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From the Desk of the

Director General

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

Dear Members,

As I look back at the past quarter to write this section, the world today faces the challenge of securing access to affordable energy within the framework of nation's climate goals and environmental sustainability. The global energy landscape has been radically reshaped since the Russian invasion of Ukraine on 24th February,2022, prompting governments, businesses and other organizations to reduce their dependence on Russian energy. The nations across the world have started to prioritize by providing greater energy security and sustainability.

The invasion of Ukraine is a humanitarian crisis having tragic consequences all over the world, especially for businesses and households dealing with energy shortages, record prices, market volatility, supply chain disruption and widespread inflation. Citing the aforementioned reasons have propelled the World Bank to cut its estimate for global GDP growth for FY 2022-23 to 2.9%.

The global energy situation has been adversely affected due to the ongoing war. The Brent Crude and WTI crude futures have been trading above $120 per barrel in the current quarter on the back of fall in Russian exports and demand recovery in China. Amidst the supply shortages, the Government of India welcomed the announcement by the International Energy Agency for collective oil stock release of 120 million barrels and US to release 180 million barrels from its Strategic Petroleum Reserves, over the next 6 months, to calm rising global fuel prices.

While the European Union (EU) is deliberating on reducing dependence on Russian oil and gas, India is stepping up its purchase of Russian oil at discounted prices. India's energy needs are enormous with daily consumption of around 5 million barrels and a refining capacity of 250 MMTPA. Around 85% of its energy needs are met through imports and increasing oil prices have a devastating effect on the country's economy with large deficits and rising inflation halting the economic recovery. Thus, with buying discounted Russian oil, India has walked a fine line, trying to balance its relationship with the West and with Russia, with whom it has deep historical and strategic ties. Further, this crisis also acts as a catalyst for India to continue its efforts to increase renewable energy generation and adoption of electric vehicles–essential for energy security and the self-reliance push.

As far as India is concerned, the World Bank has cut India's economic growth forecast for the current fiscal to 7.5 % as rising inflation, supply chain disruptions and geopolitical tensions taper recovery. High inflation prompted the Reserve Bank to raise the benchmark interest rate to 4.90 % and cash reserve ratio to 4.5%.

According to the recent World Oil Outlook 2022, publication by Organisation of Petroleum Exporting Countries (OPEC), the oil demand in India is expected to reach around 5.11 million barrels per day in 2022 as compared to 4.77 million barrels per day in 2021. The resumption of mobility and other economic activity has stimulated pent-up demand and helped projected oil demand to grow for the current year. Further, the government has reduced excise duty on petrol and diesel to address mounting inflationary pressure and enhanced subsidies for cooking gas for farmers to Rs 200 to over nine crore beneficiaries of the Pradhan Mantri Ujjwala Yojana. These factors are expected to show a spurt in demand for oil and gas in the country for FY 2022-23.

In the Indian natural gas sector, the upstream gas producers have received higher realisations as domestic natural gas price increased from April 01st which will be valid till September 30, 2022, making it the highest since 2014. The price of gas produced from the nomination fields of public sector (ONGC/ OIL) has been increased to US $6.10 per mmBtu from US $2.90 per mmBtu and for the difficult fields, the ceiling price has been increased to US $9.92 per mmBtu from US $6.13 per mmBtu on Gross Calorific Value (GCV) basis.

It is overwhelming to see that India is expeditiously moving forward on its energy transition journey and in this regard, I would like to commend the initiatives taken by the Government for a push towards energy transition. In this regard, a State Level Steering Committees for Energy Transition with Principal Secretaries of Power and New and Renewable Energy Departments, Transport, Industries, Housing and Urban Affairs, Agriculture, Rural Development and Public Works Departments, etc. as its members, will be set up to work on the annual strategy of energy transition encompassing emphasis towards addition of renewables (renewable energy) to the electricity generation mix to meet the nation's ever-increasing demand for electricity, promotion of energy efficiency more use of biofuels and green hydrogen.

Further, Government's approval on amendments related to National Biofuel Policy 2018 is a welcome step for India's oil and gas sector. India has already achieved the target of 10% ethanol blending in petrol, five months ahead of the targeted timelines of November, 2022. The Government stance on advancement of ethanol blending target of 20% blending of ethanol in petrol to ESY 2025-26 from 2030 will attract developments of indigenous technologies which will pave the way for Make in India drive, generate more employment and give an impetus to Prime Minister's vision of India becoming 'energy independent' by 2047.

Further, the Honourable Minister of Petroleum & Natural Gas and Housing & Urban Affairs, Mr. Hardeep Singh Puri and Minister of Mines and Energy of Brazil during the month of April, 2022 recognized the importance of the robust investment in the Brazilian oil and gas sector made by Indian companies and reaffirmed their commitment to safeguard existing investments, while encouraging further bilateral investments. The two sides agreed to work towards developing an Indian-Brazil Alliance for Bioenergy and Biofuels.

Another energy industry ready for take-off is hydrogen. The Honourable Union Minister for Power and New and Renewable Energy and German Minister for Economic Affairs and Climate Change signed a Joint declaration of Intent on Indo-German Green Hydrogen Task Force to strengthen mutual cooperation in production, utilization, storage and distribution of Green Hydrogen through building enabling frameworks for projects, regulations and standards, trade and joint R&D projects. Blessed with abundant renewable energy potential and experience of implementing renewable energy projects, India can produce low-cost Green Hydrogen to progressively decarbonize a range of industry sectors, and also export it to meet global demand.

During the quarter, FIPI had organized various knowledge sharing events and webinars covering aspects related to Energy transition, Decarbonisation, Sustainable Aviation fuel etc, the details of which are presented below.

On 05th April, 2022, FIPI organized a webinar where experts from Axens delivered lecture on Sustainable Aviation Fuel (SAF). The webinar focussed on various technology pathways for Sustainable Aviation Fuel production to promote the objectives of greenhouse gas emission reduction, import dependency reduction, generating employment, and providing better remuneration to farmer. The webinar witnessed participation of 75+ professionals working across the oil and gas value chain.

On 08th April, 2022, FIPI organized an exclusive webinar on 'Gas-Hydrogen Blending', aimed at sharing of knowledge from various gas-hydrogen blending initiatives. Mr. Charles Perez-Storey, Project Lead, Progressive energy, U.K highlighted the major developments of the HyDeploy project of U.K. Mr. Ashu Singhal, ED- GAIL has highlighted various blending projects initiated by various companies in India including GAIL. Mr. Evan Reznicek, National Renewable Energy Laboratory (NREL) U.S, briefly pointed out the development, demonstration, and progress of the HyBlend Project of U.S. The session witnessed an overwhelming participation by over 125+ participants across the oil and gas value chain in the country.

On 11th April, 2022, the CGD Helpdesk on the direction of Ministry of Petroleum & Natural Gas organized a virtual meeting with the CGD ecosystem's manufacturers and suppliers – being the 1st of its kind. The main aim was to understand the current scenario of demand & Supply of equipment pertaining to CGD Industry. The CGD Sector in India promises an interesting and

consistent opportunity for global as well as local equipment OEMs to invest under "Make in India" scheme. The CGD Helpdesk is supporting all the CGD entities in a big way and is playing a crucial role for faster resolution of CGD entities' issues under the guidance of MoP&NG.

On 23rd April 2022, FIPI PDEU Student Chapter has organized TechnoAltar Researchers' Quest 6.0 with the theme "Reinventing oil and gas Industry for Energy Transition" held at PDEU, Gandhinagar. Mr. D L N Sastri, Director (Oil refining & Marketing), FIPI participated as a Chief guest and shared his views on the theme with the students and the academicians.

FIPI along with the Energy and Climate Initiatives Society (ENCIS), a non-profit entity has organised the 6th edition of Global Refining & Petrochemicals Congress (GRPC) on 5- 6th May 2022 at New Delhi. This year's theme was "Agility & Innovation for Downstream Resilience, Sustainability & Excellence". The GRPC 2022 brought together hundreds of policy makers, asset owners, licensors, contractors, technology majors and equipment suppliers from global organizations to explore next generation downstream opportunities whilst collaborating on emerging & future risks across industry markets.

On 08th June, 2022, FIPI organized an exclusive webinar on 'Energy Transition & Decarbonization - Role of LNG & Application of CCUS'. Dr Raj Deo Tewari, Chief Scientist R&D in Group Research & Technology, Petronas emphasised the objective of the CCUS as a viable CO_2 mitigation option and its long-term outlook in decarbonizing the energy sector. Dr. A K Balyan, former MD & CEO, Petronet LNG, detailed about the role of Natural gas and LNG in the energy transition. The webinar witnessed intense participation.

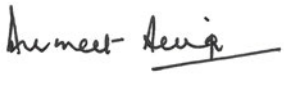
FIPI is currently carrying out an industry study on 'Emerging Hydrogen Market and its Opportunities in India' thereby assessing the hydrogen market potential in India.

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

The hydrocarbon sector has contributed enormously to global economic progress of the country over the last decade. With new and emerging energy options, India can only move ahead towards cleaner and more sustainable environment. We firmly believe that Indian oil and gas sector along with other low-carbon options will get progressively entrenched in the energy mix, with appropriate policy backing. Our Indian oil and gas industry is continuously evolving and reinventing themselves to play a lead role in providing efficient, clean and green energy solutions for all customer segments and businesses across the country.

As the entire country looks forward to new beginning, I assure you that FIPI will always be at the forefront willing to deliberate on industry issues and scripting the growth story of Indian oil and gas industry.

Wishing you the very best



Gurmeet Singh

Porosity - Permeability Prediction using Artificial Intelligence Enabled Methodologies

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Summary

This study is focus on estimation of permeability using wireline log data by applying machine learning techniques. In this study Basic log data like gamma ray (GR), neutron log porosity and density logs are taken into account for sandstone reservoir in one of the fields of India to estimate permeability. Rock typing is also incorporated as input data. Different regression models were prepared and results were compared. It was found that Random forest Algorithm is giving best results among different methods compared.

Keywords
Porosity-permeability, Data analytics, AI

Introduction

The porosity and permeability of rocks is important in determining which rocks will make a good reservoir. A rock that is both porous and permeable would make a good reservoir rock as it allows oil and gas to move through the pores in the rock closer to the surface where it can be extracted. Permeability of porous media is usually expressed as function of some physical properties of the interconnected pore system such as porosity and tortuosity. Permeability values depend on effective Porosity; however, it is not simple to determine the appropriate relationship. It would require a detailed knowledge of size distribution and spatial arrangement of the pore channels in the porous medium. Two porous systems can have the same porosities but different permeability.

One of the most widely accepted and simplest model for the permeability-porosity relationship is the Kozeny-Carman (KC) model [Kozeny, 1927; Carman, 1937].

$$K = C\frac{\emptyset^3 {D_p}^2}{(1-\emptyset)^2}$$

Where:
Ø is the porosity of the bed (or core plug) [fraction]
Dp is average diameter of sand grains (mm)
K is absolute (i.e. single phase) permeability (mD)
C is the proportionality and unity factor [mD / mm^2]

Proper porosity-permeability modeling, reservoir rock typing and incorporation of hydraulic-flow-units are crucial parts of an integrated reservoir characterization/ modeling and dynamic simulation study. These control the quality of a reservoir model with effect on wells production behavior and prediction performance.

Challenges in deriving Porosity-Permeability Relationship

Porosity from log response such as density provides a continuous representation of pore volume as function of depth in a well, which can be calibrated with core analysis data. Obtaining a continuous log of permeability is not as straightforward as there is yet no means of logging permeability. While DST-derived permeability values are useful in calibrating dynamic models, they only represent an average value over the radius investigated by the test and will not readily correlate to permeability values derived from core especially where there are lateral

and vertical permeability variations within the reservoir. It is, however, possible to obtain a depth continuous permeability estimate by deriving a free regression algorithm known as the poroperm transform function, which defines how the permeability varies as a function of porosity. Such correlations are typically derived empirically from overburden corrected core derived porosity and permeability data. General poro- perm trends are far too scattered to be used. However, better poro- perm trends can be obtained by use of rock typing to identify suitable analogues.

If the reservoir of interest is homogeneous, with similar pore network geometry, the permeability predictions via this approach may be error free even with a single function fitted for the entire reservoir. However, prediction inaccuracies are often large in typical sandstones, and the errors in predicted permeability commonly range across orders of magnitude. The reason for this is that permeability is not exclusively determined by pore volume, but is also controlled by other variables such as network channel tortuosity, pore throat geometry etc., hence the need for rock typing arises. Permeability prediction for reservoir characterization relies on understanding the factors that control reservoir heterogeneity. (Teh et al., 2012).

Why Machine Learning Approach for poro-perm prediction

It is of great importance for geoscientist to develop a permeability regression model that exhibits high accuracy, robustness, computational efficiency, and transparency. Geoscience data, sourced from log data for example, is complex, nonlinear, and contains a great deal of uncertainty. Furthermore, the data are polluted with noise caused by measurement errors.

Reservoirs with high degrees of heterogeneity reflect nonlinear system-identification problem, which is a crucial but complex problem. There have been several published studies on modeling permeability on the basis of empirical correlations multilinker regression (MLR), multilayer perception (MLP), and fuzzy neural networks (FNNs) (N. P. Singh, 2018, Huang et. Al. 1996; Huang et al. 2001; Cuddy 2000; Taghavi 2005). One of the main shortcomings of empirical models is that they are constructed by using all the available data, and prediction accuracy is good within the input data set. Therefore, these models have poor generalization capability. Although MLR models perform better on unseen data (data not included in the training part of the process), they tend to overestimate low values and underestimate high values, showing their consistent characteristic of averaging the entire data to yield reasonable values for statistical indicators (Al-Anazi et al. 2009). These drawbacks can lead to significant errors when modeling permeability in heterogeneous reservoirs.

