to liquefaction, and is emitted by many LNG facilities . Furthermore, as illustrated in Figure 2, shipping of LNG will affect the carbon intensity of the electricity generated from LNG. Considering these factors, it is possible that LNG from other international producers may yield slightly different carbon intensities than those illustrated in Figure 2.

There are several key challenges in LCA that directly impact their utility in decisionmaking. As we have discussed, allocation of environmental impacts to co-products can be a subjective process, as the system impacts are partitioned among the co-products on the basis of physical relationships between them (e.g. relative mass or energy of co-products) or other functional relationships (e.g. relative economic value of co-products). Moreover, the complexity and interconnectedness of natural gas treatment, processing and liquefaction is often proprietary, potentially impeding transparency in communicating how one models the emissions to be allocated to various products.

Despite great progress over the past ten years, the handling of uncertainty and variability in LCA remains an area of active investigation. There are real differences in energy sources (e.g. gas compositions, pressures), infrastructure (e.g. gas plant configurations) and conversion facilities (e.g. power plants). Each specific pathway from an energy source (coal, gas) to final products (electricity, fuels) will have a different environmental impact. This real process variability is distinct from uncertainty in LCA results associated with uncertainty in data. Variability cannot be reduced, whereas uncertainty might be reduced by incorporating additional measurements into the LCA. Characterization of uncertainty is particularly important when the results of life cycle assessments are to be used for decision-support.

When the guidelines of the ISO are followed using representative data and robust environmental metrics, LCA may provide a robust estimate of the environmental impact of an energy pathway from "cradle to grave". In this paper, we have explored the life cycle GHG emissions associated with LNG and coal power in India. In principle, LCA of renewable power may be conducted using data representative of operations in India as well. In such studies, practitioners will inevitably encounter challenges associated with data acquisition, allocation, and variability, as we have discussed. The management of complexity, uncertainty and variability inherent in energy systems is never simple. Sound science, particularly in the area of environmental research, requires interpretation and understanding of the processes involved.

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*****CO_2 *separated from natural gas is not always emitted. For example, Qatargas sequesters* CO_2 *captured from several of its liquefaction trains (https://corporate.exxonmobil.com/-/media/Global/Files/energy-and-carbon-summary/Energy-and-Carbon-Summary.pdf)*

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Underground Caverns for Storage of Hydrocarbon Products

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Abstract

Large hydrocarbon stocks could be stored in various underground storage structures with an option of creating separate compartments for storing different variety of products. The stockpile could be used both as strategic and commercial measures depending on situations. Storage of hydrocarbon products in underground storage structures could be considered as a recommended option in view of the various distinct advantages such as low surface land requirement; technology proven, safe and environment friendly, minimum safety hazards on account of sabotage, storms, earthquake & explosions, very low maintenance etc.

This article discusses in brief unlined rock cavern technology, requirements of various underground & top side facilities, layout, design & construction aspects and development of underground storage facilities in India.

Introduction

Depending on the suitability of geology and hydrogeology of site, mainly four types of underground storage options are available. They are underground unlined caverns, solution mined salt caverns, depleted reservoirs and underground concrete tanks. Selection of a storage concept for underground storage of crude oil & natural gas is made according to: Storage requirements; Geological setting of the site; Subsurface rock mass quality; Hydro-geological regime of the site; Storage product loading & unloading facilities and Safety and environment conditions.

Unlined rock cavern could be considered as an option for the underground storage of crude oil/ LPG. The technology of unlined rock cavern is not only more secure and safe but also has several environmental and operational advantages. The established technology of unlined rock cavern has been successfully adopted in the Scandinavian countries. This is also the only avenue that had been adopted so far in India for storage of crude oil and LPG.

Advantages of underground storage

The major advantages of storage in underground are:

- The Product storage is located at a depth and is fully isolated
- Technologically proven, safe and environment friendly
- Principle of containment ensures no leakage or contamination
- Safety hazards on account of sabotage, storms, earthquakes and explosions are minimized
- External Fires will not affect Storage
- Surface land requirement is low
- Caverns by their very nature require very low maintenance and hence safety is in-built

Unlined Rock Cavern Technology

The basic principle of storage of crude oil in underground unlined rock caverns is the hydro-geologic containment as shown in Figure 1. This is based on two facts: Crude Oil/ LPG is lighter than water & is insoluble in water. Thus the rock caverns are planned at a depth such that adequate hydrostatic pressure is maintained to counter the vapour pressure of the stored product. In order to secure the flow vector of water from the rock mass towards the cavern, a water curtain system is provided. The system consists of galleries located above the crown of the cavern. Boreholes are drilled from the water curtain tunnel to intersect the predominant and open joint sets of rock mass. Saturated rock mass coupled with ground water flowing into caverns, ensures proper sealing of the stored product and prevents leakage. Since de- saturation of rock mass is almost irreversible process, a mandatory requirement is made to have a charged water curtain system and resultant saturation of rock mass in advance of the underlying excavation of the storage cavern.

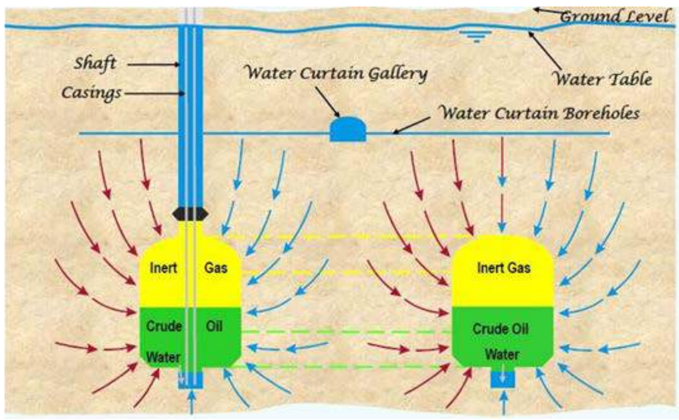


Figure 1: Principle of Unlined Rock Cavern

Further, the underground facilities are constructed through underground access tunnel/ shafts and would have shafts for crude oil/ LPG intake and dispatch piping in addition to the other instruments. All openings are required to be closed through water tight concrete plugs of varying thickness.

Underground Layout

The layout consists of parallel caverns generally of U-shaped in plan and D shape/ oval shape in cross section. The underground facilities essentially consist of access tunnel and main cavern (around 30 m height, 20m width and variable length). The layouts of storage units are adapted to requirements, land availability and techno-commercial considerations. Water curtain tunnels running parallel to and 20m above each U shaped storage caverns with a series of water curtain boreholes drilled perpendicular to it. Each leg of the cavern are having a separation distance of 30m between them. Also vertical shafts for various pump installation are excavated from surface which connects water curtain tunnel & cavern at various levels. Figure 2 illustrates typical layout of underground cavern.

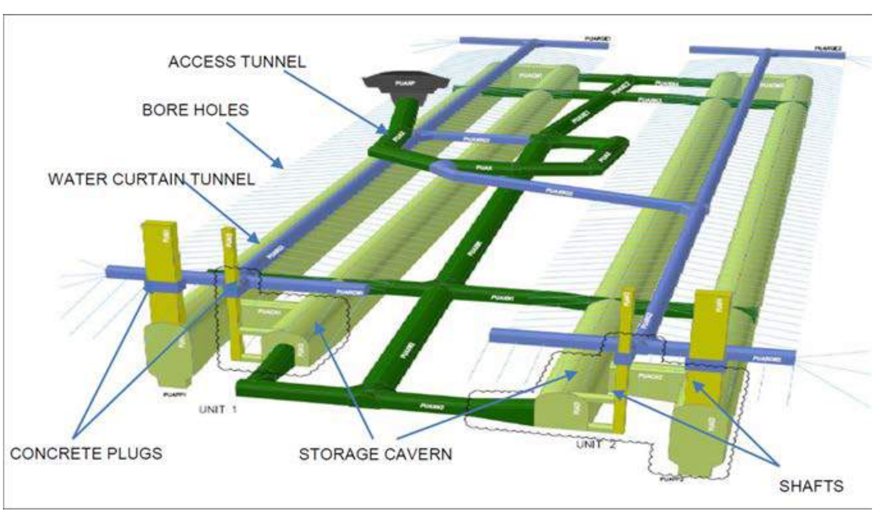


Figure 2: Typical Layout of Underground Cavern

Above Ground Works

In shaft Equipment

For loading and unloading of stored product, either circular shaft of suitable diameter or square inlet and outlet shafts could be used. The product is pumped out with submersible pumps of designed capacity. Seepage water is removed from caverns by submersible pumps installed in the casings anchored in the concrete plug at cavern roof depth extending down into the cavern sump. Also casing for level & temperature transducers, chemical injection, steam injection, hot crude oil injection etc., are installed in casing pipe.

Above ground Facilities

Requirement of various above ground facilities such as raw water tanks & pumps, power, LPG, nitrogen, fire station, fire water pump house, fire water tank, boiler, electrical cables, flare, storm water reservoir, raw water tanks and pumps, drinking water sump and pumps, heat exchanger, substation and local control room etc., are to be developed. Capacity of ETP would depend on the amount of the seepage water flows.

Design Aspects

Though the underground unlined rock cavern storage technologies are well proven and implemented elsewhere in the world, adaptation to the specific site conditions remains a significant challenge to overcome. Unlike the above ground oil and gas installations, these storage facilities are associated with underground uncertainties. Very limited exploratory investigations coupled with derived inferences for creating an interpretative and predictive geological model of the site form the key input during the basic design stage of these facilities. The layout of facilities and cross-section of caverns are selected so as to achieve a favourable stress situation in the rock mass considering all major adverse geological features/ discontinuities. The excavation sequence and methodology are also considered while finalizing the cavern layout and sizing of the tunnels.

A priority attention is given to the systematic exploratory investigation campaign at various stages of project. Exploratory investigation campaigns and due consideration of the acquired information are one of the major factors not only towards design assumptions but also for smooth construction progress.

Based on site campaign involving geological, geo-physical, geo-technical and hydro-geological investigations, it is imperative to establish that rock formations in conjunction with ground water conditions are competent for construction of caverns and suitable to store the hydrocarbons.

Some of these design aspects adopted are briefly outlined.

(a) Geological Model

The main purpose of preparing geological model is to establish co-relation of the geological setting of the project site intended with respect to regional geological setup. It essentially encompass the topography, geomorphology, rock type, lineaments and major discontinuities of the project such as dykes, faults & folds. The model describes characteristics of host rocks & soils, thickness of soil cover and extent of weathered rock, major geologic features, anticipated region of weakness zones intersecting the layout, seismicity of the site etc. Typical geological model showing important geological features is shown in Figure 3.

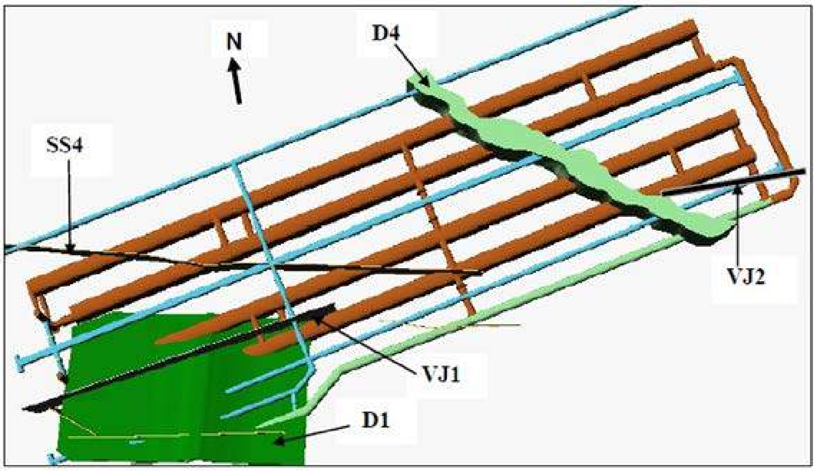


Figure 3: Typical geological model showing important geological features

(b) Hydro-geological Model

Owing to the containment principle of storage, the hydrogeological regime of the site forms an important aspect including topography, annual rainfall, recharge, geological setting and hydrogeological properties. Hydro-geological model studies are carried out to check the flow pattern around the caverns (Figure 4) so as to confirm hydraulic containment and estimate seepage rates based on the data collected during the investigations. The important design parameters which are considered as a part of hydrogeological studies are provision of water curtain above the cavern with boreholes charged to a head equivalent to required pressure, maximum operating gas pressure at the cavern crown and the vertical distance between water curtain gallery and cavern to satisfy the requirement of hydraulic gradient greater than 1.0 at cavern roof level.