Modeling Workflow

The following workflow (Figure 1) has been adopted first in mapping the problem as machine learning problem and then solving it utilizing the machine learning algorithms and tools.

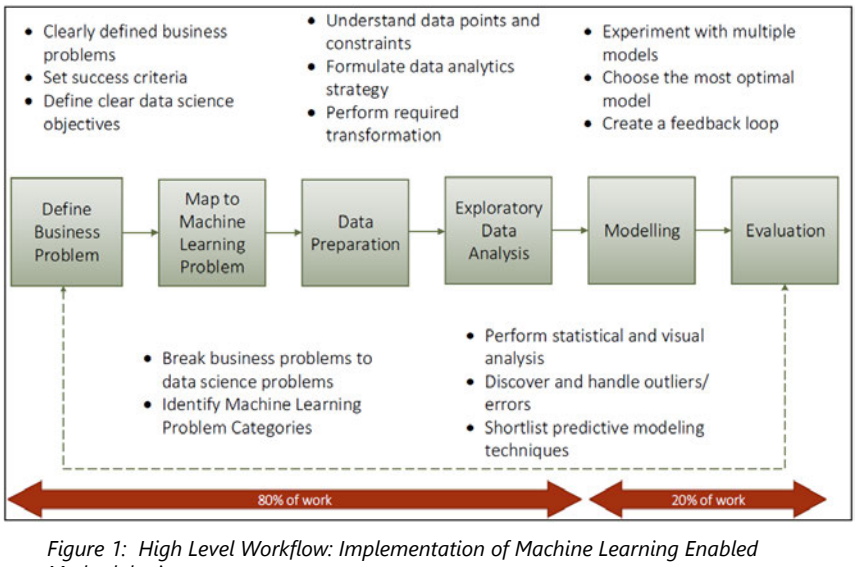


Figure 1: High Level Workflow: Implementation of Machine Learning Enabled Methodologies

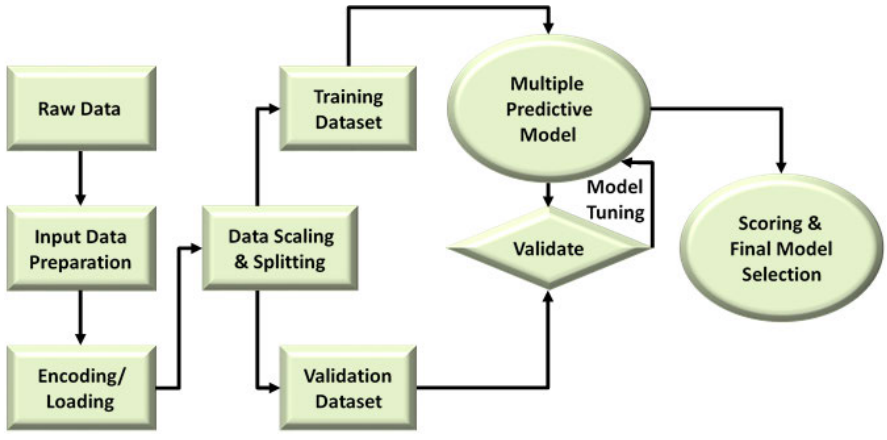


Figure 2: Workflow

Reservoir/Field Selection for Study

To apply data analytic in Porosity permeability relation data of one of the fields of India has been taken. In all the wells drilled in the field complete set of log data is recorded. Extensive coring has been done in reservoir interval and RCA (Routine Core Analysis) data has been generated.

Data available

To apply data analytic, as a complete set of logs, interpreted results like V-clay, water saturation and available core data was taken. These data was process and combined according to depth and a tabular data structure was prepared. Data was loaded in the python project created for the study in CSV format. The statistical details of input data is given below.

	zone	DEPTH	AT90	HSGR	PIGN	SUWI	NEUTRON	RHOB	VCL	PERM
count	944	944	944	944	944	944	944	944	944	944
mean	8.33	4849.37	7.44	103.34	0.09	0.87	0.13	2.49	0.21	3.36
std	1.64	272.49	5.51	56.41	0.05	0.14	0.03	0.08	0.13	18.26
min	4.00	4281.93	1.77	23.64	0.00	0.33	0.03	2.31	0.00	0.00
25%	8.00	4664.96	4.02	64.49	0.05	0.77	0.11	2.43	0.11	0.31
50%	9.00	4830.09	5.65	92.02	0.10	0.92	0.13	2.48	0.19	0.79
75%	10.00	5040.36	8.67	128.09	0.13	1.00	0.15	2.55	0.30	1.90
max	10.00	5367.51	53.11	591.58	0.20	1.00	0.26	2.78	0.69	349.00

Data Visualization

Exploratory data analytics was carried out to generate multiple visualizations to get maximum insight into the data.

The box plots show the distribution of numerical data and skewness through displaying the data quartiles. Box plots show the five-number summary of a set of data: including the minimum value, first (Twenty-five percent of values) quartile, median, third (Seventy-five percent of the values) quartile, and maximum score.

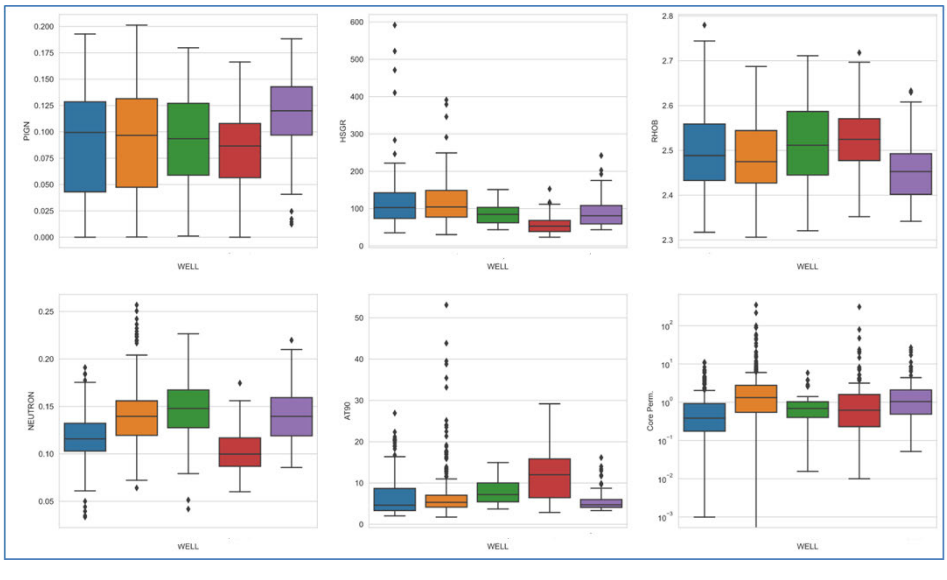


Figure 4: Box plot of different parameters plotted against different wells

Various combination of plot were drawn to see the relations between different variables (Figure 4). The cross plot of porosity permeability plot coloured with Vclay and permeability density plot coloured with effective porosity are shown in figure 5 and 6.

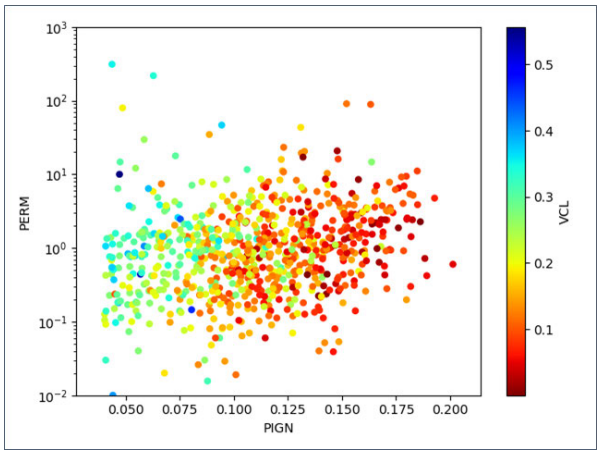


Figure 5: Porosity vs permeability cross plot coloured with VCL

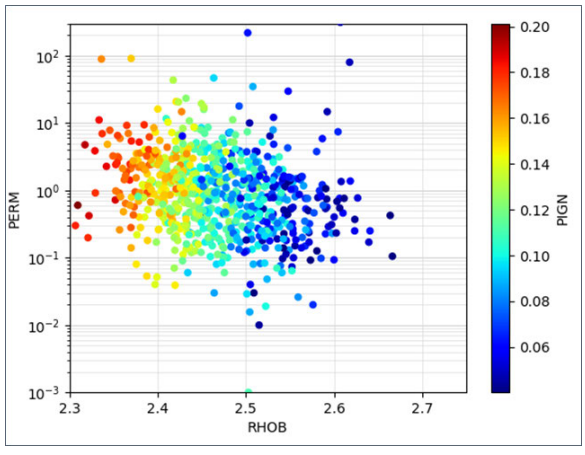


Figure 6: Permeability vs Density cross plot coloured with effective porosity

The wide spread in the poro-perm cross plot indicates heterogeneity of the reservoir. As evident from plot, no single porosity-permeability transform can be applied to this scattered data for capturing the heterogeneity of the reservoir.

To address the heterogeneity encountered in the reservoir, RQI based approach has been used for permeability modelling (Ref: SPE 97033, Rock tying as an effective tool for permeability & water saturation modelling, G. Guo, et al). Rock Quality index (RQI) is a technique of classifying the quality of the reservoir in terms of its producibility. Where

RQI= 0.0314 * SQRT (K/PHI)

Where K is Permeability in mD and PHI is porosity in fraction. Normalized porosity index (NPI) is calculated as

$$NPI = \frac{\emptyset}{(1-\emptyset)}.$$

Flow zone indicators FZI is calculated as

$$FZI = \frac{RQI}{NPI}$$

In this paper we have modified the FZI formula to make it an integer by rounding it to nearest integer. Now as shown in cross plot between RQI vs NPI coloured with FZI, some clustering in terms of FZI could be seen. Most of the data in above plot lies in the FZI values less than 5. This can also be seen from histogram of FZI.

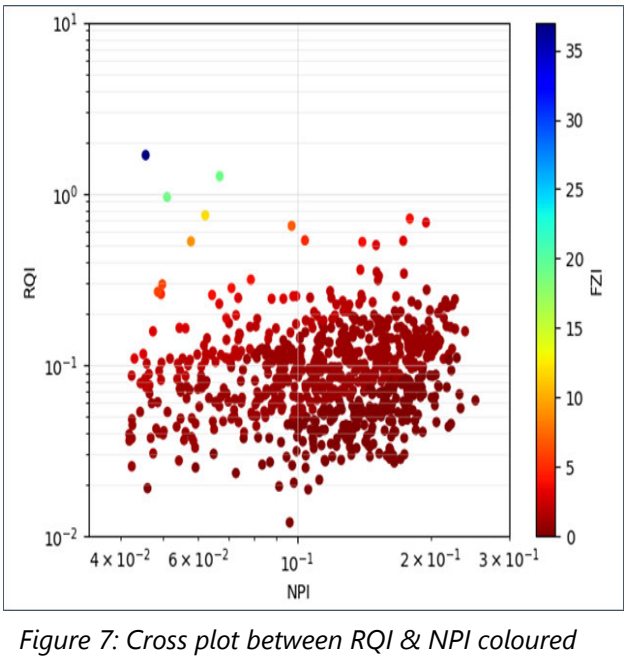


Figure 7: Cross plot between RQI & NPI coloured with FZI

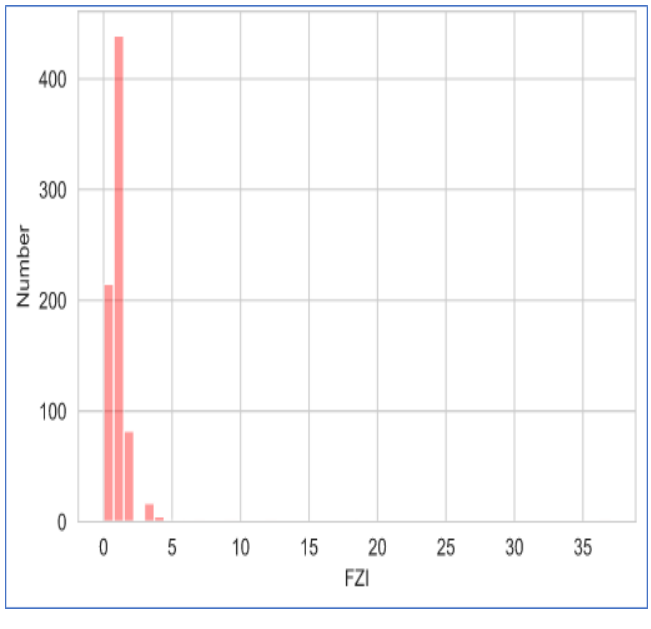
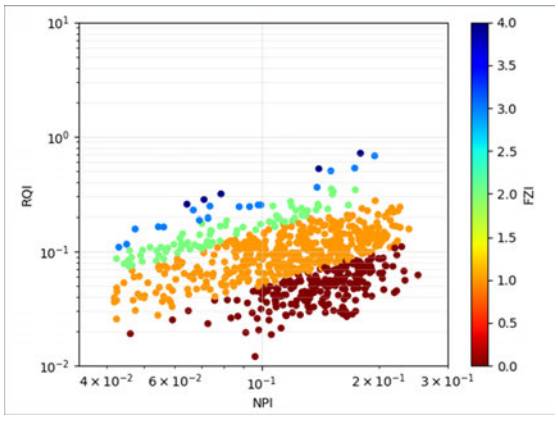


Figure 8: Histogram of FZI

After removing data with FZI>5 we could clearly see four type of rock types emerging in RQI vs NPI cross plot.



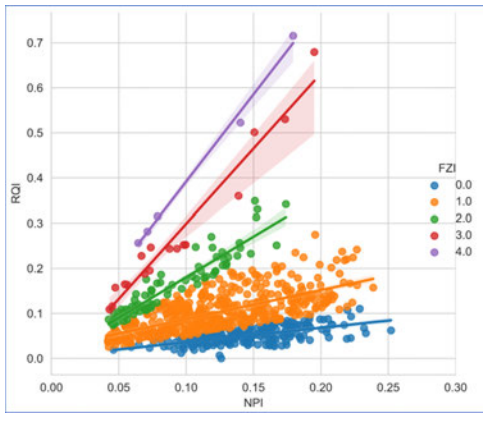


Figure 10; linear relation between RQI and NPI for different FZI

Figure 9: RQI vs NPI

Thus, the FZI and RQI were included in the data. Since, permeability was included in RQI, it was dropped. So final input data for further analysis had following columns.

	FZI	AT90	HSGR	PIGN	NEUTRON	RHOB	VCL	RQI
507	0.0	8.543373	60.057873	0.121024	0.106004	2.427313	0.102425	0.061548
864	2.0	5.244177	106.039337	0.068729	0.120119	2.551189	0.243470	0.112591
428	1.0	7.087540	46.322601	0.118799	0.127378	2.482399	0.139205	0.183057
255	1.0	3.123779	157.754425	0.087207	0.147815	2.453436	0.302743	0.080225
489	0.0	11.672068	129.355804	0.102317	0.088393	2.459644	0.055593	0.041689

In this analysis, FZI was taken as Input along with log data and RQI was the output that we wanted to predict based on supervised learning. FZI cannot be treated as numerical variables so it was considered as categorical variable. One-Hot Encoding was done to convert FZI into columns and the input data was normalized.

Model Fitting:

A number of modelling methods are available. Depending upon problem statement and input data set every algorithm serve different purposes. Different Models were tried for model fitting viz Linear Regression, Linear Ridge, Linear Bayesian Ridge, Huber Regressor, Lasso Regressor, Bagging Regressor, Random Forest Regressor, Ada Boost Regressor, Support vector Machine

Model Evaluation and Final Model Selection

The Model was fitted with Train dataset. K-Fold cross validation with 5 split was used on training data to generate score for all the regressors. Random forest regression gave the highest value of R2 for training data and test data.

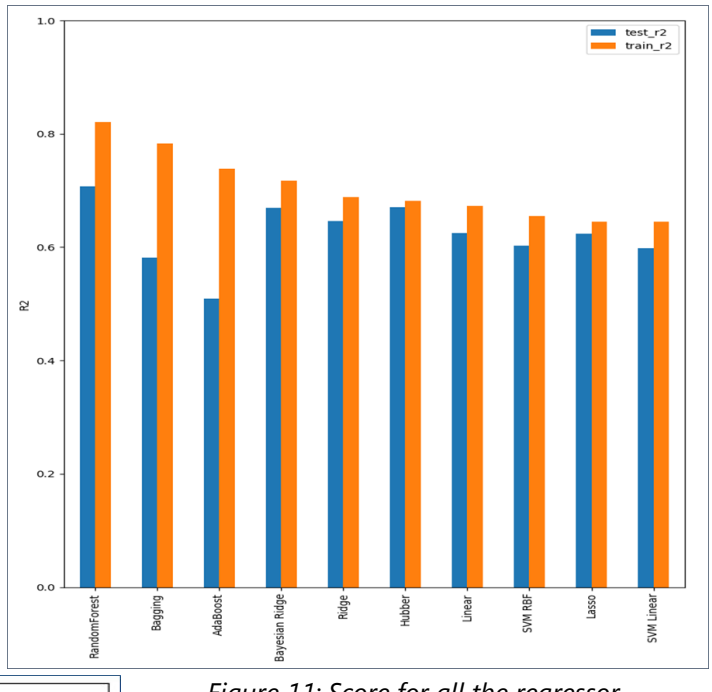


Figure 11: Score for all the regressor

Prediction from Random forest

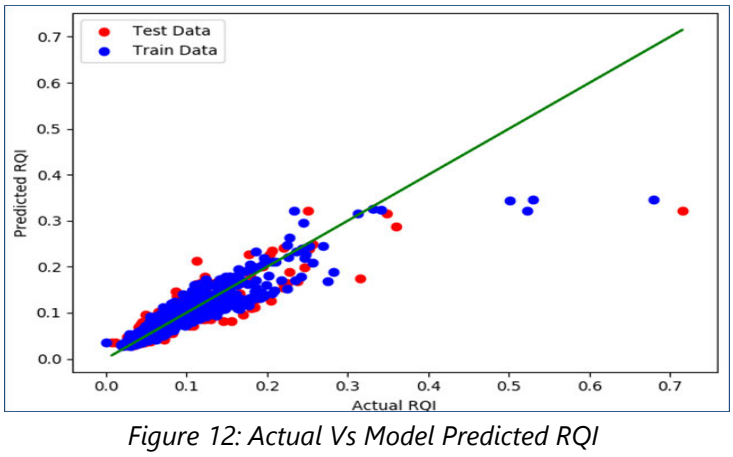


Figure 12: Actual Vs Model Predicted RQI

After Hyper-parameter tuning, the predicted RQI vs Actual RQI is given in the Figure 12. Most of the data points are falling on unit slope line.

The predicted RQI is then converted to predicted permeability and the results are plotted in Figure 13.

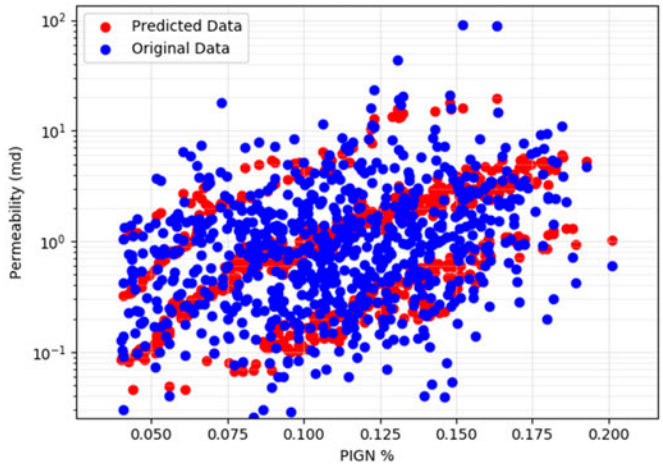


Figure 13: Model predicted vs original data

Predicted permeability vs core permeability is given in the Figure 14 below.

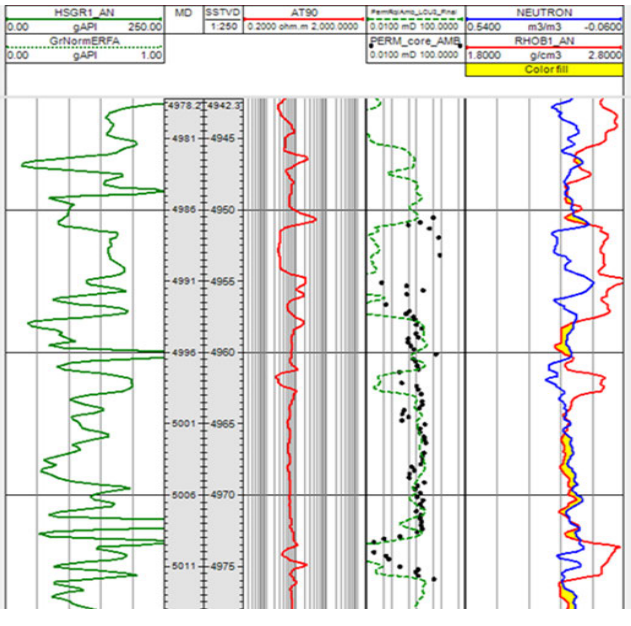


Figure 11: Predicted permeability vs core permeability

To apply this technique in static modeling, following steps are needed.

- Using input data to develop a ML classifier for classifying input data in terms of FZI
- Collect log data of all the wells. Using classifier, calculate FZI
- Add FZI column into input data. Using one hot-encoding to encode the FZI data.
- The formatted data is then scaled and fed to the model to predict the RQI values.
- From the predicted RQI values, predicted permeability can be calculated.
- The well wise permeability data can then be used to populate the permeability in 3D grid.

Conclusion

This study was taken to demonstrate the use of AI in establishing the Porosity Permeability relations. Basic log data were taken as input to build a model.

RQI was used as an output parameter. Model was prepared based on different supervised learning algorithm. It was trained and parameters were tuned to fine-tune the model. After fine-tuning the model, the RQI was predicted and compared with actual RQI.

The Methodology used here can be applied to reservoir, having sufficient number of training data. Once the model is trained, the model can be used to predict Permeability by taking only basic log data as input.

References

Al-Anazi, A., Gates,I.D., and Azaiez, J. 2009. Innovative Data-Driven Permeability Prediction in a Heterogeneous Reservoir. Paper SPE 121159 presented at the EUROPPEC/EAGE Conference and Exhibition, Amsterdam, 8-11 June. Doi:10.2118/121159-MS

Al-Anazi, A. and Gates,I.D., J. 2010. Support-Vector Regression for Permeability Prediction in a Heterogeneous Reservoir: A Comparative Study. SPE paper 126339-PA

Singh N. P., 2018. Permeability prediction from wireline logging and core data: a case study from Assam-Arakan basin, Journal of Petroleum Exploration and Production Technology, https://doi.org/10.1007/s13202-018-0459-y

Regional/AAPG Pacific Section Joint Meeting held in Long Beach, California, U.S.A., 19-24 may 2003.

G. Guo, M.A. Diaz, F. Paz and E.A. Waninger, 2005, Rock Typing as an Effective Tool for Permeability and Water-Saturation Modeling: A Case Study in a Clastic Reservoir in the Oriente Basin. Paper SPE 97033 prepared for presentation at the 2005 SPE Annual Technical Conference and Exhibition, Texas, 9-12 Oct 2005.

Huang, Y., Gedeon, T.D., and Wong, P.M. 2001. An integrated neural fuzzy-genetic-algorithm using hyper-surface membership functions to predict permeability in petroleum reservoirs. Engineering Applications of Artificial Intelligence 14 (1):15-21. Doi: 10.1016/ S0952-1976(00)00048-8.

Huang, Z., Shimeld, J., Williamson, M. and Katsube, J. 1996. Permeability prediction with artificial neural network modeling in the Venture gas field, offshore eastern Canada. Geophysics 61 (2): 422-436.doi:10.1190/1.1443970.

Cuddy, S.J. 2000. Litho-Facies and Permeability Prediction Predication from Electrical Logs Using Fuzzy Logic. SPE Res Eval & Eng 3(4): 319-324. SPE-65411-PA.doi: 10.2118/65411-PA.

Kozeny, J. (1927), Uber kapillare Leitung der Wasser in Boden, Sitzungsber. Akad. Wiss. Wien, 136, 271– 306.

Carman, P. (1937), Fluid flow through a granular bed, Trans. Inst. Chem. Eng., 15, 150– 167.

Teh, W. J., Willhite, G. P. and Doveton, J. H. 2012. 'Improved Reservoir Characterization using Petrophysical Classifiers within', Eighteenth SPE Improved Oil Recovery Symposium pp. 1-13. doi: 10.2118/154341- ms.

Occupational Noise Induced Hearing Loss and Vibrations exposure and its Determinants in Oil & Gas Industry in India- A Review Article

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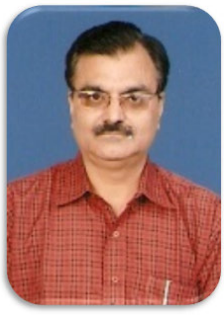

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Introduction

Occupational Noise Induced Hearing Loss and Whole Body Vibrations are the common hazards in modern industries. These hazards are a cause of concern as they cause occupational diseases and deaths worldwide, which significantly affect the quality of life of the employees and increase the global burden of non-communicable diseases (NCDs).

According to WHO non-communicable diseases (NCDs) make up 70% of the occupational health risks. This should not be overlooked as many workers are persistently challenged by occupational hazards.

Noise and Whole Body Vibrations are the most common work-place hazard in most Oil and Gas industries.
Noise is the insidious of all industrial pollutants, involving every industry and causing severe hearing loss in every country in the world. Exposure to excessive noise is the major avoidable cause of permanent hearing impairment. Oil and Gas developmental (E&P) activities generate noise. Following are the operations of the E&P industry which generate high level noise:

1. Airborne Surveys
2. Seismic Operations for Oil and Gas exploration and discovery
3. Construction activities (such as construction of rigs, pits etc.)
4. Drilling and Production of oil & gas.
5. Transportation of oil

Whole body vibrations & Segmental Vibration are also a common hazard of the Oil and Gas development (E&P) industries. The frequent use of hand held vibrating tools on offshore platforms like grinders, needle guns, impact wrenches air drills and chipping hammers is the reason for the common health hazard of Hand Arm Vibration Syndrome (HAVs), a type of segmental Vibration Syndrome.