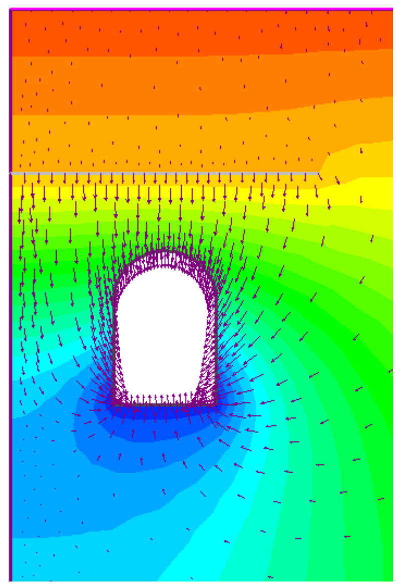


Figure 4: Flow modelling for caverns

(c) Geotechnical Model

Support system design and the excavation method are evaluated by the combination of rock mass classification, stress analysis and wedge analysis.

Rock mass classification is done to divide a particular rock mass into groups of similar behaviour and to provide a basis for understanding the characteristics of each group. After identification of the main joint sets carried out from core geological observation, the potential unstable wedges formed by the main gallery intersecting the identified joint sets are investigated using dedicated block stability software (Figure 5). Also stress analysis is carried out to analyse the stress/ strain situation and distribution in the rock mass, extension of possible yielding zones, pillar stresses and rock displacements, internal stresses and forces.

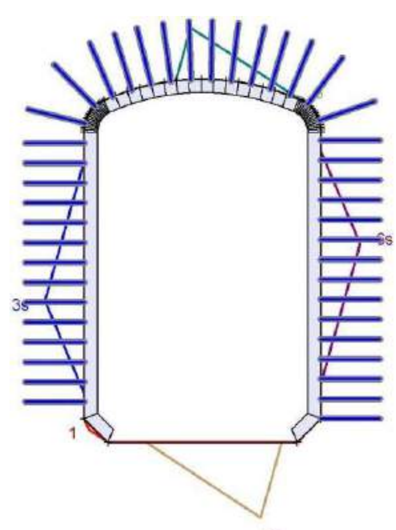


Figure 5: Wedge Analysis in cavern

Based on the above analysis, permanent rock support combined in the form of fully cement grouted rock bolts and fibre reinforced shotcrete is provided.

(d) Design During Construction

The design performed at the basic stage is checked, validated, updated and modified based on the actual geological, geotechnical and hydro-geological conditions encountered during excavation. Adoption of the "on the go design" concept through an observational approach not only ensures successful completion of the underground cavern works, it also validates the design assumptions during the entire process of excavation.

(e) Other Aspects

Underground works also include concrete floor, concrete plugs in access tunnels and shafts, pump pit, casings for crude and seepage pumps, instrument cables and concrete encased hot oil circulation pipe. Design of the concrete plugs are critical as these have to be designed for gas tightness. In addition to the above, detailed design of above-ground process facilities are carried out. The caverns are tested for tightness using pressurized air after completion of concrete plugs and filling of the water curtain tunnels and access tunnels.

Construction Aspects

Availability of land around cavern site and the depth of the cavern are two most important considerations which contribute to decide construction methodology at site. Construction of underground storage caverns involves excavation by drill & blast method, followed by installation of permanent support including fully grouted un-tensioned rock bolts & fibre- reinforced shotcrete. Controlled blasting techniques are adopted to obtain a smooth surface at plug/ barrier location. All tunnels except the main cavern i.e. access tunnel, water curtain tunnel, connection tunnels etc., are advanced using full face excavation and is paved with reinforced concrete. The main storage cavern is constructed by the heading- and-benching method in stages (Figure 6) with the top heading being taken up first followed by excavation of the benches. The number and sizes of the headings and benches is decided as per the approved construction methodology and the proposed equipment. Special precautions is taken at the intersection of tunnels and shafts with the caverns.

Figure 6: Cavern excavations in stages

On completion of the excavation, the caverns are isolated and sealed by installation of concrete plugs. While this ensures confinement of the stored product, the shafts provide the necessary inlet and outlet pumping facilities.

Equipment used for underground construction including that for drilling, blasting, scaling, mucking, conveying, rock support, concreting, dewatering, hoisting, ventilation, illumination, testing and monitoring etc., is planned as per the approved construction methodology and is made compatible with the geological conditions, tunnel dimensions, construction sequence, time schedule and safety requirements.

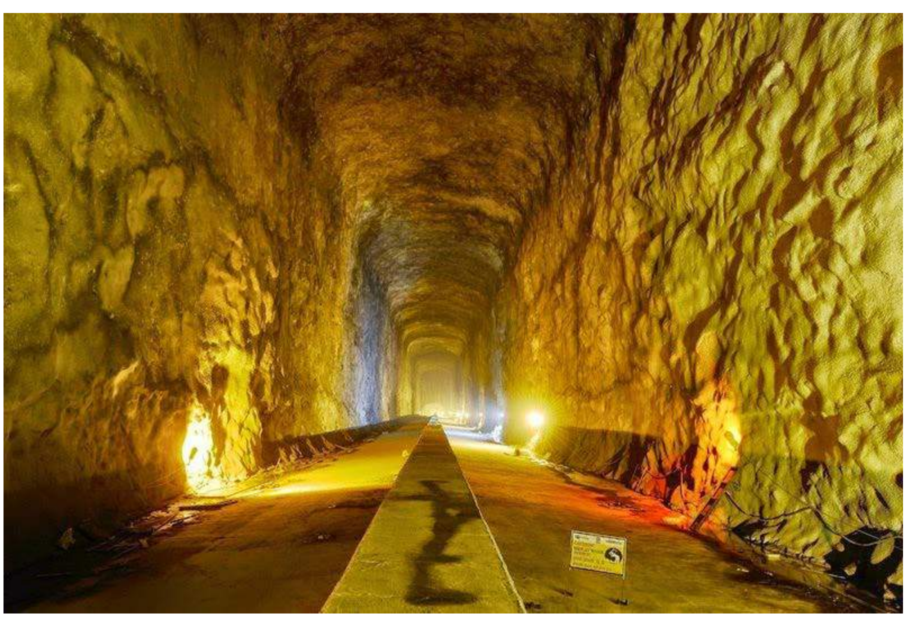
Some of the major construction equipment which will be required are listed below:

- Drill Jumbos
- Shotcrete Robots
- Loaders
- Dumpers
- Drilling rigs for water curtain bore holes
- Grouting equipment

EIL in Underground Storage

Engineers India Limited (EIL) has been privileged to be associated with coveted underground projects involving storage of crude in the very significant role of Project Management Consultants (PMC). All the three underground caverns in India for storage of crude oil in first phase are already commissioned. EIL has also carried out Detailed Feasibility studies for next phase of underground storage of crude oil. As a part of these studies, developing the storage facilities in solution mined salt caverns and underground concrete tanks have also been studied. EIL is also involved as PMC for the ongoing underground LPG storage project.

EIL has built up considerable expertise in area of investigations, feasibility studies, basic design including geological, hydro-geological, rock mechanics and concrete works for underground rock caverns, field support, detailed design of critical items etc.



Ambient Air Quality Monitoring

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(IPSHEM)

Abstract:

This article investigates the concentration of PM 10, PM 2.5, NO_2 and SO_2 in ambient air, restricted to the campus of Institute of Petroleum Safety, Health and Environment Management (IPSHEM), ONGC, Goa. It also calculates the Air Quality Index (AQI). The results are compared with the permissible limits as set by CPCB, and are found to be satisfactory.

Keywords- PM 10, PM 2.5, NO_2, SO_2, AQI, CPCB

Introduction:

The air around us is a mixture- of gases and particles, both solid and liquid. Air pollutants can be either solid particles, liquids or gaseous- their sources being both natural (like volcanos) and anthropological (like industries, vehicles, etc.). When these pollutants are present in quantities that have adverse effects on the health of humans, plants and animals, it is called air pollution. Hence, monitoring the air quality and managing it, has emerged as an important task for both governmental and non-governmental organisations.

Among the most common and poisonous air pollutants are sulphur dioxide (SO2), formed when fossil fuels such as coal, gas and oil are used for power generation; suspended particulate matter (SPM), solid and liquid particles emitted from numerous man-made and natural sources such as industrial dust, volcanic eruptions and diesel-powered vehicles; and nitrogen oxides (NOx), from natural sources such as lightning, fires (Hayatham A. Ahmed, 1999).

The pollutants those are under study, in this project are:

(i) Sulphur dioxide
(ii) Nitrogen oxides
(iii) PM 10 and 2.5

(i) Sulphur dioxide: It is a colourless gas with a pungent and suffocating odour. The gas is produced by the combustion of fossil fuels (Naik S.,2005). Sources include industrial activities such as flaring at oil and gas facilities and diesel power generation, commercial and home heating and vehicle emissions. The amount of SO_2 emitted is directly related to the sulphur content of the fuel (Air Quality Monitoring Network, 2008).

(ii) Nitrogen oxides (NOx): NOx represents the sum of the various nitrogen gases found in the air, of which Nitric Oxide (NO) and Nitrogen Dioxide (NO_2) are the dominant forms. The emission sources are varied but tend to result from high temperature combustion of fuel for industrial activities, commercial and residential heating, and vehicle use. Forest fires can be a large natural source of NOx (Air Quality Monitoring Network, 2008).

(iii) PM: Besides gaseous pollutants, the atmosphere can also be polluted by particles. These particles (either in suspension, fluid or in solid state), have a divergent composition and size and are sometimes called aerosols. They are often catalogued as 'floating dust', but are best known as particulate matter (PM). This floating dust is most often categorised based on their aerodynamic diameter. The aerodynamic diameter of a dust particle is the diameter of a sphere-shaped particle that shows the same behaviour in the atmosphere as a dust particle (which does not necessarily have a sphere shape). In the framework of air quality problems, particulate matter is the most important. Particulate matter such as PM10 & PM2.5 is defined as the fraction of particles with an aerodynamic diameter smaller than respectively 10 & 2.5 µm. In comparison, the average diameter of a human hair equals 50-70 µm. *(https://www.irceline.be/en/documentation/faq/what-is-pm10-and-pm2.5)*

Harmful effects of the above air pollutants are discussed below in detail:

(i) Sulphur dioxide: Elevated concentrations of SO_2 can be indicated by an odor of 'burning matches' and are associated with human health impacts, including respiratory (breathing) effects, especially asthma. Environmental effects include acid deposition and formation of PM 2.5. Vegetation, especially lichens, can be very sensitive to SO_2 at relatively low concentrations (Air Quality Monitoring Network, 2008). The gas irritates airways and eyes and is known to cause longer-term heart diseases, other cardiovascular ailments, and bronchitis. It also readily causes shortness of breath and coughing amongst asthma sufferers. SO_2 is also a major contributor to acid rain, which damages the environment and upsets ecosystems (Chan Wai-Shin et al, 2007).

(ii) Nitrogen oxides (NOx): It causes severe respiratory problems, especially in children. When combined with water, it forms nitric acid and other toxic nitrates. NO_2 is also a main component in the formation of ozone at the surface level. The gas irritates the lungs and has been known to lower the immune system (Chan Wai-Shin et al, 2007). It may cause acidification and eutrophication harmful to health (mainly the respiratory system), materials, cultural artifacts, vegetation and crops (Sida ,unknown) . Elevated concentrations of NO_2 can also affect visibility though creation of a 'reddish brown' haze. However, the effects of NO on vegetation is coming under increasing investigation in Europe, while NOx is also a concern due to the role it plays as a precursor pollutant for PM 2.5 formation and its association with acid deposition (Air Quality Monitoring Network, 2008).

(iii) Particulate Matter: There are many health effects from exposure to particulate matter. Despite extensive epidemiological research, there is currently no evidence of a threshold below which exposure to particulate matter does not cause any health effects. Health effects can occur after both short and long-term exposure to particulate matter.

Short-term exposure (hours to days) can lead to
- irritated eyes, nose and throat
- worsening asthma and lung diseases such as chronic bronchitis (also called chronic obstructive pulmonary disease or COPD)
- heart attacks and arrhythmias (irregular heart beat) in people with heart disease
- Increases in hospital admissions and premature death due to diseases of the respiratory and cardiovascular systems.

Long-term exposure (many years) can lead to:
- reduced lung function
- development of cardiovascular and respiratory diseases
- increased rate of disease progression
- Reduction in life expectancy.

(https://www.health.nsw.gov.au/environment/air/Pages/particulate-matter.aspx)

Objective:

To calculate the Air Quality Index and find out whether the PM, NOx and SOx levels in the monitoring area i.e. IPSHEM campus ONGC, Betul, Goa are within permissible limits as per National Ambient Air Quality Standard.

Methods of Measurements:

Procedures for analysis of various air pollutants as per the latest National Ambient Air Quality Standards (NAAQS) are described below:

Sulphur Dioxide (SO_2): The most versatile procedure for measuring Sulphur Dioxide is improved West and Gaeke method. Sulphur dioxide from the ambient air is absorbed by bubbling air through a Potassium tetrachloromercurate (TCM) absorbing reagent solution kept in an impinger tube to form a stable dichlorosulphitomercurate complex. The resultant complex is reacted with Pararosaniline and Formaldehyde to form the coloured Pararosaniline methylsulphonic acid. The concentration then is measured through absorbance at 560 nm by UV-Vis Spectrophotometer. Analysis is to be carried out as per details contained in IS 5182 (Part 2):2001.

Nitrogen Dioxide (NO_2): Nitrogen dioxide is collected by bubbling air through a Sodium hydroxide-Sodium Arsenite absorbing solution kept in an impinger tube to form a stable solution of sodium nitrite ($NaNO_2$). The nitrite ion produced during sampling is reacted with phosphoric acid, sulphanilamide and N-(1-naphthyl) ethylenediamine dihydrochloride to form an azo dye. The concentration is then measured through absorbance at 540 nm by UV-Vis Spectrophotometer. This method is known as modified Jacobs & Hochheiser method. Analysis is to be carried out as per details contained in IS 5182 (Part 6):2006.

Particulate Matters (PM_{10} - size less than 10 μm): PM_{10} is determined gravimetrically by collecting the particulate matter less than 10 microns in size over a GF/A filter paper using fine dust sampler having aerodynamic cut point at 10 microns according instrument manufacturer's manual. Air is drawn at about 16.67LPM into the air sampler having omni-directional air inlet with PM10 separation through an impactor. The concentration of particulate matter PM_{10} in ambient air is computed by measuring the mass of particulates collected over the filter papers and the volume of air sampled. Procedure details are contained in IS 5182 (Part 23):2006.

Particulate Matters ($PM_{2.5}$- size less than 2.5 μm): $PM_{2.5}$ is determined gravimetrically by collecting the particulate matter less than 2.5 microns in size over a Teflon (PTFE) Membrane filter paper using fine dust sampler having aerodynamic cut point at 2.5 microns according instrument manufacturer' manual. Air is drawn at about 16.67LPM into the air sampler through WINS impactor to separate $PM_{2.5}$ particulates. The concentration of particulate matter $PM_{2.5}$ in ambient air is computed by measuring the mass of particulates collected over the filter paper and the volume of air sampled. Procedure details are contained in IS 5182 (Part 23):2006.

Equipment Used:

1. Respirable Dust Sampler, Gaseous Sampling Attachment, PM 2.5 Sample; Make: Ecotech; Model: AAS 127
2. UV-VIS Spectrophotometer; Make: Analytic Jena; Model: Specord 210
3. Semi Micro Weighing Balance; Make: Citizon; Model: CX 205

Results & Discussions:

Central Pollution Control Board has given pollution level to maintain for annual mean concentration range for residential and industrial zone. CPCB has given National ambient air- quality standards) vide Ministry of Environment and Forests (MoEF) Notification No.G.S.R. 826 (E), dated 16.11.2009.

Ambient air quality monitoring was conducted near the DG set area within IPSHEM, ONGC, Betul. Results obtained are recorded below and detailed calculations are attached as Annexure-I.

S.No.	Parameter	Location: DG Set Area	NAAQ standard value: - Industrial, Residential, Rural and Other Area - Annual avg
1	PM_{10} (μg/m^3)	56.49	60
2	$PM_{2.5}$ (μg/m^3)	20.63	40
3	SO_2 (μg/m^3)	25.01	50
4	NO_2 (μg/m^3)	17.83	40

Air Quality Index (AQI) = ***56.5 (Satisfactory)***

Conclusion:

The ambient air quality monitoring data indicates that the concentration levels of particulate matter (PM10 & PM2.5), nitrogen dioxides and sulphur dioxides are within prescribed permissible limit as per National ambient air quality standards.

Author Contributions:

The analysis was performed by Mr. Shanker Jha, Ms. Nikita Chiripal and Mr. Gladwin Gonsalves, under the supervision of Mr. Gada Lal Das. The article was written was Ms. Nikita Chiripal.

Acknowledgement:

The authors acknowledge the support of Head IPSHEM, Mr. Atul Garg for carrying out the project and preparing the article.

Annexure- I

CALCULATIONS

PM 10

Date of sampling: 09.02.2021 – 10.02.2021
Duration : 24-hr (1449.44 mins)
Initial Air Flow : 0.98 m^3/min
Final Air Flow : 0.95 m^3/min

Readings	Initial weight of filter paper (gm)	Final weight of filter paper (gm)
1.	2.59530	2.67432
2.	2.59531	2.67431
3.	2.59530	2.67433
Average	**2.59530**	**2.67432**

PM 10 (µg/m^3)
= ((Final Weight- Initial Weight in gm)/Average Flow Volume in m^3)*10^6)
= ((2.67432-2.59530) / (((0.98+0.95)/2) * 1449.44))* 10^6)
= 56.49

PM 2.5

Date of sampling : 09.02.2021 – 10.02.2021
Duration : 24-hr (1460.31 mins)
Initial Air Volume : 45.713 m^3
Final Air Volume : 70.924 m^3

Readings	Initial weight of filter paper (gm)	Final weight of filter paper (gm)
1.	0.16589	0.16642
2.	0.16590	0.16641
3.	0.16589	0.16641
Average	**0.16589**	**0.16641**

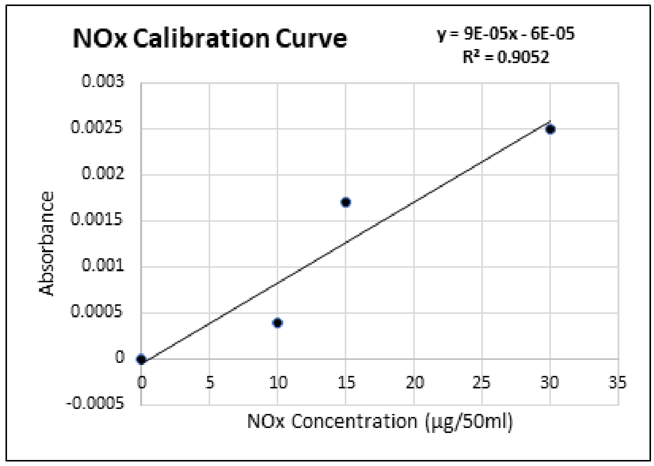
PM 2.5 (µg/m^3)
= ((Final Weight- Initial Weight in gm)/(Final Air Volume – Initial Air Volume in m^3))*10^6)
= ((0.16641-0.16589) / (70.924-45.713))* 10^6)
= 20.63

NO_2

Date of sampling : 09.02.2021 – 10.02.2021
Duration : 24-hr (1449.44 mins)
Initial Air Flow : 0.5 L/min
Final Air Flow : 0.45 L/min
Average Air Flow : 0.475 L/min

Calibration Curve :

Nox Concentration (µg/50 ml)	Absorbance
0	0
10	0.0004
15	0.0017
30	0.0025



Absorbance of Sample : 0.0003
NO_2 Concentration in sample from calibration curve equation
= (Sample Absorbance + 6E-05) / 9E-05
= 4 µg/50 ml

$$\text{Concentration of NO2 in air, µg / m3} = \frac{\text{µg } NO_2 \times V_1}{0.82 \times V_2 \times V_3}$$

Where,
µg NO_2 = Value from standard calibration curve in µg per 50 ml
V_1 = Volume of absorbing reagent used in sampling (ml)
V_2 = Volume of air sampled in m^3
V_3 = Volume of sample taken for analysis in ml
0.82 = Factor for collection efficiency

Calculation of air volume (V_3):

$$V_3 \text{ in } m_3 = \frac{(f_1+f_2)}{} \times t \times 10^{-3}$$

Where,
f_1= air flow rate before sampling in litre per minute
f_2= air flow rate after sampling in litre per minute
t = sampling time in minutes
10^{-3} = Conversion of litre to m^3

NO_2 Concentration in air in µg/m3 (as per formula detailed above)
= (4 x 25) / (0.82 x 0.475 x 1449.44 x 10^{-3} x 10)
= 17.83

<u>SO_2</u>

Standardisation of Thiosulphate

Readings	Volume of Thiosulphate required (ml)
1	44.5
2	44.5
3	44.5

Normality of prepared Thiosulphate solution
= 1.50078 x 2.8 / 44.5
= 0.0944 N

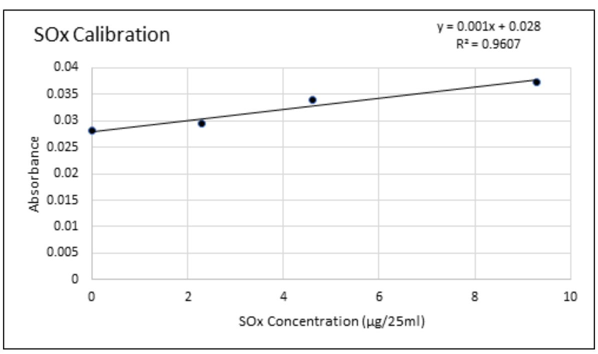
Standardisation of sulphite solution

Readings	Volume of Thiosulphate required for blank (ml)	Volume of Thiosulphate required for sulphite (ml)
1	38.6	19.2
2	38.4	19.4
3	38.4	19.2

Concentration of SO_2 in working sulphite-TCM solution
= (38.4 - 19.2) x 0.00944 x 32000 x 0.02 / 25
= 4.64 µg/ml

Date of sampling: 15.02.2021 – 16.02.2021
Duration : 24-hr (1430.32 mins)
Initial Air Flow : 0.25 L/min
Final Air Flow : 0.20 L/min
Average Air Flow: 0.225 L/min
Calibration Curve:

SO_2 Concentration (µg/25 ml)	Absorbance
0	0.0281
2.3	0.0295
4.6	0.0339
9.3	0.0374



Absorbance of Sample : 0.0295
SO_2 Concentration in sample from calibration curve equation
= (Sample Absorbance – 0.028) / 0.001
= 2.3 µg/25 ml

SO_2 Concentration in air:

$$SO_2\ \mu g/ml = \frac{(V_1 - V_2) \times N \times 32000 \times 0.02}{25}$$

V_1 = Volume in ml of thiosulphate used for blank
V_2 = Volume in ml of thiosulphate used for sample
N = Normality of thiosulphate solution
32000 = milli equivalant weight SO_2, µg
25 = Volume in ml of standard sulphite solution
0.02 is the dilution factor

SO_2 Concentration in air in µg/m^3 (as per formula detailed above)
= (2.3 x 3.5) / (0.225 x 1430.32 x 10^{-3})
= 25.01

Air Quality Index
Calculated on the basis of worse pollutant, i.e., PM10
AQI
= Worst sub index
= Sub index of PM 10
= [{(100-50) / (100-50)} * (56.49-50)] + 50
=56.49 (Satisfactory)

(Ref: https://app.cpcbccr.com, a CPCB Central Control Room for Air Quality Management website)

Implementation of Work from Home and Monitoring Productivity of Remote Employees in Oil and Gas Sector PSUs

Neha Shukla
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Introductory Background

The COVID-19 outbreak has been declared a public health emergency of international concern by the World Health Organization (WHO), causing a huge impact on people's lives, families and communities. Today Businesses are learning to adapt and innovate their work environments and practices, in response to crises like Covid-19.

Covid-19 have led to uncertainties of the global trade and triggered rapid innovation. Covid-19 compelled businesses to rethink their strategies, structures, work designs and human behaviors for survival in future. Covid-19 crises have proved to be an accelerator for one of the greatest workplace transformations for organizations in India.

'Work from Home' concept has been popularized by many Silicon Valley tech giants, it has yet to catch on in India as a regular feature. Owing to poor infrastructure, poor networks and connections, lack of literacy and training in use of information technology at work, lack of top management commitment towards investing in technology and employee resistance to change, working remotely was never a priority for majority of companies in India.

Oil and Gas sector is one of the six core industries in India and has contributed significantly to GDP and economic growth of India. Oil and Gas Sector public sector undertakings are characterized by production / project schedules and serving public with quality products at cheap / affordable prices. Oil and Gas Organizations in India, involve high costs and interests of several stakeholders, thus are in continuous pressure of completing production and projects within schedules, sticking to strict obligations with regard to maintaining scope, cost, quality, safety and transparency in procedures. Thus, never tried to explore Work-From-Home Option for their employees, due to fear of losing on employee commitments and profit margins as far as deliverables are concerned.

The concept of remote working is no more a privilege for employers and employees, but a necessity to stay afloat in such difficult times. Remote working is expected to cause the next big shift in working style and expectations of workforce of India, especially youngsters.

Despite the reluctance of the public sector oil companies in adopting work from home concept, they were forced to do so because of the government's directive to mitigate the wider spread of Corona Virus. Implementation of Work from Home during lockdown was the first experience for oil and gas sector PSUs, without comprehensive preparations.

From a sectoral perspective, Oil and Gas sector is categorized by nature of work which is highly manpower intensive and executed in production line, it is more difficult to introduce flexible working time and remote working. The result is relatively low implementation of flexible work arrangements i.e; only 2-3 days in a week. And, those public sector enterprises in Oil and Gas Sector have allowed their employees to work from home as immediate response to Covid-19 crises, have done so as an experiment without addressing the challenges and implications inherent to this type of intervention. Employer (or organisational) and managerial attitudes towards remote working comprise another important factor – either for driving or restraining the growth of this work arrangement.