Noise-Induced Hearing Loss (NIHL)

Introduction to NIHL

Noise-induced hearing loss (NIHL) is an irreversible damage of cochlear hair cells of the inner ear. It may be represented as partial or complete hearing loss of the patient. It has been long recognized more as an occupational disease after the advent of the Industrial Revolution. Noise-induced hearing loss, when associated with noise exposure at workplace is called Occupational Noise-induced hearing loss (ONIHL).

Prevalence of Noise induced hearing loss

It has been suggested that 12% or more of the global population is at risk of hearing loss from noise. Though global estimates are scarce, and methods vary widely, the prevalence of noise exposure at work (i.e., the percent number of cases at a given time) has been reported to be approximately 15% in Canada (Feder et al., 2017), 20% in European Union (Eurostat,2004) and 20% in Australia(Williams,2013).

Key Words: OH Hazards in petroleum industry, NIHL, Whole Body Vibration,

Table 1- Noise levels in different industries:

Industries	Range (dBA)
Textile industries	102-114
Pharmaceutical firms	93-103
Fertilizer plants	90-102
Oil and natural gas complex in Bombay high	90-119
Road traffic in Ahmedabad city	60-102
Surface rail traffic	90-102
Metro rail	70-111
Air traffic	90-112

While some evidence indicates that occupational exposure to high levels of noise may be slowly decreasing in the developed world, whereas workplace noise is increasing in the developing countries like India as developing economies shift from an agriculture to a more industrial base (WHO, 1998; Fuente and Hickson, 2011).

Studies carried out by the National Institute of Occupational Health, India, showed that sound levels at Oil and Natural Gas complex at Bombay High were very high (90-119 dBA).

Hearing test data collected by British Columbia employers in Oil and Gas drilling sector between 2012 and 2017 show that the percentage of workers who showed signs of Noise-induced hearing loss increased from 33 percent in 2012 to 45 percent in 2017.

A study published in American Journal of Industrial medicine showed in Oil and Gas extraction sector of the U.S 14% of the overall noise-exposed workers and 28% of the noise-exposed workers in the Natural Gas Liquid Extraction had hearing loss.

Causes of Occupational Noise induced hearing loss and difficulty faced by affected people: Noise exposure is the primary reason behind cause of primary cause of preventable hearing loss (Le et al., 2017). Noise exposure at work is responsible for an 16% of disabling hearing loss in worldwide (Nelson et al.,2005).

Left untreated, hearing loss can lead to communication difficulty, social isolation, stress and fatigue (review Theman et al., 2013). It is additionally associated with depression, cognitive decline, dementia, falls, and mortality (review Basner et al.,2014).

Workers with hearing loss face challenges to their personal safety, are at higher risk of injury (with the inability to hear alarms or having difficulty in judging the direction of sound sources), and are more likely to be underemployed.

Simply put Occupational Noise induced hearing loss (ONIHL) can have substantial negative impact on the quality of life of employees affected by it.

Symptoms of Noise-induced hearing loss (NIHL)

Noise-induced hearing loss is associated with damage to the hair cells in cochlea which results in partial or complete hearing loss of the patient. The hair cells in the cochlea are responsible for initiating the neural impulses that carry information to the brain regarding the sounds. The human cochlea has one row of inner hair cells (sensitive to lower frequency) and three rows of outer hair cells (sensitive to higher frequency). The amount of direct hair cell damage depends on the intensity of sound.

Exposure to noise at sub traumatic levels exhibits a temporary shift in hearing sensitivity that returns to normal with time away from hazardous exposure. However, higher sound levels damage the outer hair cells, stereo cilia, further destruction of intercilial bridges and recovery takes longer. An even higher level of sound leads to collapse of stereocilia and hair cell is permanently damaged.

If the outer hair cells are not properly functioning, a greater stimulation is required to initiate a response, which is perceived as hearing loss. Once damaged the auditory sensory cells cannot repair themselves nor can any medical procedure restore normal functioning.

Table 2- Grading Of The Hearing Impairment:

Grade of impairment	Corresponding audiometric ISO value	Performance	Recommendations
0 - No impairment	25 dB or better (better ear)	No or very slight hearing problems. Able to hear whispers	Nil
1 - Slight impairment	26-40 dB (better ear)	Able to hear and repeat words spoken in normal voice at 1 m	Counselling. Hearing aids may be needed
2 - Moderate impairment	41-60 dB (better ear)	Able to hear and repeat words spoken in a raised voice at 1 m	Hearing aids usually recommended
3 - Severe impairment	61-80 dB (better ear)	Able to hear some words when shouted into the better ear	Hearing aids needed. If no hearing aids available, lip reading and signing should be taught
4 - Profound impairment including deafness	81 dB or greater (better ear)	Unable to hear and understand even a shouted voice	Hearing aids may help understand words. Additional rehabilitation needed. Lip reading and sometimes signing essential. No treatment available.

Grades 2, 3 and 4 are classified as disabling hearing impairment. The audiometric ISO values are averages of values at 500, 1000, 2000 and 4000 Hz

Diagnosis of NIHL:

Audiometry is a standard test to detect and evaluate hearing loss. Audiometry is used to determine the auditory threshold of an individual to pure tones of 250-8000 Hz and sound levels between 10 (the hearing threshold of intact ears) and 110 dB (maximal damage).

The patient should not have been exposed to noise during the previous 16 h to eliminate the effects of a temporary threshold shift. Air conduction is measured by ear phones placed on the ears, while bone conduction is measured by placing a vibrator in contact with the skull behind the ears.

Each ear is evaluated separately and test results are reported on a graph known as an audiogram. Comparison of air and bone conduction allows classification of hearing loss as conductive or sensorineural.

The audiogram in case of NIHL is characterized by an onset of hearing loss at 4000 Hz, visible as a dip in the audiogram. As exposure to excessive noise level continues, neighboring frequencies are progressively affected and the dip broadens, intruding into neighboring frequencies. NIHL is usually bilateral and shows a similar pattern in both the ears. The difference between the two ears should not exceed 15 dB at 500, 1000 and 2000 Hz and 30 dB at 3000, 4000 and 6000 Hz, respectively.

Best practices of the Hearing Conservation Program

The most effective way to prevent NIHL is to protect the worker from hazardous noise at the workplace.

Hearing protectors should be used when engineering controls and work practices are not feasible for reducing noise exposure to safe levels. A personal hearing protection device is a device designed to reduce the level of sound reaching the eardrum. Ear muffs, ear plugs and ear canal caps are the main types of hearing protectors. To select hearing protectors, we should consider the following:

1. The workers who will be wearing them.
2. The need for compatibility with other safety equipment.
3. Workplace conditions such as temperature, humidity and atmospheric pressure.

A variety of style should be provided so that workers may select a hearing protector on the basis of comfort, ease of use and handling and impact on communication. Each worker should receive individual training in the selection, fitting, use, repair and replacement of hearing protectors.

The most common excuses reported by workers for not wearing hearing protectors include discomfort, interference with hearing speech and warning signals and the belief of workers that there is no control over an inevitable process that causes hearing loss.

Given adequate education and training, workers can realize the crucial importance of wearing hearing protectors.

Table 3- OSHA's / Indian Factories Act (Schedule II) Permissible Exposure Limits for Noise in Air

Sr	Exposure Intensity	Permissible Duration
1.	82-85 dBA	16 hours
2.	90 dBA	8 hours
3.	95 dBA	4 hours
4.	100 dBA	2 hours
5.	105 dBA	1 hours
6.	110 dBA	30 mins
7.	115 dBA	15 mins
8.	More Than 115 dBA	0 Mins

Vibrations Exposure Hazards:

Introduction to hazards of Vibrations

Vibration is defined as oscillatory motion. Oscillatory displacement involves alternate velocity in one direction and then a velocity in the opposite direction. This change of velocity means that the object is constantly accelerating, first in one direction and then in the opposite direction. The oscillatory motion from a source, e.g., a vehicle or a tool, may be simple harmonic sine wave or a multiple wave complex differing in frequency and acceleration; or a random non- repeating series of complex waves.

The human responses to vibration depend on the part of the body that is exposed. There are two broad types of vibrations that workers are exposed to, Vibrations can be classified as 2 types based on mode of transmission:

1. Hand Transmitted Vibration: When vibrations transmit from tools to the hand-arm system it is referred to as Hand-transmitted vibration (HTV). Hand-arm vibrations occur in employees who use regularly the hand-held machines.

2. Whole body Vibration:Whole body vibrations are mechanical vibrations transmitted to the body via buttocks or back in case of sedentary work , via feet in case of work done standing or the head and back while working in supine position.

Prevalence of vibration related health hazards:

In India prevalence of vibration hazard related health problems are hardly documented. Dasgupta and Harrison studied 66 drillers and 35 blasters as control subjects from limestone mines. They reported a significantly higher prevalence of tingling, numbness, paresthesia (18.2%); pain in finger, wrists, arms, etc. (31.7%); stiffness in hand (13.6%); and hyperhidrosis (48.5%) among drillers as compared to blasters. The prevalence of ulnar neuropathy and soft tissue wasting in hands was also significantly higher among the drillers. They concluded that complaints of neurological symptoms in the musculoskeletal problem accounts for nearly 70 million visits to doctors.

Although the problems these workers faced was not only caused by the exposure to vibration (it also included wrong posture, repetitive motion etc. i. e. Ergonomic Problems) the role of vibrations in causing Work-related musculoskeletal disorders (WRMSDs) cannot be neglected.

In 2008, according to the survey conducted by National Hazard Exposure Worker Surveillance (NHEWS) (Australia) reported that overall:

1. 24% percent of workers were exposed to vibration at workplace
2. 43% of workers were exposed to HAVs, 38% to WBVs, 17% to both
3. 27% of workers reported that they received training
4. Large percentage of workers in smaller workplaces reported they were not provided with any vibration control measures

Whole-body vibration and segmental vibration need to be studied separately because they are measured and evaluated using different standards. They also require different control measures and have differing effects on the human body

Hand and Arm Vibration Syndrome (HAVs) / Segmental Vibration Syndrome:

Jackhammers are used both in opencast and underground mines; and the operators, popularly known as drillers, are regularly exposed to hand-arm vibration (HAV). Vibrating hand tools like hand drills, chipping machine, riveting guns; control systems of modern large drill machines, locomotive handles; and hand-held grinders, scrapers, etc., are other sources of HAV exposure in mines.

Regular exposure to vibration causes both vascular and neural disorders. Involvement of arms manifest as vibration-induced white finger (VWF) or hand-arm vibration syndrome (HAVS). In 1911, Giovanni Loriga of Italy first reported HAVS among stone cutters using pneumatic hammers on marble and stone blocks.

They suffered from finger-blanching attacks similar to the digital vasospastic response to cold or emotional distress, described by Raynaud in 1862. Later in the U.S, it was found to result from daily use of vibrating pneumatic hand tools (air-hammers) by workers in limestone quarries of Indiana.

The clinical symptoms for HAVs.

1. Tingling and/or numbness in the finger(s) initially - similar to but not same as Carpel Tunnel Syndrome.
2. As the exposure continues, the appearance of a single white or blanched fingertip occurs - usually, but not always - in the presence of cold.
3. With further exposure, these attacks increase in number, intensity and duration, especially in cold conditions. In the later stages, HAVS attack will occur in all seasons. Simultaneous combination of vibration, cold and nicotine (from smoking) are particularly harsh since all three tend to act as synergistic vasoconstrictors. Later stages of HAVS are generally irreversible.
4. In extreme and rare cases, the loss of blood supply to the fingers can lead to gangrene, which may require amputation.

The existence of sensory and vascular components in HAVS led to the adoption of the Stockholm grading based on the subjective history supported by the results of clinical tests to classify the severity.

Table 4: Stockholm workshop scale for classification of hand- arm vibration syndrome

White Finger Syndrome due to Raynaud's phenomenon:		
Stage Grade		**Description**
0	-	No attacks
1	Mild	Occasional attacks affecting only the tips of one or more fingers.
2	Moderate	Occasional attacks affecting distal or middle (rarely also proximal) phalanges of one or more fingers.
3	Severe	Frequent attacks affecting all phalanges or most fingers.
4	Very severe	As in stage 3, with trophic changes in the finger tips.
Sensory neural effects:		
0 SN	-	Exposed to vibration bur no symptoms.
1 SN	-	Intermittent numbness, with or without tingling.
2 SN	-	Intermittent or persistent numbness, reduced sensory perception.
3 SN	-	Intermittent or persistent numbness, reduced tactile. Discrimination and or manipulative dexterity.

Whole Body Vibration:

The most pronounced long-term effect of whole-body vibration is the damage to the spine. In the spinal region is the most frequently affected is the lumbar part, where spinal deformation, lumbago and sciatica can develop. Other organs systems, such as peripheral and autonomic nervous, vestibular, vascular, digestive and reproductive organs are also liable to be affected.

Damage to the body from exposure to vibration depends on:

1. Length of exposure time
2. The frequency of vibration, Magnitude
3. Amplitude

Vibration transmitted to the body through the supporting surfaces such as feet, buttocks or back is known as whole- body vibration (WBV). There are various sources of WBV in the mining industry, such as the seat-transmitted vibrations from dumper, dozer, shovel, backhoes, load-haul-dump vehicles (LHD), road graders, etc.;

WBV transmitted through feet while standing on or moving near vibrating machines like various types of crushers, vibrating screen or while operating certain types of loaders/ drilling rig, operating from standing on centrifuge tank, mud pump, shale shakers.

There is strong epidemiological evidence that occupational exposure to WBV is associated with an increased risk of lower back pain, sciatic pain and degenerative changes in the spinal system, including lumbar intervertebral disc disorders.

Symptoms of Whole Body Vibration:

There is a shortage of conclusive evidence to establish 1) The probability and extent of vibration-induced injury and 2) a definite dose-response relationship between whole-body vibration and injury or health damage. Results from epidemiological studies, subjective data, biodynamic models and knowledge of the physical properties of the body reveal ill effects of WBV. These constitute:

i) Diseases of spinal column: These are very common and associated with long-term exposure to whole-body vibration. The back is especially sensitive to the 4-8 Hz vibration range. WBV exposure has been linked to severe lower back pain (lumbar spine) and degeneration, bucking/ slipping of the lumbar discs.Chronic exposure to WBV takes some time before lower back problems develop. Poorly designed vehicle seats, awkward postures and manual cargo handling in addition to WBV exposure tend to aggravate lower back pain symptoms. There is a higher risk of varicose veins, menstrual disorders, proneness to abortion and hyperemesis gravidum in women exposed to WBV. Further, there is a distinct increase in blood volume during the phases of ovulation and menstruation.

ii) Digestive system diseases are often observed in persons exposed to whole-body vibration over a long period of time. This is due to resonance movement of the stomach at frequencies between 4 and 5 Hz.
iii) Prolonged exposure to whole-body vibration at frequencies below 20 Hz affects cardiovascular system and results in hyperventilation, increase in heart rate, oxygen intake, pulmonary ventilation and respiratory rate

Conclusion:

1. There is lack of awareness about vibration hazard and its ill effects. This needs to be rectified.
2. The exact number of Oil mine workers occupationally exposed to vibration is not known. Estimated number may be in lakhs.
3. There is an urgent need to investigate the population suffering from vibration exposure above safe limits and its ill effects on their health.
4. The clinical presentation of HAVS in India is not the classical VWF. Subclinical manifestations and dose-response relationships need to be worked out for HAV and WBV in Indian miners.
5. Indian mining legislation is not specific enough to develop a definite strategy for evaluation and control of occupational vibration. Specific rules based on Indian data need to be framed.
6. Vibration monitoring should be made mandatory for all semi-mechanized and mechanized mines.
7. The effective way of reducing hazards of the vibrations is through precautions. Precautions against hazards of vibration:
   a. Do routine medical check-ups of employees for the early detection of HAVS
   b. Limit time spent by employees with vibrating tools/vibrating surface
   c. Ensure the vibrating equipment are well maintained to reduce excess vibration
   d. Creating awareness among employees.
   e. Use of protective equipment's like vibration damping seats, vibration damping pads etc.

8. Noise is the hazardous industrial pollutant causing severe hearing loss in workers of every country in the world. The workers in industries like mining, construction, printing, saw mills, crushers, etc are at risk. Workers are exposed to high levels of noise throughout their lifetime of work, but there are very few NIHL studies in India to show its prevalence.
9. Awareness should be created among workers about the harmful effects of noise on hearing and other body systems by implementing education and training programs.
10. Research studies are needed to know the exact prevalence of NIHL among various industries in India.
11. A national program should be established considering the amount of damage the NIHL causes to the quality of life of workers. The effective way of controlling NIHL is noise level reduction and protecting the worker from hazardous noise at the workplace. The various option of noise level reduction include may include:

   1. The first and simple way to control the noise is through insulation.
   2. Regular maintenance and observance of equipment to reduce the noise by replacing bearings and tightening of all loose part which can vibrate and create extra noise.
   3. Choosing a quieter manufacturing process and equipments where possible (e.g. DC Engines, Bush bearing)
   4. Putting silencers on the exhaust of the various flow machines.
   5. Operating equipments at optimum level rather than at higher levels which increases the noise levels.
   6. The precautions that must be taken from both the sides of the employee and the employer
   7. Frequent monitoring of sound levels in where there is consistent high sound level.
   8. Providing the workers with various type of hearing protection devices, PPEs as well as training in the selection, fitting, use, repair and replacement of hearing protectors.
   9. Creating awareness among the employees about Noise-induced hearing loss(NIHL)
   10. Frequent mandatory audiometric testing of employees for early detection.
   11. The workers must also try to reduce the noise level during their off working hours when not necessary.

Compensation: Nearly 3 billion dollars has been paid in the U.S as compensation for NIHL in the last 2 decades.

In India, it was in 1996 that the first case got compensation, although, it was compensable since 1948 through the Employees State Insurance Act (1948). Awareness must be created among workers about the harmful effect NIHL could have on their lives.

Way forward

In the past 20 years, curative treatment of NIHL and HAVS have been explored but as yet no promising results have been found. As they are irreversible once occurred, the best approach is prevention through taking precautions, implementing standard rules and regulation, expansion of training programs to create awareness and periodic mandatory health teat for early detection of these diseases.

Conflict of interest: Nil

Ethical concerns and limitations of the study

No standard published data available on Whole body Vibration & Occupational Noise induced hearing loss in India.

References

1. Wang et al.(2021)Sex differences in noise-induced hearing loss:a cross sectional study in ChinaBiology of Sex Differences 12:24
2. Kumar R ,Sharma R,Kumar V, KhanAA.Relation of work stressors and work related MSDs among Indian heavy vehicle drivers.Indian J Occup Environ Med 2021;25:198-203
3. Ravinder Kumar et al 2021 J.Phys: Conf. Ser.1854 012033
4. Stedman TL. Stedman's Medical Disctionary. Baltimore : Williams and Wilkins,1990
5. Nelson Dl,NelsonRY,Concha-Barrientos M, Fingerhut M. The global burden of occupational noise-induced hearing loss.Am j IndMed 2005;48(6):446-58
6. MrernaR,YlikoksiM,Makitie A, Pirovola U, Ylikoski J. Occupational noise-induced hearing loss reports and tinnitus in Finland. ActaOtolaryngol2007; 127(7):729-35
7. Lynch ED,Kil J. compound for the prevention and treatment of noise-induced hearing loss.DrugDiscov Today 2005;10(19):1291-8
8. Thai T., Kucera, P.; Bernatik, A. Noise Pollution and Its Correlations with Occupational Noise-Induced Hearing loss in Cement Plants in Vietnam. Int J Environ. Res. Public Health 2021,18,4229.
9. MukkamalaN,Parmar L, Kumar P. Musculoskeletal disorders in tyre manufacturing workers. Indian J Occup Environ Med 2021;25:133-7
10. Ramita KL, Ankita T, Alankruta RV, Anitha CT. A cross-sectional study on occupational health and safety of municipal solid waste workers in Telangana,India. Indian J Occup Environ Med 2021;25:169-77
11. Crista L. Themann,Elizabeth A. Masterson Occupational noise exposure:A review of its effects, epidemiology, and impact with recommendations for reducing its burden. The Journal of Acoustical Society of America 146, 3879
12. Kristine Krajnak Health effects associated with occupational exposure to hand-arm or whole body vibrations. Journal of Toxicology and Environment Health Part B. Dec 2018
13. DwiNoerjoedianto Noise- Induced Hearing loss (NIHL) Risk factors among Manufacturing Industry Workers: A Systematic Review
14. Noise pollution in petroleum industry Dr. Mandira
15.Noise-Induced hearing loss: A preventable condition Ian Gillispie(M.D) BCMJ vol 53,No.3,April,2011, President's Address
16. Nandi,Subroto S and Sarang V Dhatrak "Occupational noise-induced hearing loss in India" Indian journal of occupational and environmental medicine vol. 12,2(2008):53-6
17. https://www.osha.gov/noise/hearing-programs
18. Karen Niven, Ron McLeod. Offshore industry: management of health hazard in the upstream petroleum industry
19. issa. Guide for Risk assessment in Small and Medium Enterprises (8) Hazards arising from whole-body and hand-arm vibrations
20. Bogadi-Sare A. (1993) Djelovnje opcih vibracija: nedovoljno poznat zdravsteni problem[The effect of whole-body vibration: an unrecognised problem] Arhiv za higijenu rada I toksikologiju, 44(3),269-279
21. https://www.ohsrep.org.au/effects_of_vibration

The New, Better Approach to Manage Domestic Connections in City Gas Distribution – A Case Study

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Present scenario

To date, the City Gas Distribution (CGD) companies use the services of many vendors and contractors to provide PNG customer connections, including metering, installation, payments and servicing connections over their lifetime.

Domestic customers for any CGD is its largest constituent in terms of numbers, and thus, an enduring solution for its customer base is necessary for customer centric services.

Following 9th-11th rounds of CGD authorization, with about 100 million projected domestic PNG connections spread across metropolitan, urban, semi urban & rural areas, managing all this would become a big challenge for all CGDs.

Moreover, the domestic segment generates the least revenue and cash flow for any CGD, thus necessitating a low cost-to-serve model.

A unique approach

Generally, the CGD market operates in a traditional way of procurement of meters, material from manufacturers, execution by field contractors and purchase of software solutions from third parties to deliver customer centric services and manage the revenue services through different service providers. Secure Meters came with a unique approach by amalgamating all these works in one basket in its offering. This supply, service and solutions proposition was offered to a CGD.

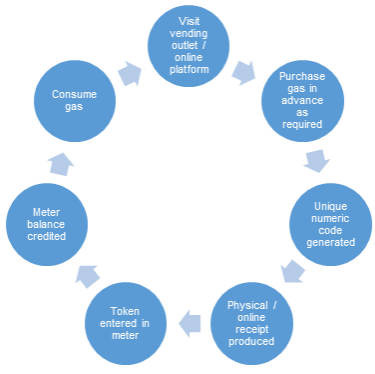
The CGD had entered gas distribution space with an open mind and was ready to experiment. They decided to opt for an approach which can enable them to collect money for gas in advance, will have less dependency on multiple contractors for supply and services, and will reduce paperwork for different services.

What did we do?

The scope of work handled by Secure Meters included

- New connection management
- Demand assessment, customer acquisition/ enrollment
- Supply of prepaid G1.6 gas meter with Bluetooth technology for domestic PNG connection
- Supply of all associated material for domestic PNG connection
- Installation, testing and commissioning of domestic PNG
- Material inventory management system
- Reading meters periodically
- Field force management
- Establishment of customer relationship management (CRM) system
- Customer management services
- Establishment of customer pre-payment vending system
- Customer revenue management
- IT Infra establishment and maintenance
- Establishing and operating 24X7 customer care centre
- Customer mobile app for consumption monitoring and top-up
- B2B integration with CGD system

Uniqueness of the solution



Pre-payment

At the heart of the system lies prepayment metering – offering advance payment to the CGD with zero debt and no recovery hassles. The CGD is assured of their customer payments. Past experience of huge bad debts in urban & semi urban areas in other utility space like electricity discoms has made them move away from postpaid to prepaid solution. Prepaid gas metering for CGDs from day one helps them avoid the debt trap and does away with many payment related business processes.

The customer is also greatly facilitated as they can directly get all information in monetary terms through their mobile app. The meter also stores monthly snapshot of historical monthly readings which helps in gas reconciliation.

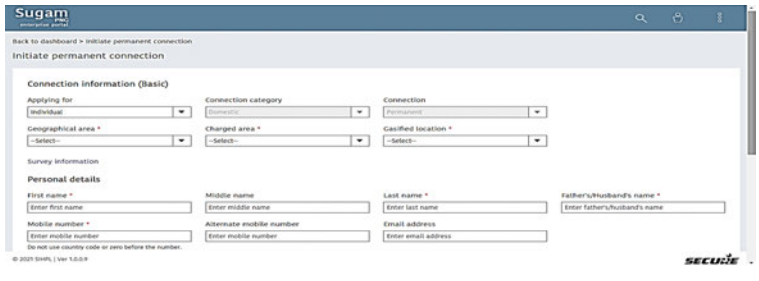
Choice of payment mechanism for customers

Secure has also tied up with payment gateways for online payment facilitation, facilitating online payments through mobile app and over the internet.

We also have tied up with Common Services Center (CSC) of the Government of India for facilitating offline payment by customers through its pan-India network of more than 350,000 centres. This allows a huge access to customers for making offline payments.

Custom built ERP system

A home-grown fully customised pre-payment and CRM system exclusively developed for gas services further ensures that each small process and sub process is accounted for.

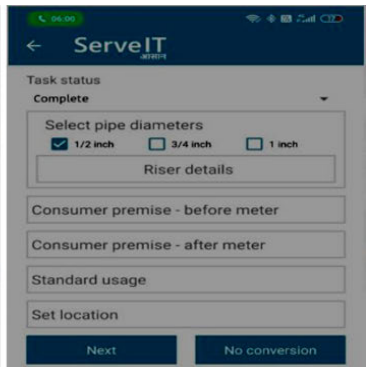


The services are system driven and log all customer interactions which help in hassle free services. A system driven workflow-based activity list for all logs, requests and processes ensure minimum manual intervention and a paperless concept.

Operational practices

Use of Technology

Most of the paperwork related operations are digitised. Tab based registration, digital storage of technical feasibility of connection, customised kit preparation for customer installation and workflow based notification through mobile app to the installer for installation help in quick information flow, removes duplication of work, prevents errors and helps all relevant stakeholders stay on the same page at all times.