Apart from rigid organization culture and strong work ethics, employers/ management not convinced of the economic benefits of "Work from Home" is another major reason for the low take-up rate of remote working in public sector oil and gas companies. They believe most of the benefits accrue to the workers but not the company.

Research evidences suggest that public sector undertakings consider subordinates absence from the workplace as lack of devotion to work (Williamsn et al., 2013; Kossek, Thompson, & Lautsch, 2015). Remote working tends to signal an employee's prioritization of personal and family concerns above work (Golden, Veiga, & Simsek, 2006a; Kossek, Lautsch, & Eaton, 2006). Golden & Veiga, 2008 have illustrated in their research that Organizations trying to control their flexible working employees through traditional means (e.g., bureaucratic or outcome-based control) is not really possible with remote working. The existence of different perceptions and different values of managers, subordinates and staff cadre employees in organizations is one of the factors influencing manager's acceptability to remote working. Managers often make decisions about promotions and special assignments based on employees' presence in the workplace and their face-to-face contact with them (Elsbach & Cable, 2012). Managers also face the increasing complexity of managing blended workgroups comprising virtual and non-virtual members, which creates challenges for coordinating and motivating remote employees (Van Dyne et al., 2007).

The Architecture of What's Next- 'Work from Home' Organization Culture in Oil and Gas Sector PSUs

Overcoming challenges before and during the implementation of any new initiative is highly crucial for its overall success, especially in a PSU Environment.

Several challenges faced in Oil and Gas Sector PSU Environment w.r.t to implementation of "Work from Home" are as follows:

1. Infrastructural costs associated with the process.
2. Managing Employees and Managerial Resistance to Change
3. Managing the overall dynamics of the organization- "Work from Home" by one or many employees impacts other organizational members, relationships among co-workers, and relationships between subordinates and their managers.
4. Creation of employee friendly 'Work from Home' policy
5. Fostering an Organizational Culture that measures Employee Performance based on Results rather than Appearances

Designing a full proof structure for 'Work from Home' Culture in an Oil and Gas Public Sector Undertaking that balances the health of the employees and employee productivity, involves high level of commitment of the top management and focused approach integrating Behavioral Science Principles and Digital Platforms.

What to Include in Work from Home Policy for Oil and Gas PSU

First and the foremost thing is the "Change of Mindset" – Employers/ Managers must not think that remote workers invest more time doing their personal works while working from home and are un-productive. In short, a good worker is a good worker - whether they're in the office or not. It's more important that their output is consistent and they're meeting KPIs. Make a conscious effort to recognize remote workers for the value they bring to the company. At the same time, employees must not take undue advantage of the opportunity and own the work providing quality and timely deliverables.

• Define who is eligible to work from home along with necessary approvals in place- Not all job functions can be conducted remotely. Clearly lay out which departments/ project teams are eligible to work remotely, and which have to be in the office. Define levels and numbers of employees eligible to work from home and those to be present in office premises, based on their job functions and employee capabilities is the first step.

• Set regular working hours- Work from Home Policy should clearly state when employees are expected to work in a day. Flexibility should not dilute a total number of working hours in a day (i.e., employees are expected to work a total of 8 hours per day).

• Devising a Code of Conduct for "Work from Home"- It is must for employees to adapt to the discipline required to be productive out of the office.

• Creating a Dress Code – A formal dress code should be set as employees have to interface with customers, clients, or partners via video conferencing.

• Digital Record of receipt of Work- Recording daily work allocation and employee work output between managers and employees is essential aspect of remote working. Using a digital e-signature solution like Docu Sign to record employee receipts of work/jobs can be useful.

• Establishing a continuous connect with employees working from home.

• Providing necessary infrastructure at residence of employees working from home such as office laptops equipped with office software's/licenses, mobile phones, tabs along with cyber security feature using Virtual Private Network (VPN), to protect all system users.

• Selection of appropriate digital platforms that could enable 'Work from Home'- based on their popularity, ease of usage and cost involved.

• Increased virtual sessions & training- Owing to increased need for up skilling of employees and learning new technology, not just in their area of expertise but in other functional areas. Appropriate training of employees on functioning and cyber security features of Information Technology platforms to be used for remote working is the need of the hour.

• Creating a 24*7 Helpline System for remote employees, and outline the procedure through which remote employees must take, in order to escalate technology issues.

Technologies aiding Implementation of Work from Home

Basecamp-all in one Toolkit for Working Remotely

BaseCamp is one of the most effective single window IT Software, suitable to modern organizations, that ease the remote working. BaseCamp makes it easy to see the big picture as top management, a project manager or an individual contributor.

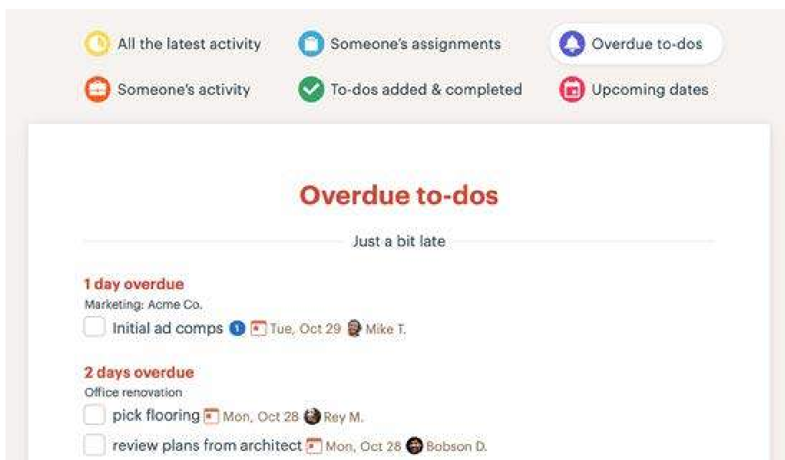
Remote working becomes challenging when stuff's spread out across emails, file services, task managers, spreadsheets, chats, meetings, etc. It becomes easy when it's all together in a single window, you'll see where everything is, understand what everyone's working on, and know exactly where to put the next thing everyone needs to know about. An essential aspect of every project is keeping people informed so that nothing falls through the cracks and everyone knows what to do. Base Camp Software includes the tools all teams need to work together; message boards, to-dos, schedules, docs, file storage, real-time group chat, and automatic check-in questions.

Utility for Employees

BaseCamp "My Stuff" Menu lets, employees see everything that's on plate such as assignments across every project, project meets, work schedules etc.

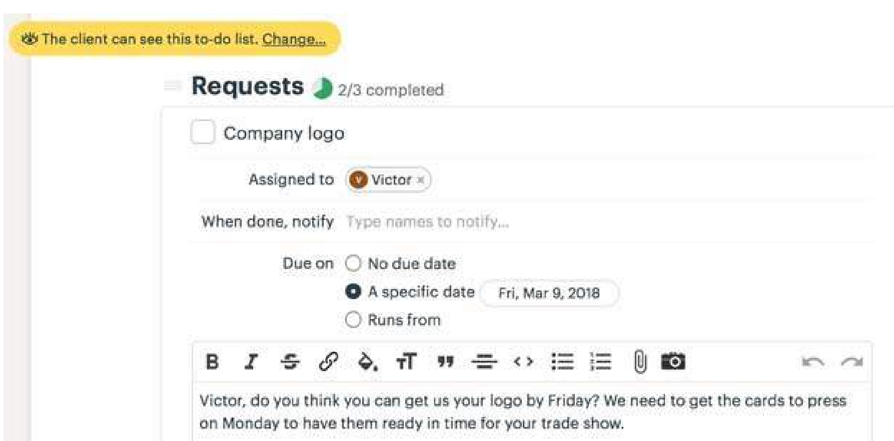
Utility for Managers

BaseCamp Activity View gives project managers one place to see everything that's going on. All the tasks that are overdue, all the work that's due soon, upcoming milestones and more.



Features of Basecamp Software

1. Work Teams/ Departments can access BaseCamp from anywhere - on the web, on iOS, and Android.
2. BaseCamp assigns tasks with a due date, get notified about the request, and automatic reminders when it's due soon or overdue.



3. Basecamp Software keeps both sides organized, everyone's feedback on the record, and all decisions, approvals, files, tasks, deadlines, and project communications safe and centralized (including that of the Client).
4. Maintains confidentiality- You decide what your clients can see. Projects start off private to your team. When you're ready to share a message, a to-do, or a file with the client, just flip the switch.
5. Allow real time sharing of any of the project's folders or files with the client keeping them informed all the time.
6. Acts as a Message Board- Keep the entire conversation about a specific topic together on a single page. No more digging through email or trying to reassemble a story from a series of fragmented replies.
7. BaseCamp's real-time group chat (Campfires) is a perfect platform for immediate query raising and solving. All without reaching for a separate app.
8. BaseCamp's exclusive Hill Charts and Auto generated Reports helps in understanding where projects really stand over time, real time project progress.

As per the famous saying in the field of Management- "You Can't Manage What You Can't Measure." So, the last effort is to accurately measure productivity of remote employees in accordance with deliverables using Digital Solutions available in the market, these include:

"Work Smart Software for productivity tracking on daily basis" - With the help of active web and desktop activity, mobile calls and GPS location application downloads, keyboard activity and webcam photos, it generates a real time - time card every 10 minutes for each Individual/ Team. This helps both manager and employee, to view logbooks where all of employee's timecards are displayed in a dashboard.

"A Weekly Scorecard" Software for assignment of project action plans and timelines - This uses of Master Google Docs spreadsheet accessible 24/7 to the entire project team where people are assigned to individual projects actionable activities what they want to work on. Each project activity expected to get completed by an estimated timeline, e.g., four- six hours, and individuals or teams have to strictly follow the timelines, to be judged as more productive.

"Timely" Software for productivity tracking on weekly basis - automatically track and capture log hours of all remote employees/ teams, working on different projects and clients using Artificial Intelligence and translated them into individual/ team time sheets. The following are the real time outputs generated by this IT tool:

(i) Employee Billable Percentage = (Total Weekly billable hours logged/total weekly hours logged) x 100
This provides overall ratio of directly profitable work in project job numbers to overhead work each employee engages in. This generates a report on how much time of individual/ team spends on billable and non-billable activities, while working from home.

(ii) Average Task Completion Rate = Total Time to complete the same task (across set timeframe)/ number of times performed
This provides a rough estimate on the overall efficiency of individual/ team. It is extremely useful to determine time spent on each activity pertaining to the project such as project planning, contract execution, setting infrastructure for production, installation of equipments, actual production activity, marketing of products, etc.

Conclusion
Thus, Work from Home not only benefits employees by eliminating their daily commutes, but also increases productivity and leads to healthier lifestyles. It's just that well laid procedures and systems at place, creates a win-win situation. Balancing both Employee Engagement and Business Competitiveness, is the need of hour and the ultimate beauty of "Work from Home" Culture. Thus, this is the perfect time to convert crises into opportunity for Oil and Gas Sector Public Sector Enterprises by adapting to the New Normal of "Work from Home" in the best possible way.

Union Budget 2021 and its Impact on Oil and Gas Sector

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A. Backdrop

With Covid-19's onset in early 2020, the world saw drastic and immediate changes in day-to-day life and conventional methods of trade. Doing business was suddenly no longer restricted to brick and mortar. Non-essential businesses were forced to adopt digital means of doing business or remain shut during the lockdown.

The biggest change in people's everyday life was curb on travel. Governments, the world across, imposed stringent restrictions on the movement of persons. All forms of travel immediately came to a stop. People were entirely confined to their houses, and this led to an instantaneous plunge in demand for fuel (and therefore, crude oil).

Aforesaid situation combined with little to no reduction in crude supply resulted in oil prices slumping[1] from over USD 60 per barrel in early January 2020 to sub-USD 17 levels in April 2020 due to overwhelming burden on oil storage facilities across the world. Mankind witnessed a rare event where oil futures traded in negative territory as oil traders received money to take away excess oil which producers could no longer store. Oil production companies were seen taking desperate measures to conserve cash and preparing business survival strategies.

India entered into a complete lockdown at a time when India only had 100 confirmed cases[2] of Covid-19. This early lockdown, coupled with policy changes rolled out by the government all through 2020, resulted in saving lives and economic revival[3] among many sectors of the economy.

India emerged out of complete lockdown towards September 2020 and saw gradual resumption of business. This led to recovery accelerating faster than envisaged. Oil prices steadily climbed back[4] to pre-Covid levels of USD 60 per barrel by February 2021.

The Finance Minister ('FM'), on 1 February 2021, laid down the Union Budget 2021 paving the foundation for bold policy measures coupled with increase in capital expenditure and various tax measures to aid the economic recovery. The Budget seeks to provide an impetus to get the one of the world's fastest-growing major economy back on track to achieve the US$5 trillion economy by 2025.