On ground practices

Customised PNG Van and Custom built trolleys for material handling

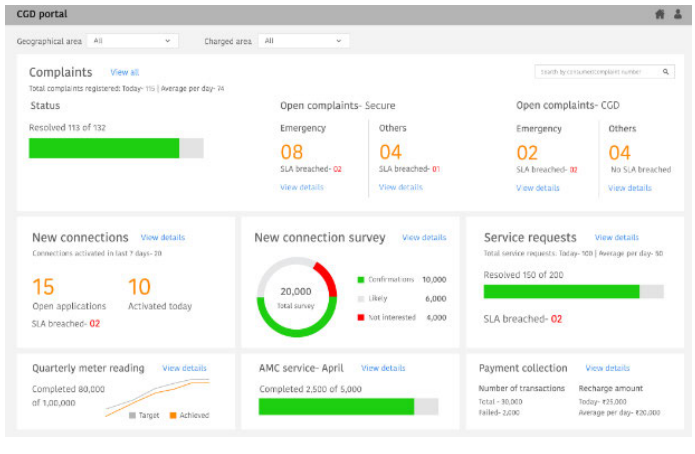
A custom-built van with rack-based storage has been designed. It helps in storing standard kits prepared for individual customers. Custom kits are prepared in advance, based on customer feasibility; this avoids the need for preparing a kit at site, thus speeding up the installation process.

Pre-fabricated concept

Pipes used for installation are pre-fabricated using an auto thread cutting machine and put in kits to ease the installation at site.

CGD portal

A unique portal has been created for the CGD, which keeps them updated on all the works related to customer onboarding, feasibility, connections, complaint handling, payment collection and other operations.



In a nutshell, the whole system is designed and works in a way that the CGD does not have to engage with a long list of contractors, meter providers, equipment providers, software solution providers, service agencies etc. to provide all customer centric services; their only point of contact & responsibility is one company - Secure Meters. Moreover, amalgamation of all the services into one basket ensures costs are controlled and customer 'cost to serve' is minimized & improves operational efficiency of domestic PNG ecosystem. Similar operations were commenced two years back in a CGD, and now running in 10 towns of four states.

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Natural Gas Pipeline Operations through Data Analytics

Naveen Sikka
Oil & Gas Subject Matter Expert

SAS India

Brief: Natural gas transmission and distribution pipeline network are utilized to deliver natural gas from the production points to the consumers. To know the natural gas network behavior, it is necessary to simulate and analyze the pipeline network. Many a times, the large complex pipeline network requires huge data points to simulate the complete pipeline network through traditional engineering applications and thus the need arises to simulate the pipeline flows based on historical PVT and quality data.

Managing a gas transport network is a complex problem because of the number of possibilities of routing the gas through the pipes. The most important aim in this kind of systems is to fulfill the demand within the pressure bounds. A gas network basically consists of several controllable elements such as compressor stations and control valves that are connected via pipes. In a typical problem, the flow rate and pressure in one node is known (source node), and it is required to find the flow rates and pressures at all the other nodes. For a looped system, the direction element for flow is important. In the pipes of the network, the pressure of flowing gas decreases due to the friction with the walls of the pipes. This pressure loss makes more difficult to guarantee the security of supply: to meet the demand at the exit points with gas supplied at the entry points within the pressure bounds. The current framework of management of natural gas pipeline systems, based on off-line simulation, is facing challenges because of the increasing complexity, uncertainty, and several time-dependent factors. To be effective, it requires comprehensive knowledge of system characteristics, accurate initial and boundary conditions. Off-line simulation is typically applied for the analysis, decision support and optimization of pipeline networks. Many efforts have been made for the improvement of the numerical models and model solvers. Some unconventional off-line simulation methods have also been developed. However, an accurate simulation requires exact conditions, e.g., comprehensive system characteristics, accurate initial states, and imposed boundary conditions. Furthermore, off-line simulation has difficulties in accounting for the time-dependent factors of the system dynamics and in treating the uncertainties in the model and its parameters. Finally, the computational burden can be quite significant for complex pipeline networks.

To overcome this computational burden, we observe that the innovations brought by artificial intelligence, machine learning and big data are changing the vision of traditional energy industry. In natural gas pipeline network systems, large amounts and various types of data of operation, device status and gas consumption are generated and collected by SCADA (Supervisory Control and Data Acquisition) systems. Now-a-days it is almost mandatory that natural gas transmission companies' setup SCADA network to monitor & control the operations of their pipeline network., Centralized SCADA system setup for all trunk and regional pipelines includes front-end processors servers (FEP) to poll the Remote Terminal

Units (RTUs) on dual channel (primary and health) along the pipeline. The main priority in the pipeline network modeling is to calculate volumetric flow rate in pipeline and pressure at the network nodes (or pressure drop in pipeline). Primarily, the pipeline operators are always looking for a way to calculate the volumetric flow rate and pressure, and the relationship between these two parameters.

In natural gas pipeline networks, the future states of the components and the system dynamics depend on the previous state history and external disturbances. Because of the complex system structure of the pipeline network and the complex transient process of gas flow in the pipelines, traditional machine learning methods have difficulties in accurately regressing the dynamic behaviors of complex gas pipeline networks. The application for the analysis of the dynamics of a complex pipeline network needs to be further explored. Many factors must be considered in designing a modern pipeline system. These include the nature and the volume of gas to be transmitted, the length and the size of the pipeline, the operating temperature and pressure, the type of terrain to be crossed, the type of gas produced, process plant operating conditions, plant location, the elevation change over the route, and so on. Among these, the pressure drops along the pipe and the quantity of natural gas that flows through the pipe are the most important of the first items of information required for design. Flow of natural gas in pipelines is dependent upon Reynolds number, friction factor, pipe roughness, pipe diameter, pipe length, temperature, pressure, pressure drop and gas properties. Accurate predictions are required for optimum design. Following are the steps, as depicted in the figure 1, to be adopted for a deep learning-based method to predict system dynamic behavior and component states in large, complex natural gas pipeline networks.

- Data quality improvements w.r.t outlier identification, abnormal data auto-correction
- Pressure, Flow, Inventory (Line pack) either on supply side or distribution side
- Perform what-if analysis on any of the input parameters to analyze the impact on output parameters
- Show alert, in advance, for expected disruptions and variations for a given pipeline section
- Provide gas sourcing or input operational parameter recommendations to maintain inventory (line pack)

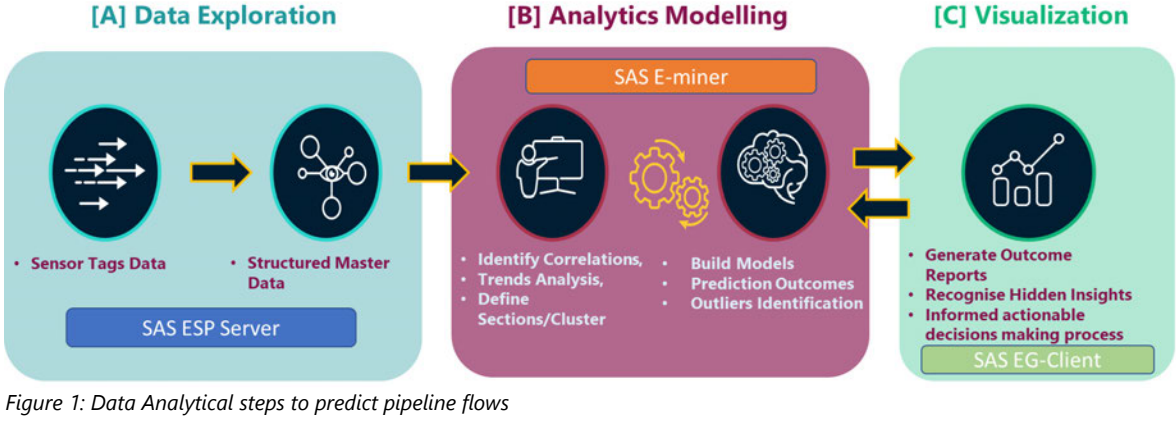

Figure 1: Data Analytical steps to predict pipeline flows

Finally, a method for natural gas pipeline dynamic behavior prediction is developed. The deep learning method shows a stable performance under different conditions and can provide effective information for decision support. It can accurately predict the system responses under abnormal conditions without prior knowledge, which can help to improve the efficiencies of preventive actions and to reduce potential losses. To some extent, this work paves the way for the application of deep learning to complex gas transmission systems. Indeed, this work shows that deep learning is very powerful in learning the complex dynamic features of gas pipeline networks, which is crucial for demand-side management, detection and early-warning, decision support and so on.

A prediction model, based on real-time data, is developed by combining a forecasting model with a neural network layer. To reduce the problem size, structural controllability theory was applied for selecting the input data most relevant for prediction, and a data window has been used to create a proper "memory" for the deep learning model. The accuracy of prediction of the deep learning model has been verified by benchmarking against neural network and forecasting model, on a case of a multi node complex gas pipeline network. The effectiveness of the proposed framework has been analyzed and verified from multiple perspectives, i.e. type of input, length of prediction time and level of noise, with respect to a relatively complex gas pipeline network.

To analyze the deep learning method for abnormal conditions, three scenarios were considered. The results show that the proposed deep learning model can accurately capture the evolution of system conditions under different abnormal changes. The average accuracy of prediction of the working condition within 24 h is significantly higher than 0.9. Besides, the deep learning model presents robust performances and can maintain the high level of accuracy even under a relatively high level of noises (from±0.5% to±2.5% of the nominal values of input data). Also, the given use case includes the fluctuations/events in gas supply at supply locations, compressors stations, customers and various transmission junctions, whose working conditions are changing according to predefined rules, and the results show that the developed method can make good predictions with changing working pressures at these locations.

After development of data analytics-based pipeline operations model, we can definitely say with assertion that the any outcome out of any untoward event in pipeline operations is not learned; it is predetermined.

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Naveen has 24 years of experience in Energy Sector domain with focus on use of technology for supply chain, Manufacturing Operations, Business development, Marketing & Sales, Overall Program and Project Management & Execution
Naveen has spent years in India's largest state-owned natural gas processing and distribution company in India as well as worked with biggest IT services and product majors
Naveen has successfully managed and delivered diversified IT projects in Oil and Gas sectors covering entire value chain from production till retail of finished products.
He has delivered many meaningful engagements around Advance Analytics, MES, Business Consulting, ERP, etc.
He has spoken widely in different industry forums on varied topics on Analytics – Artificial Intelligence, MES, IOT,, Data Mining, etc.

Green Hydrogen – The Next Generation Fuel

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Hydrogen is the smallest and the lightest element on earth and available in abundance in air and water. Our task is to harness the potential available in our earth to meet our energy needs in the cleanest possible manner. Green Hydrogen which is produced from electrolysis process as normal hydrogen but the fuel used to power the process is obtained from renewable energy sources like wind, solar and hydro –power. Thus, the carbon emissions in the whole process is minimized leading to a cleaner environment.

A lot of research is going on around the world on Hydrogen production, storage and transportation which involves a lot of brain-storming to minimize costs. First to get renewable energy sources which will be used in electrolyzers to produce green hydrogen, then storing hydrogen in compressed gas form or liquid form (-253 deg Celsius) in cryogenic containers and then transporting the same to places of end usage involves a lot of costs and care. It also involves trained personnel to handle the very volatile gas. For rich countries like USA, EU countries and Russia, the whole process may be a small percentage of their GDP but for emerging economies like India, Pakistan, African countries and even South American countries, the costs involved are a substantial part of their GDP. We need to have a parity wherein all countries rich and poor may utilize their resources towards a common goal of making our planet carbon neutral.

So, there always lies a tussle between making a costly cleaner fuel or continue dependence on our traditional fossil fuels, thermal power and atomic power, which involve less costs, less infrastructure development and also less logistic costs. Just like our present refineries which produce MS, HSD, SKO, LPG, we need to have a central hub where Hydrogen is produced. After that we can transport the same in compressed gas form or liquid form to the end user points. Some experts suggest that instead of a central hub, we should have multiple production units at the user points which will reduce the transportation costs. But this has a dis-advantage of making available renewable energy sources at that point of manufacture plus land availability and skilled labour potential at those units. So, several studies are going on to optimize the logistic costs of obtaining clean green hydrogen at the plant sites where it can be used on a large scale.

The climate change patterns observed around the world have awakened the world leaders to search for ways and means to make our environment cleaner, greener and Carbon-emission free to enable our next generation to lead a more healthy life. In this context several sustainability workshops have been conducted world-wide to find out processes in the reduction of harmful gases in oil refineries, chemical and fertilizer plants and several other industrial units. Scientists are of the opinion that to reduce carbon emissions and harmful gases to be emitted in the

atmosphere, we need an energy source which is both in abundance and makes the environment cleaner and chemical free. This is where the importance of hydrogen as fuel is being advocated by one and all specially the Green Hydrogen which will reduce the harmful emissions in our factories and enable the ozone layer to be less corroded, thus leading to a much cleaner air to breathe and reduction in the warming of the planet Earth as a whole. All global companies are attaching great importance on Sustainability reports which predict the health of these companies in the next 2-3 decades.