B. Key policy announcements

i. Asset Monetization Measures

With a view to finance infrastructure construction, the FM proposed to roll out a National Monetization Pipeline in order to monetize potential brownfield infrastructure assets.

1 https://markets.businessinsider.com/commodities/oil-price?type=wti
2 Economic Survey – Vol. II, Chp. 1, Page 1 https://www.indiabudget.gov.in/economicsurvey/doc/vol2chapter/echap01_vol2.pdf

Core infrastructure assets to be covered under the said monetization program are proposed to include oil and gas pipelines of flagship government PSU enterprises.

ii. Policy Rationalization Measures

In addition to asset monetization, the FM has also announced a variety of measures to rationalize existing policy. A brief summary of such measures has been provided below:

- Extension of the government's flagship Ujjwala scheme whereby an additional 10 million women (below poverty line) shall be entitled to avail cooking gas connections free of cost
- Addition of 100 more districts to the City Gas Distribution ('CGD') network in the next 3 years
- Announcement of maiden gas pipeline project for Jammu and Kashmir
- Proposal to set up an independent gas transport system operator for facilitation and coordination of booking of common carrier capacity in all-natural gas pipelines on a non-discriminatory open access basis. Such a measure shall induce transparency in pipeline usage, give all marketers a level playing field.

C. Key Corporate Tax Announcements

In addition to aforesaid policy changes, the FM rolled out various tax measures that may have a direct and indirect bearing on the oil and gas sector. The same are summarized as under:

i. No changes in applicable tax rates
Considering the unprecedented public expenditure due to the COVID-19 pandemic in the past one year, it was expected that the government could propose an additional cess or increase tax rates.

However, to everyone's surprise, the FM did not roll out any changes in tax rates applicable to corporate taxpayers or any additional levy of a 'Covid-19' cess on taxpayers.

ii.Reduction in time limits for tax returns and proceedings

Minimum government and maximum governance was a pillar on which the Union Budget was based. In light of the same, various time limits have been curtailed with an intention to:

- Reduce compliance burden on the taxpayers as its easier to explain matters pertaining to recent years

- Increasing tax department's efficiency to detect tax evasion cases within short span of time

Proposals with respect to time limits for tax return filings and various proceedings have been summarized hereunder:

Particulars	Present timeline	Proposed timeline
Belated / revised tax return	Upto one year after the end of the relevant financial year or before completion of tax scrutiny proceedings, whichever earlier	Upto 9 months after end of the relevant financial year or before completion of tax scrutiny proceedings, whichever earlier
Time limit for issuance of scrutiny notice	6 months from the end of the financial year in which the return is filed	3 months from the end of the financial year in which the return is filed
Completion of assessment (summary / regular / best judgement assessment)	24 months from the end of the relevant financial year	21 months from the end of the relevant financial year

Further, to reduce uncertainty among taxpayers, it has been proposed to reduce the time limit for re-opening tax scrutiny to 3 years from 6 years. In cases of serious tax frauds, where income escaping assessment is INR 5 Mn or more in a year, assessment can be re-opened upto 10 years.

iii. Expansion of scope of Equalization Levy ('EL')

In current digital age, doing business is geographically agnostic. One foreign company can do business in another country ('market country') digitally without setting up a presence in another country. As per legacy tax rules, market country can tax the foreign company only if such foreign company has a taxable presence in India. To curb such lacuna in tax rules, countries globally, including India, have been attempting to amend domestic laws to bring companies operating digitally within the tax net. These attempts led to new levy in India called Equalization Levy ('EL').

EL is a levy on the online business conducted in India and when introduced, it was levied on the online advertisement services received from the non-resident companies. EL levy was fixed at 6% of the value of consideration.

Last year, the scope of EL was further expanded to levy a tax on non-resident E-commerce Operators ('EOP') providing E-commerce Supply or Services ('ESS'). The levy was fixed at 2% of the value of consideration.

There were interpretational issues pursuant to widening of EL provisions. As a welcome move, the FM has proposed clarifications in Budget 2021. While at one hand few clarifications shall provide relief to taxpayers, on other hand the scope of EL has been magnified to a very large extent.

One of the ambiguity was around the interplay of EL provisions with payments for royalty and fees for technical services ('FTS') i.e. whether on the transaction of online services income tax would levied @ 10% treating these services as 'Royalty' or FTS as well as EL would be levied (as such services were rendered online). As a relief measure, it was clarified by the FM that transactions taxable as royalty and fees for technical services would not be covered under the ambit of EL.

However, income earned by non-resident oil and gas service providers to the Exploration and Production sector in India are governed under presumptive provisions of the Income-tax Act. This income is neither classified as royalty or FTS. Hence, there exists an uncertainty as to whether such non-resident service provider who is also engaged in online sale of goods or provision of services shall subject to EL.

Further, the existing EL provisions did not define the terms "online sale of goods" and "online sale of services". The FM further clarified that the said terms for the purposes of e-commerce supply would include one or more of the following activities:

- Acceptance of offer for sale;
- Placing the purchase order;
- Acceptance of the purchase order;
- Payment of consideration; and
- Supply of goods or provision of services, partly or wholly

The aforesaid explanation would result in unwarranted hardships covering all e-commerce transactions which would also include a case wherein even one leg of the entire transaction is online.

India is largely dependent upon imports for meeting domestic oil requirements and many players would be placing purchase order online on an electronic or trading platform. Such transactions may now get covered within EL's ambit. Where currently we are seeing historic rise in Indian oil prices, there is a very big question mark on how Indian oil and gas industry will cope with additional cost due if such levy is deemed to be applicable to such mode of transaction.

It was further clarified that the taxable amount for which the EL has to be paid by an e-commerce platform will include the entire sale amount irrespective of the fact whether an EOP owns the goods or provides services.

iv. Putting rest to the tax litigation on certain technical aspects

(a) Depreciation on goodwill

The Supreme Court of India, in a landmark ruling , held that goodwill arising out of excess consideration paid over the fair value of assets on business acquisition would qualify as a depreciable intangible asset.

The said ruling has been overturned vide Budget 2021, wherein it has now been proposed that goodwill of a business or profession shall not be considered as a depreciable asset. The said proposed amendment aims to curb tax benefit obtained from depreciation on goodwill created through internal restructuring.

It will be pertinent for business organizations to ascertain potential tax impact arising on account of business reorganizations involving goodwill. It will also be interesting to see whether tax authority challenges depreciation claims of past years.

(b) Deduction for employee contributions to specified funds

Presently, taxpayers have been availing deductions for employer's contributions to specified funds, if such contributions have been made on or before the due date of filing tax return.

In absence of specific clarity, various courts took a view that the extended due date should also apply to employee's contribution to such specified funds.

3 Economic Survey – Vol. II, Chp. 1, Page 1 https://www.indiabudget.gov.in/economicsurvey/doc/vol2chapter/echap01_vol2.pdf
4 https://markets.businessinsider.com/commodities/oil-price?type=wti

Vide Union Budget 2021, it has now been clarified that employee's contribution to specified funds shall not be deductible in the hands of employer if contribution has not been deposited within the due date under respective governing regulations. Hence, even if there is a delay of one day in depositing employee's contribution, the deduction of the same for employer will be lost forever.

v. Changes in Tax Deducted at Source ('TDS') / Tax Collected at Source ('TCS') provisions

New TDS provision is proposed to be introduced for deducting tax on any purchase of goods (exceeding INR 5 Mn) at 0.1% by the buyer whose total turnover / gross receipts from business exceeds INR 100 Mn during immediately preceding financial year. The said provisions shall not be applicable to transactions subjected to other TDS / TCS provisions (except TCS on sale of goods). Where a transaction attracts both TDS on purchase and TCS on sale of goods, then only such new TDS provisions shall apply. A higher rate of TDS @ 5% has been prescribed in case seller of goods does not possess a Permanent Account Number. Currently there are no exceptions on applicability of the said provision on non-resident buyers. One will have to wait and watch how government tackles non-resident buyers purchasing goods from India who could be saddled with additional TDS compliances.

Further, to bring discipline among taxpayers, various measures have been introduced for TDS / TCS at higher rates on payment to taxpayers who defaults in filing tax return:

• TDS on payments to non-filers of tax return shall attract TDS at higher of the following rates:

o Twice the rates specified in the Act
o Twice the rates in force
o Rate of 5%

• Higher rates of TDS applicable in case of absence of PAN shall continue to apply

• Payments received from non filers of tax return shall also be subjected to TCS at higher rates

• However, aforesaid provisions are not proposedto be applicable in case of non-resident taxpayers who do not constitute a Permanent Establishment in India

Aforesaid changes in TDS / TCS regime shall be applicable from 1 July 2021. However, it remains unclear as to how the non-filing of return by recipient would be identified. It is expected that the revenue authorities shall unveil a mechanism in this regard.

vi. Faceless proceedings

In line with faceless assessment scheme, faceless appeal scheme and faceless penalty scheme, it has now been proposed by the FM that a faceless scheme for ITAT shall be launched on the same lines so as to reduce the human interface to a larger extent. Detailed directions with respect to faceless proceedings before ITAT shall be announced.

Considering the fact that ITAT is the final fact-finding authority, it is to be seen how taxpayers would receive a chance to sufficiently demonstrate facts and evidence before the ITAT. Further, it is also to be seen how the aforesaid proceedings which rely on written submissions shall fulfil the Principle of Natural Justice (i.e. an opportunity of being heard) to which every taxpayer is entitled.

D. Key Indirect Tax Announcements

• As a measure to overhaul custom duty structure, sunset clause is introduced for all conditional exemptions which are currently in force. The same shall be valid till 31 March 2023 unless withdrawn earlier.

• For the purpose of financing improvement in agriculture infrastructure and other development expenditure by the Government, a new cess called Agriculture Infrastructure and Development Cess (AIDC) is proposed to be introduced

E. Unfinished agenda

While India has made substantial progress on its road to recovery from Covid-19, it may be difficult to predict when it would completely overcome the economic stress caused by Covid-19. Changes in people's habits especially with respect to travelling in light of accelerated digitization of businesses, and the increasing awareness for the need to decarbonize, has created a lasting impact on the Oil & Gas industry. Tiding over such an impact would only be possible with the help of Government's support and strong policy backing. The measures adopted by the Government in Union Budget 2021 indicate their bold intentions to support industry in its road to recovery, and it would be interesting to watch the agenda pan out.

HPCL: Ushering in a Green Future with Renewable Energy

India has about 374 GW of installed capacity and out of which Renewable Energy contribute about 24% of the total installed capacity in the country (as on 30-11-2020). As per CERC forecast, electricity demand is expected to grow to about 5-5.5% per annum in next 20 years. During the last few years, renewable energy installation is growing at an avg CAGR of over 24%. This is mainly because of country's commitment for action on climate change, improvement in technology and CUF of Renewable plants, decline in component prices, easy financing option available etc. Renewable energy plants will play a Major role in meeting the future electricity requirement with wind & Solar being the major growth drivers.

Further, GoI has set the target of increasing renewable energy capacity to 175 GW by 2022, which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro-power. Renewable energy installed capacity has increased by over 225% in the last 5 years and stands at 90.4 Gigawatt as on 30.09.2020. The breakup is; Wind (38.4 GW), Solar (36.9 GW), Small hydro (4.7 GW), Biomass (9.8 GW).

As per Central electricity authority's final report on optimal generation mix by 2029-30, Installed capacity of RE is projected to be about 435 GW by March 2030. India surpassed its annual solar PV capacity addition over its annual wind power installation for the 3rd year in a row and now solar energy has become the most focused area in Indian Renewable Market.

Over the years, GoI has taken several initiatives such as introduction of the concept of solar Because of these initiatives, the country has become a global market for development of RE based power project especially new solar projects.

We have strategic advantage of being located in sub- tropical region and the sunlight falls about 300 days in years. Many Govt schemes are launched to promote / accelerate to tap this solar energy & the development of solar power in the country. Some of the key initiatives launched by Govt to harness the solar power are;

- Jawahar Lal Nehru National Solar Mission (JNNSM),
- Development of solar parks and Ultra Mega solar park,
- Distributed solar system for A&N island, floating solar plants etc.
- Setting up of 12 GW of Solar plant under CPSU Scheme
- Installation of solar street lights, solar lamps etc,
- Installation of solar pumps under Pradhan Mantri Kisan urja suraksha evam Uttan mahaabhiyaan (PM KUSUM)
- Off-grid concentrated solar system for heating purpose.

Being an energy company, HPCL also diversified into renewable energy in 2007 by installation of 3.75 MW of wind turbines at Dhule Maharashtra and since then, we have expanded the wind portfolio to total of 100.90 MW capacity Wind farm and about 38 + MW Solar Power (all captive) now. These wind and solar farms are generating revenue and huge captive savings to the corporation.

In addition, during the FY 2019-20, HPCL has offset about 1.83 Lacs Tonnes of CO2 by generation through wind farm.

Going forward, all our marketing SBU are looking into further solarization of balance installations basis the land availability, power requirement and local state regulations.

For wind power, we are currently selling the generated electricity to the DISCOMs of Maharashtra and Rajasthan. We are also in the process of development of framework for participation in tariff bidding for allocation of wind or solar – wind hybrid plant.

Oil & Gas in Media

Hon'ble Prime Minister receives the CERAWeek Global Energy and Environment Leadership Award

Prime Minister Shri Narendra Modi delivered the keynote address at the CERAWeek 2021 through video conference. He was awarded the CERAWeek Global Energy and Environment Leadership Award. He said "It is with great humility that I accept the CERAWeek Global Energy and Environment Leadership Award. I dedicate this award to the people of our great Motherland, India. I dedicate this award to the glorious tradition of our land that has shown the way when it comes to caring for the environment." He added that Indian are leaders when it comes to caring for the environment for centuries. He said in our culture, nature and divinity are closely linked.

The Prime Minister, Shri Narendra Modi delivering the keynote address at the CERAWeek 2021, through video conference, in New Delhi on March 05, 2021

The Prime Minister said that Mahatma Gandhi is one of the greatest environment champions to have ever lived. If humanity had followed the path laid down by him, we would not face many of the problems we do today. He urged the people to visit Mahatma Gandhi's hometown of Porbandar, Gujarat where underground tanks were constructed years ago to save rain water.

The Prime Minister said there are only two ways to fight climate change and calamities. One is through policies, laws, rules and orders. The Prime Minister gave examples. Share of non-fossil sources in India's installed capacity of electricity has grown to 38 percent, adoption of Bharat - 6 emission norms since April 2020 which is equal to Euro - 6 fuel. India is working to increase the share of natural gas from the current 6 per cent to 15 per cent by 2030. LNG is being promoted as a fuel. He also mentioned recently launched National Hydrogen Mission and PM KUSUM which promotes an equitable and decentralized model of solar energy generation. But the most powerful way to fight climate change, Shri Modi said, is behavioural change. He gave a call to fix ourselves so the world will be a better place.

Petroleum Minister Shri Dharmendra Pradhan and the New US Secretary of Energy H.E. Jennifer Granholm agreed to Revamp India-US Strategic Energy Partnership

Minister of Petroleum and Natural Gas &Steel Shri Dharmendra Pradhan held an introductory meeting virtually with US Secretary of Energy H.E. Jennifer Granholm. Minister Pradhan congratulated Secretary Granholm on assuming the high office and reviewed the India-US Strategic Energy Cooperation (SEP). Both leaders agreed to revamp the India-US SEP to reflect the new priorities of Prime Minister Narendra Modi and President Joe Biden with focus on promoting clean energy with low-carbon pathways and accelerating green energy cooperation.

They agreed to prioritise greater collaboration in cleaner energy sector- biofuels, CCUS, hydrogen production and carbon sequestration through technology exchange, joint R&D through Partnership to Advance Clean Energy Research (PACE-R), among other initiatives.

Both sides agreed to convene the third meeting of a revamped India-US Strategic Energy Partnership at an early date. They decided to intensify the efforts to take advantage of the complementarities of both the countries -advanced US technologies and rapidly growing India's energy market, for a win-win situation through a cleaner energy route with low carbon pathways. H.E Jennifer Granholm assumed the post of US Secretary of Energy in February 2021.

11th IEA, IEF, OPEC Symposium on Energy Outlook

Shri Dharmendra Pradhan, Minister of Petroleum and Natural Gas &Steel, participated in the 11th IEAIEF-OPEC Symposium on Energy Outlooks —held virtually— on 17th February 2021 under the patronage of the Minister of Energy of Saudi Arabia HRH Prince Abdulaziz bin Salman Al Saud. The symposium saw the presence of heads of all top inter-governmental energy agencies -IEF, IEA, OPEC, IRENA and the GECF. Also, dignitaries like, H.E. Norma RocíoNahle García, Secretary of Energy, Mexico and H.E. Timipre Sylva, Minister of State of Petroleum Resources of Nigeria participated in the event.

Apart from the comparative analysis of short, medium, and long-term energy outlooks that OPEC and the IEA published in 2020, the trilateral symposium reflected on the long-term outlooks of key producer and consumer countries. In his address, Shri Pradhan highlighted that there was unanimous agreement among international agencies, like IEA, OPEC, vis-a-vis reports released by them on India's robust energy growth profile during 2021 and beyond. While the world's total primary energy demand would increase at less than 1% per annum till 2040, India's energy demand would grow at about 3% per annum till 2040. The recently-released IEA's India Energy Outlook 2021 highlights that India has now emerged as the key centre for global energy demand, and is expected to become world's largest energy consumer soon. Our share in global energy consumption is set to double in the next three decades. OPEC and EIA in their nearterm outlook estimate that global fuel consumption will grow by 5.6 to 6 million barrels per day in 2021, where more than half of this growth will come from India and China. Natural gas demand is also projected to increase three-fold by 2040. 42 Policy and Economic Report: Oil & Gas Market February 2021. Given this backdrop, where the world is limping back to normalcy, Minister Pradhan reiterated that there is a need to allow consumption-led recovery that has just taken roots in several emerging economies, including India.

Shri Dharmendra Pradhan inaugurated the LNG truck-loading unit of Shell India at Hazira; describes this as another big step towards a cleaner and greener future for India

Shri Dharmendra Pradhan, Union Minister of Petroleum & Natural Gas inaugurated the LNG truck-loading unit of Shell India at Hazira, Gujarat. Speaking on the occasion, he said that the unit will boost availability of natural gas in off-grid areas where there are no gas pipelines and also promote the use of LNG in longhaul trucking. Complimenting the team of Shell India on this significant initiative taken today, Shri Pradhan said that increasing competition in the LNG sector will help in the emergence of new markets, create new employment opportunities, ensure cleaner fuels for industries and facilitate environment conservation. He said that this is another big step towards a cleaner and greener future for India. "We are committed to increase the clean energy quantum in our energy mix to transform into a gas-based economy, address issues of climate change and build an Aatmanirbhar Bharat." The Minister congratulated Shell India on this endeavour of supporting India's environmental as well as clean energy transition goals by giving thrust to creation of necessary infrastructure to promote LNG as a transport fuel.

FIPI Oil & Gas Awards 2020

The Federation of Indian Petroleum Industry organised the FIPI Oil & Gas Awards 2020 Ceremony on Wednesday, 27 January, 2021 at New Delhi. Observing the COVID-19 related restrictions, the FIPI Awards Ceremony was organised on a hybrid mode with a restricted physical participation but a much wider virtual participation.

The occasion was graced by the presence of the Hon'ble Minister for Petroleum & Natural Gas and Steel, Shri Dharmendra Pradhan and Secretary, Ministry of Petroleum & Natural Gas Shri Tarun Kapoor. The FIPI Awards ceremony was attended by key industry leaders, Ministry officials and experts among other participants. The FIPI Oil and Gas Awards have been created to recognise the leaders, innovators and pioneers in the oil and gas industry.

Shri Dharmendra Pradhan, Hon'ble Minister for Petroleum & Natural Gas and Steel addressing the august gathering

Shri Tarun Kapoor, Secretary, Ministry of Petroleum & Natural Gas addressing the participants

The objective of the FIPI Oil & Gas Awards is to celebrate the industry's most outstanding achievements.

Shri S.M. Vaidya, Chairman FIPI and Chairman IndianOil addressing the participants

Dr. R.K. Malhotra, DG FIPI delivering the concluding remarks

All companies operating in India, including those who are not members of FIPI but have significant involvement in the oil & gas sector, are eligible to apply for the awards. The applications are evaluated by the Awards Committee comprising of experts from oil and gas industry. Evaluation by Award Committee is submitted to Jury for final verdict. The decision of the Jury for selection of a particular awardee will be final and binding.

At the awards ceremony Shri Tarun Kapoor highlighted the country's growing need for energy and the significant role the oil and gas sector will have to play to support an accelerated growth of the country. In his address, the chief guest at the ceremony Shri Dharmendra Pradhan underlined that while new sources of energy are fast coming up in the country, the future energy basket of the country will have ample space for all fuel technologies. He appreciated FIPI for its efforts in the sector and all the winners of FIPI Oil & Gas Awards 2021 for their commendable contribution to the sector. The award ceremony saw an overwhelming participation both physically as well as virtually. While the ceremony saw a full house at the physical gathering, more than 500 participants joined the event through the virtual platform.

FIPI

WINNERS OF FIPI AWARDS 2020

January 27, 2021

Award Category	Winner
Young Achiever of the Year in the Oil & Gas Industry (Female)	D. Rajeshwari Bharat Petroleum Corporation Ltd. & Sayanima Kisku Oil and Natural Gas Corporation Ltd.
Young Achiever of the Year in the Oil & Gas Industry (Male)	Shubham Mishra Schlumberger Asia Services Ltd.
Woman Executive of the Year in Oil & Gas Industry	Rima Kundu Engineers India Ltd.
Innovator of the Year - Team (Special Commendation)	BPCL (team led by Srinivasulu Kaalva, Sr. Manager, R&D)
Innovator of the Year - Team	IOCL (team led by Dr. SSV Rama kumar, Director, R&D)
Best Start-up of the Year	Vasitars Private Ltd.
Digital Technology Provider of the Year	Schlumberger Asia Services Ltd.
Digitally Advanced - Company of the Year	Indian Oil Corporation Ltd.
City Gas Distribution-Growing Company of the Year	IRM Energy Private Ltd.
City Gas Distribution-Established Company of the Year	GAIL Gas Ltd.
Engineering Procurement Construction (EPC) - Company the Year	L&T Hydrocarbon Engineering Ltd.
Service Provider - Company of the Year	Baker Hughes India
Excellence in Human Resources Management - Company of the Year	Oil India Ltd.
Project Management - Company of the Year	Oil and Natural Gas Corporation Ltd.
Oil & Gas Pipeline Transportation - Company of the Year	Indian Oil Corporation Ltd.
Oil & Gas - Exploration Company of the Year	Oil India Ltd.
Refinery of the Year (Capacity up to 9 MMTPA)	Bharat Oman Refineries Ltd.
Refinery of the Year (Capacity higher than 9 MMTPA)	Reliance Industries Limited, SEZ Refinery
Oil Marketing - Company of the Year	Hindustan Petroleum Corporation Ltd.
Sustainably Growing Corporate of the Year	Bharat Oman Refineries Ltd.

FIPI & IGU Association

On 28th January 2021; FIPI and International Gas Union (IGU) have executed an agreement through which FIPI has become the "Affiliated Organization of IGU" and at the same time, IGU has become a member of FIPI.

The International Gas Union (IGU) was founded in 1931. It is a worldwide non-profit organisation registered in Switzerland with the Secretariat currently located in Barcelona, Spain. The working organisation of IGU covers the complete value of gas chain from exploration and production, transmission via pipelines and liquefied natural gas (LNG) as well as distribution and combustion of gas at the point of use. It has more than 160 members which are associations and corporations of the gas industry representing over 95% of the global gas market. The mission of IGU is to advocate gas as an integral part of a sustainable global energy system, and to promote the political, technical and economic progress of the gas industry. IGU organizes flagship conferences like World gas conference, LNG conference etc. among many other conferences.

This association will contribute, among others, to expanding FIPI's advocacy and its member companies especially from gas sector would be greatly benefited.

Webinar on 'Confluence of Energy and Mobility: Making India's Mobility Fuels Sustainable and Economically Viable'

FIPI in association with The Boston Consulting Group (BCG) and Society of Indian Automobile Manufacturers (SIAM) has organized a webinar on 'Confluence of Energy and Mobility: Making India's Mobility Fuels Sustainable and Economically Viable' on 08th Feb'21.

Concerns about atmospheric emissions have forced many countries to re-evaluate their emission sources and sustainability of their energy mix. In this context, and based on BCG's recently launched report "Confluence of Energy and Mobility"- a joint webinar was organized to explore alternative solutions to sustain the growing mobility needs of India. It focused on a myriad of problems in the automobile and energy sectors like rising fuel demand, economic viability for consumers, and the challenge of vehicular pollution and deteriorating air quality. Finally, the key insights from the report were discussed and the implications on various stakeholders while focussing on the various 'vehicle-fuel' options from a sustainability and economics perspective and thus presented a mosaic of solutions across fuel types in the near and medium term.

10th Annual Convention of FIPI Student Chapters, 19th March 2021

The Tenth Annual Convention of FIPI Student Chapters was held virtually on 19th March 2021 on the theme 'Meeting Energy Demand Amidst Climate Commitments '. Due to the on-going pandemic situation, the event was held virtually. The FIPI Student Chapters were instituted to provide a common platform to academicians, students, technologists and management experts of the university/college for regular exchange of ideas in the field of energy with special reference to Oil & Gas and Petroleum Technology.

Faculty members and students from Six Chapters, viz JNTU Kakinada; MIT Pune; PDEU Gandhi Nagar; RGIPT Rai-Bareilly, Dibrugarh University, Dibrugarh & UPES Dehradun participated in the Convention.