The need of the hour is "action", all countries have to act fast to reduce carbon emissions to make our planet a cleaner, healthier place to live in. A centrally sponsored Hydrogen infrastructure is required in each country so that costs are minimized and safe practices may be followed towards a common goal of "Making planet Earth a healthier, nicer, greener place to live in"

The Mantra for Promoting Research & Development in Transmission & Distribution of Clean Energy

Neeraj Pasricha
Vice President – Regulatory & Business Support

Pipeline Infrastructure Limited

Our world is in a transition phase as far as energy preferences are concerned. An inquest for environment friendly energy sources is being undertaken globally to minimize the greenhouse gas emission. India's commitment towards greener energy sources is evidenced by GoI's commitment at Glasgow COP 26, to reduce the carbon emissions, in a time bound manner, by increasing the non-fossil fuel energy capacity and progress towards carbon neutral and net-zero emissions by 2070.

In this drive to paint the energy landscape green, Hydrogen is playing a significant role. As of today, all the major countries have/are undertaking a plethora of research projects to make Hydrogen a commercial and economical substitute for fossil fuels. To integrate Hydrogen into the overall energy mix, it is imperative for the economies to have solutions to few primary challenges such as Hydrogen transportation, Storage, Distribution, and End User Consumption.

Keeping in mind the chemical composition of Hydrogen and the concomitant complexities such as metal corrosion, embrittlement, and leaks, one must ensure safe handling of the same. The most standard option available is blending Hydrogen with natural gas and utilizing the current gas infrastructure for delivering Hydrogen. Natural gas transmission and distribution pipeline infrastructure utilization to carry pure Hydrogen is technically feasible and may offer economic and development advantages over building new pipelines. As per a study in Germany, converting existing natural gas pipelines into dedicated Hydrogen pipelines could reduce Hydrogen transmission costs by 20% to 60% compared to constructing new Hydrogen pipelines. However, converting existing infrastructure as well as building new Hydrogen pipelines would face market uncertainty and logistical challenge. Any introduction of Hydrogen blend concentration would require extensive study, testing and modifications to the existing pipeline monitoring and maintenance practices (e.g., integrity management systems). Similarly, acceptability of higher Hydrogen concentration by the end-use equipment of the customer also needs to be tested, studied and if required, modified. A gamut of Research & Development (R&D) activities is in progress globally, to explore and address issues and concerns. These activities require additional cost, and hence the investments need to be weighed against the benefit of providing a more sustainable and low-carbon fuel to consumers.

Gas transmission pipelines and distribution network are regulated activities in India, with Petroleum and Natural Gas Regulatory Board (PNGRB) being the regulatory authority for the same. Blending Hydrogen with natural gas or converting the natural gas network to transport Hydrogen, is still at a nascent stage and requires both research and financial support. In the Indian scenario, where both expenses and revenues are regulated in gas transmission and distribution segment, highly motivating policies are required to not only recognize the cost of R&D activities but also encourage entities to undertake the R&D projects.

Globally, regulatory and federal support is playing a critical role in promoting R&D for the transportation of cleaner fuels including blended Hydrogen, converting existing natural gas pipelines or distribution network for pure Hydrogen transportation and exploring other low carbon energy options. Several projects announced and initiated by different countries are focussing on ***Collaborating***, necessary ***Funding*** and ***Knowledge Sharing*** for promoting ***R&D projects.***

In UK, Office of Gas and Electricity Markets (Ofgem) regulates gas transmission and distribution. In 2010, Ofgem introduced a new regulatory price control framework using RIIO model- Revenue set to deliver strong Incentives, Innovation and Outputs. To further make Innovation a habit, Ofgem introduced Network Innovation Competition (NIC), a scheme wherein Network Licensee can participate in the Innovation projects. Further, to stimulate innovations in a structured and transparent manner, Ofgem also brought in Gas Network Innovation Competition (NIC) Governance Document, setting out the regulation, governance, and administration of the Gas NIC. All types of innovations, including commercial, operational, and technical innovations, are eligible for the NIC Funding if the Project has the potential to deliver low carbon and/or environmental benefits to the gas customers.

The United States' strategy for transition towards environment friendly fuels continues to evolve. The use of Hydrogen as a fuel and industrial feedstock is an important element of this strategy. To address the technological challenges in transporting Hydrogen and facilitate research and development in this field, the federal government is playing a significant role.

HyBlend by the Numbers $15M R&D Portfolio >20 partners 6 national labs Duration of Current R&D Projects: 2021-2023

U.S. Department of Energy's (DOE) Hydrogen and Fuel Cell Technologies Office (HFTO), launched the HyBlend collaboratively in 2021 and coordinates related work through the DOE Hydrogen Program. The key aspects of HyBlend include material compatibility R&D, technoeconomic analysis, and environmental life cycle analysis. Hydrogen Materials (H-Mat) is leading the R&D on pipeline materials within DOE's HyBlend initiative to enable Hydrogen blending in natural gas pipelines.

Collaboration:

In UK, collaboration of Network Licensees with each other and with Non-Network Licensees on projects is encouraged as Project Partners. The collaborative approach enables stakeholders to work closely with other parties in the gas supply chain to explore the technological or commercial arrangements best address changes, in network use and the contribution they can make in facilitating low carbon and/or wider environmental benefits. Other parties, such as local authorities and universities can also carry out pilot studies and these could offer opportunities for Network Licensees to get a better understanding of how to respond to these studies.

National laboratories within the U.S. Department of Energy's (DOE) such as H-MAT Compatibility Consortium, is leading the research and development (R&D) on Hydrogen pipelines for over a decade, in collaboration with other leading research groups, industry members, non-profit organisation and academia throughout the United States.

Funding:

Ofgem's RIIO model in UK, not only recognizes the Innovation cost but also provides funding to such projects. Funding under NIC is awarded through an annual two stage competitive process. This funding is recovered through National Transmission System Transportation (NTS) Charges and transferred to the Network Licensee(s) implementing the winning Project(s).

Various federal agencies in USA are funding the R&D initiatives for Hydrogen pipeline materials, safety, and operations for many years, making significant contributions to support their commercialization and deployment. In January 2021, DoE Funding Opportunity Announcement (FOA) for Hydrogen program announced US $ 160 million fund for development of technologies that improve the cost and performance (e.g., resiliency, reliability, safety, and integrity) of Hydrogen transportation infrastructure, including pipelines.

Knowledge Sharing:

The knowledge acquired through these projects is disseminated so that stakeholders can gain on the rolling-out of successful projects and subsequent delivery of network savings and/or carbon and environmental benefits. Even where projects are deemed unsuccessful, Network Licensees stand to gain valuable knowledge that could result in future network savings. The Network Licensees have established a portal for sharing the learnings from innovative Projects.

Projects Funded in 2020

2020 Gas NIC Projects	NIC Funding Awarded
HyNTS FutureGrid The proposed project intends to build a hydrogen testing facility from a representative range of decommissioned National Transmission System (NTS) assets. The data gathered will be used to assess the impact of the hydrogen conversion of NTS assets. *Proposed by National Grid Gas Transmission (NGGT)*	£9.07m
H100 Fife The proposed project aims to deliver a 'first of a kind' 100% end-to-end hydrogen network, supplying around 300 domestic properties initially via an opt-in process. The hydrogen production method proposed for the project is electrolysis with electricity fed from an offshore wind turbine. *Proposed by Scottish and Southern Gas Networks (SGN)*	£18.10m

India has a long way to traverse. The transmission and distribution of gas, being a regulated activity, needs motivating policies to encourage entities to undertake R&D projects. As can be seen from the global scenarios, the main mantra of ongoing R&D projects is availability of ***Platform, Funding, Collaboration*** and ***Knowledge Sharing***. UK Ofgem has provided clear motivating policies for encouraging innovations, funding, collaboration, and knowledge sharing. Similarly, in USA, DoE through HyBlend and Hy-MAT has provided the platform for collaboration through federal funded R&D projects.

In Indian context, PNGRB has all the wherewithal to implement this global mantra and provide the necessary fillip to the R&D projects in the transmission and distribution segment. PNGRB in co-ordination with other stakeholders, can provide a platform wherein all interested entities can collaborate on R&D projects. Transparent and non-discriminatory regulations can be introduced, providing details including eligibility criteria, evaluation parameters, project selection procedure and mechanism to release funds. Apart from analysing and realising the expense involved in R&D, Regulator should also provide funding options to encourage companies to invest time and energy in R&D. Furthermore, the funds can be linked to milestones at different stages of the project.

To invest in the research, PNGRB can utilise the escrow account fund or seek budget from Central Government. Alternatively, the required fund may be recovered along with transportation charges as allowed by Ofgem in UK. PNGRB can also use mix of these sources depending upon the amount of the R&D project.

The shift towards Hydrogen based economy can be achieved with collaboration amongst all stakeholders including research institutes/labs and universities, material producers, customers, other related government agencies, etc. apart from authorized entities. A collaborative approach will enable a synergy between collective knowledge and expertise, thus ensuring projects are implemented in an effective manner. Presently, some entities are undertaking R&D projects at individual level, however, collaborative approach will help save resources, time, and help attain better results. Depending upon the nature and size of R&D project, PNGRB can also advise entity(s) for the collaboration.

Knowledge in silos is of no use. The project learnings can be made available on a single platform (like a web portal) to ensure the project highlights/low lights and success and failures are available to all stakeholders, thus benefitting all.

The possibility of developing a Hydrogen based economy is achievable with all the relevant stakeholders working collaboratively and ensuring all the necessary resources are available. This will further help governments to attain the climate goals. In India, PNGRB under the guidance of Ministry of Petroleum and Natural Gas and co-ordination with other relevant government authorities, is best placed to initiate the mantra for motivating the research and development activities for the gas transmission and distribution network not only for Hydrogen blending but all such projects with an objective of reducing the carbon footprint.

Acknowledgement: *Author wishes to express gratitude to Ms Shelley P. Ruszkowski, Regulatory Finance Advisor, Low Carbon Solutions, Exxon Mobil Corporation, Texas, USA.*

References:

1. Source for Fig 1Article: Innovations in Digital HR — People Matters
2. Ofgem : Gas Network Competition Governance Document
3. Ofgem: Decision on strategy for the next transmission price control - RIIO-T1 Date of Publication 31 March 2011
4. Ofgem Decision on the 2020 Gas and Electricity Network Innovation Competition
5. Pipeline Transportation of Hydrogen: regulation, Research and Policy Congressional Research Service https:// crsreports.congress.govPipeline policy document
6. https://www.energy.gov/sites/default/files/2021-08/ hyblend-tech-summary.pdf

The New Global Tax Deal – Considerations for Oil & Gas Sector

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A. Backdrop

The way the businesses were conducted traditionally has changed over last few decades and today it is possible for an overseas company to conduct business in different foreign locations without setting up a presence there. Traditional tax rules relied upon physical presence in a country and does not deal with a situation of operating in overseas locations without physical nexus in market country. For e.g. if a company in UAE is selling goods to an Indian company where title to such goods is transferred outside India, the profits of such UAE company was not taxable in India ('market jurisdiction'). Further, UAE did not have a corporate tax regime, which resulted into non taxation of such profits on sale of goods.

The aforesaid rules resulted into tax structures leading to tax savings for Multi-National Entities ('MNEs') operating in the countries having favorable tax regimes and had good tax treaty network. However, Governments all over the world examined these structures and noted that they are not getting their fair share of taxes. These resulted into an extensive discussion between the Governments to bring about tax measures multilaterally so that they receive fair share of taxes.

These discussions gave rise to Base Erosion and Profit Sharing ('BEP'S) measures, first of its instalment (called BEPS 1.0) which was implemented couple of years back to address aggressive tax planning. A comprehensive Multi-lateral Instrument was signed by over 130 countries for amending tax treaties between different countries making tax avoidance illegitimate. However, BEPS 1.0 measures were inadequate to deal with - tax rules which did not give taxation rights to market jurisdiction or structures where MNEs sets-up presence in low tax jurisdiction.

Aforesaid resulted into introduction of BEPS 2.0 initiative consisting of Pillar 1 (dealing with nexus and profit allocation) and Pillar 2 (pertaining to a global minimum tax) projects. Overall, the two Pillars of BEPS are a commendable step forward in the global fight against tax gaps and large-scale tax evasion based on a historic global consensus from 137 countries in October 2021. We will discuss hereunder each Pillar to understand the concept and how it will impact companies in the Oil and Gas sector.

B. Pillar One – new nexus rules

The aim of Pillar One is to reach a global agreement on adapting the allocation of business profits in a way that expands the taxing rights of market jurisdictions. In order to achieve this, Pillar One contains new taxing rights for market jurisdictions over a share of the residual profits of certain MNE group.

The new nexus targets to address the cases where a business has a sustained and significant involvement in the economy of the market jurisdiction such as through high revenue from customers in market

jurisdiction, consumer interaction and engagement through digital means, irrespective of its level of physical presence in market jurisdiction. This primarily targets companies which are increasingly undertaking business with customers in market jurisdiction without having physical presence.

As per draft rules released by Organisation for Economic Co-operation and Development ('OECD') for Pillar One, eligible MNEs shall be required to re-allocate 25% of residual profits in excess of 10% of its consolidated profits to market jurisdictions meeting nexus test, using revenue-based allocation key. Currently MNEs having consolidated turnover of Euros 20 billion are covered under Pillar One. The turnover will get lowered in future years based upon the consensus achieved by OECD. MNEs with turnover lower than the aforesaid threshold will not get covered under Pillar One rules as of now.

OECD estimates that globally taxing rights on more than USD 125 billion of profits are expected to be re-allocated to market jurisdiction each year based on above. Developing country gains are expected to be greater than those in more advanced countries. Prior to reaching consensus on above tax rules, many countries (including India) have already introduced digital or remote tax in their domestic law to tax MNEs. Pillar One will replace the countries' unilateral measures and will present one unified tax regime.