Mr. T.K Sengupta, Director (Exploration & Production), FIPI gave the opening remark and spoke an overview of the importance of the oil & gas sector in meeting the future energy demand amidst the talks of energy transition. Mr. Sengupta said that, oil & gas industry is here to stay, however its percentage share in the overall energy basket may decline.

On the basis of presentations given by various chapters on the activities performed during the previous year, Dr. R.K. Malhotra, Director General, FIPI & Mr. T.K Sengupta, Director (Exploration & Production), FIPI, Mr. Rajiv Bahl, Director (Finance, Taxation & Legal), FIPI evaluated the performance of each chapter and declared PDEU as the best chapter for the year 2020.

PDEU FIPI Chapter presenting their Annual Chapter Activities

On the basis of presentations given by various chapters on the activities performed during the previous year, Dr. R.K. Malhotra, Director General, FIPI & Mr. T.K Sengupta, Director (Exploration & Production), FIPI, Mr. Rajiv Bahl, Director (Finance, Taxation & Legal), FIPI evaluated the performance of each chapter and declared PDEU as the best chapter for the year 2020.

Dr. R.K Malhotra, Director General FIPI, delivering closing remarks

All the chapters also made a 15 minutes presentation on the theme "Meeting Energy Demand Amidst Climate Commitments". Dr. R.K. Malhotra, Director General, FIPI; Mr. T.K Sengupta, Director (Exploration & Production), FIPI, Mr. Rajiv Bahl, Director (Finance, Taxation & Legal), FIPI evaluated the presentations and MIT, Pune was adjudged as the winner and UPES Dehradun as the runner-up. Certificate of participation were handed over to faculty coordinators for further submission to students.

FIPI Post Budget Analysis 2021

The Union Budget for the Year 2021-22 was announced by the Hon'ble Finance Minister of India Smt. Nirmala Sitharaman on 1 February, 2021. Keeping up with FIPI's long tradition, FIPI organized its flagship FIPI Post Budget Analysis 2021 session on 2 February with Deloitte India as the knowledge partner. The session witnessed fruitful deliberations on the recently announced budget and its short, medium and long term impacts on the oil and gas sector. The attraction of the FIPI Post Budget Analysis 2021 was the moderated panel discussion on the hits and misses of the budget and the future support required for an accelerated growth of the industry. The session was attended by Mr. Subhash Kumar, Director - Finance, ONGC; Mr. Sandeep Kumar Gupta, Director - Finance, IndianOil; Mr. Anjani Kumar Tiwari, Director – Finance, GAIL (India) Ltd; Mr. Kartikeya Dube, Chief Financial Officer, Reliance BP Mobility Limited;, Director – Finance, Petronet LNG and Mr. P Balasubramanian, Chief Financial Officer, Ratnagiri Refinery and Petrochemicals Ltd among other industry leaders and participants.

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

Delivering his opening remarks, Dr R K Malhotra, Director General, FIPI welcomed all speakers and participants and highlighted that this budget was long awaited and will go on to be remembered as a historic budget to support the ailing economy after the pandemic. He pointed out that the huge public investment proposed in the budget will provide the much needed fillip to the economy and the rally in the financial markets was only a reflection of the nation's mood after the budget. He hoped that the increase in economic activity, as result of the budget, will boost energy consumption and that the industry has to stay prepared to fuel this energy requirement.

He further underlined that the announcement initiatives in the gas industry such as the creation of independent Transmissions System Operators (TSOs) and expansion of CGD network to 100 more districts will go a long way in realizing the Hon'ble Prime Minister's vision of a gas based economy. Dr. Malhotra welcomed the Government's plans to expand the very successful Ujjwala Yojana to reach another 1 crore households and he sounded certain that this will is a farsighted initiative towards social upliftment of the underprivileged and empowerment of women. Speaking on the budgetary announcement of a comprehensive Hydrogen mission, he apprised that the conventional fuel business and our refineries are geared up and equipped to produce store and distribute hydrogen fuel. Dr Malhotra further hoped that the Government soon addresses key industry issues such as reduction/abolishment of OID Cess and inclusion of key petroleum products under GST among others.

The next session was a detailed presentation by Deloitte India on Economic survey and Union Budget 2021. While Mr. Hemal Zobalia, Subject Matter Expert, Infrastructure, Energy & Public Sector presented on direct taxation aspect, Mr. Gulzar Didwania, Partner, Deloitte India briefed the participants on indirect taxation.

The following session at FIPI Post Budget Analysis 2021 was a panel discussion moderated by Ms. Bela Sheth Mao, Partner, Deloitte India. The panel comprised of key financial experts from across the oil and gas value chain. During the deliberations, it was highlighted that the pandemic has a debilitating impact on the oil sector. As result of the COVID-19 inflected lockdowns, crude demand went down by around 29-30 Mbpd. In April, while oil prices stayed negative for a short period, gas prices remained negative for an extended period of 25-30 days in some location. Though the demand has come back now but the pandemic has already taken away the growth for last 7 to 8 years. In geologies like India, the prevailing low oil prices have proved very difficult to cope with for the upstream oil and gas industry. It was underlined that to ease the pressure on the upstream companies and attract additional investment into the sector Government should consider reduction/abolishment of OID cess.

Pipeline capacity utilization is in the range of 50-52 per cent. Some of the pipelines are being utilized at 10-15 per cent as well. The budget proposed for expansion of pipeline network by another 18,000 Kms, taking the total pipeline network to 45000 Kms. Panelists believed that the introduction of Transport System Operator (TSO) is a welcome step and will ensure proper booking by the third party without any discrimination. TSO is going to bring more flexibility in capacity booking, scheduling, monitoring as well as managing the imbalance. TSO will develop its own rules and standards and will take care of the agreements with the customers, charges applicable among other things. With expansion of pipeline capacity, TSO will yield a better way of capacity booking for the third party. TSO is a welcome start but complete liberalization of the gas market should be the goal to bring more investment into the pipeline segment.

Panel discussion on ' Union Budget 2021' moderated by Ms. Bela Sheth Mao, Partner, Deloitte India

Panelists agreed that to make India gas based economy, inclusion of natural gas under GST is imperative. Till such time, the tax rates on natural gas should be moderated since the industry is not being able to pass that on. Government also needs to provide a GST roadmap to bring greater visibility for the investors. For the downstream sector investment in initial infrastructure in retail outlets, CNG stations etc. to enable an early adoption as they contribute to the dual objective of energy access and clean energy. To further encourage EVs and gas mobility, a taxation ecosystem needs to be built to encourage investment in cleaner mobility.

For growth of new refineries and petrochemical complexes in the downstream side of the industry, Government needs to introduce policy support and lower taxation rates. To further reduce the capital costs, the sector will require a substantial reduction in excise duty. Reduction in customs duty will also be required. Lower GST on input services for the sector will also be crucial. Taking account of the Cyclical risk and risks arising due to changing business model, tax holidays and reduced rates that are presently being extended to other industries should also be offered to the new entrants in oil and gas downstream. Government should also look into providing policy support on land prices, stamp duty exemption, ecosystem development, infrastructure development etc. To make the new projects in the sector more viable, policy support will be absolutely necessary from both central and the state Governments.

Delivering the closing remarks at the session, Mr. Rajiv Bahl, Director – Finance Taxation and Legal, FIPI thanked all the speakers and the participants for making the session successful. Noting that there were a few issues arising out of the Budget as emerged during the discussions, he reassured the speakers and the industry members that FIPI will take up the issues brought forward during the session with relevant Government authorities and seek relief. He requested the industry members to forward all such issues so that FIPI can take up the same with Government at the earliest. Bringing the session to an end he thanked the FIPI team and Deloitte India for their efforts to make this session a huge success. Similar to its previous editions, FIPI Post Budget Analysis 2021 witnessed an overwhelming participation of over 250 participant hailing from across the Indian oil and gas industry.

Mr. Rajiv Bahl, Director(Finance Taxation and Legal), FIPI giving the closing remarks

FIPI R&D Conclave 2021

The Federation of Indian Petroleum Industry (FIPI) organised it's flagship FIPI R&D Conclave between 24-26 March, 2021 at New Delhi. The FIPI R&D Conclave serves as a platform for the entire research community in the Indian oil and gas sector to gather under one roof, and showcase some of the most ground breaking research, and cutting-edge technologies being developed by some of the best minds in the business. Over its previous three editions, the FIPI R&D Conclave has witnessed in-depth discussions and deliberations on some of the most innovative technologies being developed across the oil and gas value chain in India. Many of these technologies have proven hugely successful commercially in subsequent years. In view of the ongoing COVID-19 Pandemic, this fourth edition of the FIPI R&D Conclave is being organized in a hybrid mode with a limited physical attendance but a wider virtual attendance.

Dr. R.K. Malhotra, DG FIPI delivering the welcome address

Shri Tarun Kapoor, Secretary, MoPNG delivering the Inaugural Address

The Federation of Indian Petroleum Industry (FIPI) organised it's flagship FIPI R&D Conclave between 24-26 March, 2021 at New Delhi. The FIPI R&D Conclave serves as a platform for the entire research community in the Indian oil and gas sector to gather under one roof, and showcase some of the most ground breaking research, and cutting-edge technologies being developed by some of the best minds in the business. Over its previous three editions, the FIPI R&D Conclave has witnessed in-depth discussions and deliberations on some of the most innovative technologies being developed across the oil and gas value chain in India. Many of these technologies have proven hugely successful commercially in subsequent years. In view of the ongoing COVID-19 Pandemic, this fourth edition of the FIPI R&D Conclave is being organized in a hybrid mode with a limited physical attendance but a wider virtual attendance.

The inaugural session of the FIPI R&D Conclave 2021 was attended by R&D experts from across the oil and gas value chain in India. Speaking at the session, the Guest of Honour, Dr. Anil Kakodkar, Chairman, Rajiv Gandhi Science & Technology Commission and Former Chairman, Atomic Energy Commission highlighted the need for indigenous R&D activities in the Indian energy industry. Speaking at the session, Chief Guest, Shri Tarun Kapoor, Secretary, MoPNG appreciated the commendable work done by the R&D community in the oil and gas sector. He highlighted that imperatives such as efficiency gain, carbon capture and low carbon footprints have opened a plethora of opportunities for the R&D community in the industry. He acknowledged the phenomenal role played by FIPI in providing a platform for R&D experts and encouraging research activities in the sector.

Dr. S.S.V. Ramakumar, Director (R&D), IndianOil delivering the Special Address

During the Inaugural Session Dr. Ajit Sapre, Group President (R&D), RIL delivered a special address on Role of Decarbonization & Achieving Atma-Nirbhar Bharat: One Perspective.

The FIPI R&D Conclave 2021, over the three days hosted various targeted sessions on various upcoming technologies and research work across the value chain. The sessions did not only witness showcasing of some of the state of the art technologies but also drew much interest from participants joining both physically and virtually.

The FIPI R&D Conclave 2021 concluded with a panel discussion on R&D and deployment of indigenously developed technologies. The panellists at the session included Dr. S.S.V. Ramakumar, Director (R&D), IOCL; Dr. Sanjeev Katti, Director General, ONGC Energy Centre; Mr. S. Bharathan, Head (R&D) HPCL; Dr. Anjan Ray, Director, CSIR-IIP; Ms. Vartika Shukla, Director (Technical), EIL; and Dr. V. Ravikumar, Head (R&D), BPCL. The panel discussion was moderated by Dr. R.K. Malhotra, Director General, FIPI. The FIPI R&D Conclave proved hugely successful and saw a participation from over 500 participants.

Panel discussion on R&D and Deployment of indigenously developed Technologies

A Section of the participants

NEW APPOINTMENTS

Akshay Kumar Singh assumes charge as MD & CEO of Petronet LNG Ltd

Akshay Kumar Singh

Mr. Akshay Kumar Singh assumed charge as the Managing Director and Chief Executive Officer (MD & CEO) of the Petronet LNG Limited on 1st February 2021.

Mr. Akshay Kumar Singh is a Mechanical Engineer from MIT, Muzaffarpur and a post graduate in Turbo Machinery from South Gujarat University. He has more than 3 decades of experience and possesses vast domain knowledge and has made significant contributions in Petroleum & Natural Gas Sector.

Prior to joining Petronet LNG Limited, he was Director (Pipelines) in Indian Oil Corporation Limited. He has vast experience in executing challenging, complex and large size cross-country pipeline network of national importance. He has extensive experience in the field of design engineering, planning, execution and O&M of hydrocarbon cross-country pipeline system and process plants. He had also served as an Executive Director in GAIL India Limited in Projects division before Indian Oil Corporation Limited.

STATISTICS

INDIA: OIL & GAS

DOMESTIC OIL PRODUCTION (MILLION MT)

		2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020	% of Total
Onshore	ONGC	6.1	5.8	5.9	6.0	6.1	6.1	4.5	39.3
	OIL	3.4	3.2	3.3	3.4	3.3	3.1	2.2	19.6
	Pvt./ JV (PSC)	9.1	8.8	8.4	8.2	8.0	7.0	4.7	41.1
	Sub Total	**18.5**	**17.8**	**17.6**	**17.5**	**17.3**	**16.2**	**11.3**	**100**
Offshore	ONGC	16.2	16.5	16.3	16.2	15.0	14.5	10.8	92.3
	OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pvt./ JV (PSC)	2.7	2.5	2.1	1.9	1.9	1.5	0.9	7.7
	Sub Total	**18.9**	**19.1**	**18.4**	**18.1**	**16.9**	**16.0**	**11.6**	**100**
Total Domestic Production		37.5	36.9	36.0	35.7	34.2	32.2	23.0	100.0
	ONGC	22.3	22.4	22.2	22.2	21.0	20.6	15.2	66.2
	OIL	3.4	3.2	3.3	3.4	3.3	3.1	2.2	9.7
	Pvt./ JV (PSC)	11.8	11.3	10.5	10.1	9.9	8.4	5.5	24.1
Total Domestic Production		**37.5**	**36.9**	**36.0**	**35.7**	**34.2**	**32.2**	**23.0**	**100**

Source : PIB/PPAC

REFINING

Refining Capacity (Million MT on 1st January 2021)

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	2.35
Paradip	15.00
Total	**69.70**

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

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

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

Hindustan Petroleum Corp. Ltd.	
Mumbai	7.50
Visakhapattnam	8.30
Total	**15.80**
Other PSU Refineries	
NRL, Numaligarh	**3.00**
MRPL	**15.00**
ONGC, Tatipaka	**0.07**
Total PSU Refineries Capacity	**142.57**

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

Total Refining Capacity of India 249.9 (5.00 million barrels per day)
Nayara Energy Limited (formerly Essar Oil Limited)
Source : PPAC

CRUDE PROCESSING (MILLION MT)

PSU Refineries	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020 (P)
IOCL	53.59	58.01	65.19	69.00	71.81	69.42	44.76
BPCL	23.20	24.10	25.30	28.20	30.90	31.53	17.90
HPCL	16.20	17.20	17.80	18.20	18.44	17.18	12.03
CPCL	10.70	9.60	10.30	10.80	10.69	10.16	5.60
MRPL	14.60	15.53	15.97	16.13	16.23	13.95	7.40
ONGC (Tatipaka)	0.05	0.07	0.09	0.08	0.07	0.09	0.06
NRL	2.78	2.52	2.68	2.81	2.90	2.38	1.99
SUB TOTAL	**121.12**	**127.03**	**137.33**	**145.22**	**151.04**	**144.71**	**89.73**

JV Refineries	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (P)	April-Dec. 2020 (P)
HMEL	7.34	10.71	10.52	8.83	12.47	12.24	8.23
BORL	6.21	6.40	6.36	6.71	5.71	7.91	4.29
SUB TOTAL	**13.55**	**17.11**	**16.88**	**15.54**	**18.18**	**20.15**	**12.52**

Pvt. Refineries	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (P)	April-Dec. 2020 (P)
NEL	20.49	19.11	20.92	20.69	18.89	20.62	12.50
RIL	68.10	69.50	70.20	70.50	69.14	68.89	45.61
SUB TOTAL	**88.59**	**88.61**	**91.12**	**91.19**	**88.03**	**89.51**	**58.11**

	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (P)	April-Dec. 2020 (P)
All India Crude Processing	**223.26**	**232.90**	**245.40**	**251.90**	**257.17**	**254.38**	**160.36**

Source : PIB Release/PPAC

CRUDE CAPACITY VS. PROCESSING

	Capacity On 01/01/2021 Million MT	% Share	Crude Processing April - Dec.2020 (P)	% Share
PSU Ref	142.6	57.1	89.7	56.0
JV. Ref	19.1	7.6	12.5	7.8
Pvt. Ref	88.2	35.3	58.1	36.2
Total	**249.9**	**100**	**160.4**	**100**

Source: PIB/PPAC

POL PRODUCTION (Million MT)

	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020 (P)
From Refineries	217.1	227.9	239.2	249.7	257.4	258.2	165.9
From Fractionators	3.7	3.4	3.5	4.6	4.9	4.8	3.2
Total	**220.7**	**231.2**	**242.7**	**254.3**	**262.4**	**262.9**	**169.1**

DISTILLATE PRODUCTION (Million MT)

	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020 (P)
Light Distillates, MMT	63.2	67.1	71.0	74.7	75.4	76.8	48.6
Middle Distillates , MMT	113.4	118.3	122.5	127.5	130.8	130.2	79.6
Total Distillates, MMT	176.6	185.4	193.5	202.2	206.1	206.9	128.2
% Distillates Production on Crude Processing	**77.8**	**78.5**	**77.8**	**78.8**	**78.6**	**79.9**	**78.4**

Source: PIB/PPAC

PETROLEUM PRICING

OIL IMPORT - VOLUME AND VALUE

	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020 (P)
Quantity, Million Mt	189.4	202.9	213.9	220.4	226.6	227.0	143.2
Value, INR ₹000 cr.	687.4	416.6	470.2	565.5	783.4	716.6	294.0
Value, USD Billion	112.7	64.0	70.2	87.8	112.0	101.4	39.5
Average conversion Rate, INR per USD (Calculated)	61.0	65.1	67.0	64.4	70.0	70.7	74.4

OIL IMPORT - PRICE USD / BARREL

	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020 (P)
Brent (Low Sulphur - LS-marker) (a)	85.4	47.5	48.7	57.5	70.0	61.0	38.7
Dubai (b)	83.8	45.6	47.0	55.8	69.3	60.3	39.4
Low sulphur-High sulphur differential (a-b)	1.7	1.8	1.7	1.6	0.7	0.6	-0.7
Indian Crude Basket (ICB)	84.16	46.17	47.56	56.43	69.88	60.47	39.32
ICB High Sulphur share %	72.04	72.28	71.03	72.38	74.77	75.50	75.62
ICB Low Sulphur share %	27.96	27.72	28.97	27.62	25.23	24.50	24.38

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

	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020 (P)
Gasoline	95.5	61.7	58.1	67.8	75.3	67.0	41.4
Naphtha	82.2	48.5	47.1	56.3	65.4	55.1	38.2
Kero / Jet	66.6	58.2	58.4	69.2	83.9	70.4	39.9
Gas Oil (0.05% S)	99.4	57.6	58.9	69.8	84.1	74.1	44.8
Dubai crude	83.8	45.6	47.0	55.8	69.3	60.3	39.4
Indian crude basket	84.2	46.2	47.6	56.4	69.9	60.5	39.3

CRACKS SPREADS ($/ BBL.)

	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020 (P)
Gasoline crack							
Dubai crude based	11.7	16.1	11.1	12.0	5.9	6.7	2.0
Indian crude basket	11.3	15.6	10.6	11.4	5.4	6.5	2.1
Diesel crack							
Dubai crude based	15.7	12.0	12.0	13.9	14.8	13.8	5.4
Indian crude basket	15.3	11.5	11.4	13.4	14.2	13.6	5.5

DOMESTIC GAS PRICE ($/MMBTU)

Period	Domestic Gas Price (GCV Basis)	Price Cap for Deepwater, High temp Hingh Pressure Areas
November 14 - March 15	5.05	-
April 15 - September 15	4.66	-
October 15 - March 16	3.82	-
April 16 - September 16	3.06	6.61
October 16 - March 17	2.50	5.30
April 17- September 17	2.48	5.56
October 17 - March 18	2.89	6.30
April 18 - September 18	3.06	6.78
October 18 - March 19	3.36	7.67
April 19 - September 19	3.69	9.32
October 19 - March 20	3.23	8.43
April 20 - September 20	2.39	5.61
October 20 - March 21	1.79	4.06

Source: PIB/PPAC/OPEC

GAS PRODUCTION

Qty in MMSCM

	2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020 (P)
ONGC	22088	23429	24677	23746	16544
Oil India	2937	2881	2722	2668	1870
Private/ Joint Ventures	6872	6338	5477	4766	2715
Total	**31897**	**32648**	**32875**	**31180**	**21129**

		2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020 (P)
Onshore	Natural Gas	9294	9904	10046	9893	7173
	CBM	565	735	710	655	477
	Sub Total	**9858**	**10639**	**10756**	**10549**	**7650**
Offshore		22038	22011	22117	20631	13479
	Sub Total	**22038**	**22011**	**22117**	**20631**	**13479**

Total	**31897**	**32649**	**32873**	**31180**	**21129**
(-) Flare loss	1049	918	815	923	671
Net Production	30848	31731	32058	30257	20458

	2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020 (P)
Net Production	30848	31731	32058	30257	20458
Own Consumption	5857	5806	6019	6053	4350
Availabilty	24991	25925	26039	24204	16108

AVAILABILTY FOR SALE

	2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020 (P)
ONGC	17059	18553	19597	18532	12792
Oil India	2412	2365	2207	2123	1457
Private/ Joint Ventures	5520	5007	4235	3549	1859
Total	**24991**	**25925**	**26039**	**24204**	**16108**

CONSUMPTION (EXCLUDING OWN CONSUMPTION)

	2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020 (P)
Total Consumption	49677	53364	54779	57884	40775
Availabilty for sale	24991	25925	26039	24204	16108
LNG Import	24686	27439	28740	33680	24667

GAS - IMPORT DEPENDENCY

	2016-17	2017-18	2018-19	2019-20 (P)	April - Dec. 2020 (P)
Net Gas Production	30848	31731	32058	30257	20458
LNG Imports	24686	27439	28740	33680	24667
Import Dependency (%)	44.5	46.4	47.3	52.7	54.7
Total Gas Consumption*	**55534**	**59170**	**60798**	**63937**	**45125**

* Includes Own Consumption

Source:PIB/PPAC

SECTOR WISE DEMAND AND COMSUMPTION OF NATURAL GAS

Qty in MMSCM

		2018-19 (P)	2019-20 (P)	April-December 2020									
				April	May	June	July	August	September	October	November	December	Total
Fertilizer	R-LNG	**8711**	**9539**	708	818	875	967	951	868	1141	1100	1125	**8553**
	Domestic Gas	**6258**	**6519**	581	754	699	507	526	509	414	452	458	**4900**
Power	R-LNG	**2869**	**3595**	27	160	352	346	347	279	385	328	402	**2626**
	Domestic Gas	**9194**	**7473**	731	772	709	647	610	597	578	538	526	**5708**
City Gas	R-LNG	**3981**	**4746**	125	384	184	199	232	374	417	403	474	**2792**
	Domestic Gas	**5240**	**5736**	256	195	323	310	413	434	462	466	503	**3362**
Refinery Petrochemical Others	R-LNG	**12650**	**13169**	854	1049	1141	1088	1155	1024	1259	1053	1020	**9643**
	Domestic Gas	**5225**	**5061**	628	738	853	351	380	217	321	368	399	**4255**

Source:PPAC

1. CGD INFRASTRUCTURE

		As on 31st March 2018	As on 31st March 2019	As on 31st March 2020	As on 31st Dec. 2020 (P)
PNG	Domestic	42,80,054	50,43,188	60,68,415	72,47,137
	Commercial	26,131	28,046	30,622	31,735
	Industrial	7,601	8,823	10,258	10,823
CNG	CNG Stations	1,424	1,730	2,207	2,629
	CNG Vehicles	30,90,139	33,47,289	37,10,916	38,49,023

Source: PPAC/Vahan

2. MAJOR NATURAL GAS PIPELINE NETWORK

Nature of pipeline		GAIL	GSPL Groups	PIL	IOCL	RGPL	Others*	Total
Operational	Length	8,241	2,338	1,460	132	312	171	**12,654**
	Capacity	171.6	48.1	85.0	20.0	3.5	9.1	**337.3**
Partially commissioned#	Length	3,533	806		23			**4,362**
	Capacity	-			-			**-**
Total operational length		**11,774**	**3,144**	**1,460**	**155**	**312**	**171**	**17,016**
Under construction	Length	6,352	4013		1,398		3,780	**15,543**
	Capacity	-			-		-	**-**
Total length		**18,126**	**7,157**	**1,460**	**1,553**	**312**	**3,951**	**32,559**

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

Source: PPAC/PNGRB

3. EXISTING LNG TERMINALS

Location	Companies	Capacity (MMTPA) As on 1st Feb. 2021	Capacity Utilisation (%) April-Dec. 2020 (P)
Dahej	Petronet LNG Ltd	17.5	95.8
Hazira	Shell Energy India Pvt Ltd	5	89.3
Dabhol*	RGPPL (GAIL- NTPC JV)	5	58.7
Kochi	Petronet LNG Ltd	5	17.1
Ennore	Indian Oil LNG Pvt Ltd	5	11.9
Mundra	GSPC LNG Ltd	5	36.7
Total Capacity		**42.5 MMTPA**	

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

Source: PPAC

Member Organizations

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

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

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