Illustrated below is a case study indicating how Pillar One would affect the tax burden on MNE group:

Particulars		Amount
Consolidated turnover (including sales to market jurisdiction i.e. India of 150)	(a)	250
Profit before tax ('PBT')	(b)	100
% of PBT	(c) = (b)/ (a)	40%
Excess of PBT over 10%	(d) – 10%	30%
25% of excess over 10%	(e) = (d) X 25%	7.5%
Total Amount A	(f) = 7.5% of (a)	18.75
Export turnover of USCO	(g) = Assumed	150
Amount A which gets allocated to overseas market jurisdiction ie India	(h) = (e) X (g)	11.25

US Co shall be required to pay taxes in India on Amount A allocated. The additional taxes paid on Amount A shall be creditable in-home country. Where tax rate in market jurisdiction is higher than the tax rates applicable in home country, the overall taxes paid by the entity may be higher vis-à-vis Pre-Pillar One.

Various players operating in India through remote manner such as providing IT services remotely or online sale of oil & oil products, equipment, goods, etc may get impacted once Pillar One is effective.

It is important to note that Pillar One rules are not finalised yet. There are discussions between various countries on the contours of Pillar One and its implementation. It is expected that final rules may be different from the draft rules in certain aspects and hence it is important to see developments on Pillar One and timeline by which it will be implemented.

C. Pillar Two – Global Minimum Tax

Setting tax rates is a sovereign right of jurisdiction, but where rates are set too low, they adversely affect sovereign rights of another jurisdiction – forcing them to lower tax rates. Many jurisdictions are engaged in tax competition (referred to as the race to bottom) by offering reduced taxation to attract foreign investment.

Pillar Two addresses remaining BEPS challenges and is designed to ensure that large internationally operating businesses pay a minimum level of tax regardless of where they are headquartered or the jurisdictions, they operate in. It ensures that decisions on investment and effective capital allocation are based on non-tax factors such as infrastructure, education levels or labour costs.

Pillar Two addresses the aforesaid through a number of interlocking rules that seek to -

(i) ensure minimum taxation while avoiding double taxation or taxation where there is no economic profit;
(ii) cope with different tax system designs by jurisdictions as well as different operating models by businesses;
(iii) ensure transparency and a level playing field; and
(iv) minimize administrative and compliance costs.

To achieve these objectives, Pillar Two sets out the rules that would provide jurisdictions with a right to "tax back" where other jurisdictions have not exercised their primary taxing rights, or the payment is otherwise subject to low levels of effective taxation.

In a situation where the Effective Tax Rate ('ETR') paid by an entity in a jurisdiction is less than 15 percent, the objective of Pillar Two is to recover the balance as top-up tax from the MNE group. Assuming that the ETR of the group is 5 percent in a particular jurisdiction, the Pillar Two rules aim to recover the balance 10 percent as top-up tax.

Pillar Two rules are divided into the following two parts:

Subject to tax rule (new treaty limitation rule or STTR)	- Subject to tax rule is the first rule applicable - Under this rule, payer country denies treaty benefits for covered payments to the extent they are not subject to a **nominal** tax rate of ≥ 9% (standalone treaty provision) - In practice expected to broaden the scope of withholding taxes and limit treaty benefits
GloBE (minimum tax rules)	- **Jurisdictional Top-up Tax: Top-up tax on** excess profits from the net income from a particular jurisdiction computed in manner given in final Pillar 2 rules (**ETR** below 15%). This can be levied by the country in which entity of MNE group is present where ETR is below 15%. The differential tax of 15% and ETR can be recovered by the country in which ETR is below 15%. - **The income inclusion rule ('IIR'):** IIR triggers an inclusion at the level of the shareholder where the income of a controlled foreign entity is taxed at below the effective minimum tax rate. This can be levied by the country having ultimate shareholder. IIR would be difference between 15% rate and ETR and Jurisdictional Top-up tax recovered. - **Undertaxed payments rule ('UTPR')** (backstop to IIR): Minimum tax calculated for purposes of the IIR is allocated to countries having MNE group entities (**ETR** below 15%) in a prescribed manner. This rule can be invoked only if jurisdictional top up tax or IIR cannot recover minimum tax.

In terms of the order of application, STTR takes on a primary role and is applied in priority to GloBE rules. Under GloBE rules, application of IIR will take precedence over the UTPR. UTPR will apply only in the absence of IIR.

Notably, Pillar Two leaves jurisdictions free to determine their own tax system, including whether they have a corporate income tax (CIT) and where they set their tax rates, but also considers the right of other jurisdictions to apply the above rules as proposed where income is taxed at an effective rate below a minimum rate.

Timing in relation to the introduction of the new rules is currently uncertain. The earliest timeframe being considered is for the rules to be effective in 2023 for the Income Inclusion Rule (IIR) and 2024 for the Undertaxed Payments Rule (UTPR).

Impact analysis

(a) For non-resident E&P service providers in India

Typically, non-resident oil & gas service providers offers income to tax in India under special tax regime whereby 10% of gross receipts is deemed to be profit and hence effective tax rate of 4% (i.e. 40% of 10% deemed excluding applicable surcharge and cess).

Considering the same, NR service provider may end-up paying additional taxes in India so as to match minimum tax rate under Pillar Two rules.

Accordingly, it would be critical for NR services provider to evaluate the impact of Pillar Two in terms of additional tax outflow, as well as compliance burden so as to incorporate additional tax cost while bidding for contracts.

Separately, while Pillar Two excludes international shipping income from its ambit, the question arises on whether income from lease of vessels or transportation of vessels would be included in this exclusion. Vessel operating entities may have to re-look at their operating structure depending upon applicability of these exclusions.

Further, it would be relevant to examine the supply chain of the companies to see if Vendors operating out of low tax jurisdiction will pass on the increase in tax cost by increasing rates for sale of goods or services.

(b) For Resident Companies

While historically India had a relatively high corporate tax and number of tax incentives/ exemptions, recent direction of tax policy has been to aim for moderate rate of taxation with gradual phase out of most tax incentives. Accordingly, the rate of corporate tax which was in the range of 29% to 34% until recently, has now been brought to competitive rate of 25%, with a lower rate of 17% (including surcharge and cess) being available for new manufacturing companies. The corporate tax rates are still higher than minimum global tax rate of 15% and may not have much impact on Indian players. However, if these companies have subsidiaries or joint ventures in low tax jurisdictions, then impact of Pillar 2 needs to be examined as it can decrease the ETR of the Group.

D. Adopt to flourish

The two Pillar solution represents a historic development and seeks to dramatically change the old tax laws.

Implementation of two Pillar solution may have far reaching tax and operational challenges for both Indian headquartered groups with international operations (India outbound) and foreign headquartered groups (India inbound) with Indian operations.

The minimum tax rate may benefit developing countries, which typically impose higher corporate income taxes, but it could make tax havens/ regions providing tax exemptions less attractive.

Considering the complexity and proposed time-frame to prepare for the implementation, it is important for companies to evaluate the potential impact of the proposed global tax changes, prepare for additional tax compliance burden and re-evaluate their legal structure and operating business model.

Oil & Gas in Media

ONGC inks MoU with Norway's Equinor to collaborate on E&P, Clean energy

Oil and Natural Gas Corporation Limited (ONGC) has signed a Memorandum of Understanding (MoU) with Equinor ASA, the Norwegian state-owned multinational energy company. The MoU was inked on 26 April 2022 in New Delhi for collaboration and partnership in areas of upstream Exploration & Production, midstream, downstream and Clean energy options, including Carbon Capture Utilization & Sequestration (CCUS). Equinor is the leading operator on the Norwegian continental shelf, present in around 30 countries worldwide.

The MoU was signed during the visit of a high-level delegation of Norway to India. Union Minister of Petroleum and Natural Gas Shri Hardeep Singh Puri, Norwegian Foreign Minister Ms Anniken Huitfeldt, ONGC CMD Dr Alka Mittal and Executive Vice President of Equinor Ms Irene Rummelhoff were present on the occasion.

As per the agreement, both ONGC and Equinor will collaborate with each other in the field of upstream oil and gas, midstream, marketing and trading, besides exploring further options in low carbon fuel, renewables, Carbon Capture Storage (CCS) as well as Carbon Capture Utilization and Sequestration (CCUS) opportunities in India.

The MoU is valid for two years under which both companies have agreed to work together in the areas identified.

Petroleum Minister Hardeep Singh Puri dedicates two projects worth more than 6000 Crores to the nation

Hardeep Singh Puri, Minister of Petroleum & Natural Gas and Housing and Urban Affairs dedicated two major projects of ONGC to the nation at Western offshore on 23 April 2022. He was accompanied by CMD, Dr. Alka Mittal, Director (T&FS), O P Singh and Director (Offshore), Pankaj Kumar. The two projects will result in an incremental gain of 7.5 MMT of oil and more than 1 BCM of gas.

The minister expressed his appreciation for ONGC team for implementing the two projects. He exhorted ONGC to further enhance their efforts to add more oil and gas to the kitty of nation adopting accelerated exploration activities.

NWIS Platform, part of the Mumbai High South Redevelopment phase IV

The state-of-the-art 8 legged water Injection-cum-Living Quarter platform has been installed as part of implementation of low salinity water flood (LSWF) process, an Enhanced Oil Recovery (EOR) pilot project, part of the Mumbai High South Redevelopment phase IV at a total CAPEX of Rs. 3740 Crores. NWIS-R installed under GoI initiatives of Enhanced Recovery (ER) Policy 2018 for oil and gas. The project will result in incremental gain of 3.20 MMT of oil and 0.571 BCM of gas. This is the first EOR project of Indian offshore.

The concept involves reducing the salinity of the injected sea water, which is about 28000 ppm, up to the level of 8250 ppm with a desalination plant. The mechanism of LSWF involves complex Crude Oil-Brine-Rock (COBR) interactions for improving both microscopic and macroscopic displacement efficiency.

The project has been implemented with strategic emphasis on local procurement of Rs. 1700 Crore, in line with Make in India Initiative of the government. Out of total 45 major Pumps/packages in NWIS project, 42 major Pumps Packages have been manufactured in India. 40,000 MT of Structural Steel, enough of make 5 Eiffel Towers have been used in the structure.

The Energy Recovery Unit to save power will result in reducing 8314 MT of C02 emission yearly there by reducing carbon foot print.

Cluster 8 Marginal Fields

The cluster 8 Marginal Field development project at Mumbai High has been implemented with a total cost of Rs. 2292.46 Crores. The project will result in incremental production of 4.38 MMT of oil and 0.464 BCM of gas. These marginal fields were discovered in 2017-18 & 2018-19. CO2 mitigation system has been implemented for the first time in offshore as part of the project. The oil and gas is being evacuated through FPSO (Floating Production Storage and Offtake).

India has achieved the target of 10 percent ethanol blending, 5 months ahead of schedule

Government of India, with the aim to enhance India's energy security, reduce import dependency on fuel, save foreign exchange, address environmental issues and give a boost to domestic agriculture sector, has been promoting the Ethanol Blended Petrol (EBP) Programme. The 'National Policy on Biofuels' notified by the Government in 2018 envisaged an indicative target of 20% ethanol blending in petrol by year 2030. However, considering the encouraging performance, due to various interventions made by the Government since 2014, the target of 20% ethanol blending was advanced from 2030 to 2025-26.

A "Roadmap for Ethanol Blending in India 2020-25" was also released by the Hon'ble Prime Minister in June, 2021 which lays out a detailed pathway for achieving 20% ethanol blending. This roadmap also mentioned an intermediate milestone of 10% blending to be achieved by November, 2022.

However, due to the coordinated efforts of the Public Sector Oil Marketing Companies (OMCs) the target of 10% blending under the programme has been achieved much ahead of the targeted timelines of November, 2022 wherein the Public Sector OMCs have attained an average 10% ethanol blending in petrol across the country.

This achievement in the course of last 8 years has not only augmented India's energy security but also translated into a forex impact of over Rs.41,500 crores, reduced GHG emissions of 27 lakh MT and also led to the expeditious payment of over Rs.40,600 crores to farmers.

With all the initiatives taken by the Government, the EBP Programme is on track to achieve the target of 20% blending by 2025-26.

IndianOil's Octamax Technology wins Country's Top Technology Award

History was made yet again when Octamax technology developed by IndianOil R&D swept the country's top technology award. The much-coveted award was presented by Dr. Jitendra Singh, Hon'ble Minister of State for Science and Technology (I/C), to IndianOil R&D team led by Dr. SSV Ramakumar, Director (R&D), and Dr. Madhusudan Sau, ED (Refining Technology), in a glittering event that saw the presence of India's top technocrats and luminaries from the domain of science & technology from across the country. Dr. Srivari Chandrsekhar, Chairperson, TDB & Secretary, Department of Science and Technology, was also present.

IndianOil was declared winner of the coveted National Award-2022 under the category "Successful Commercialization of Indigenous Technology" for commercialization of Octamax® Technology. The recognition carries a cash award of Rs. 25 lakh and a trophy. IndianOil was adjudged first in the Category A of the National Awards alongside a medical devices company that also won this prestigious award for fluting stents. It is understood that IndianOil's entry withstood tough competition from technologies across domains / industrial sectors and competed against 300 technologies vying for the top honour.

Commending the recognition, Mr. Shrikant Madhav Vaidya, Chairman, IndianOil, said, "This National Award for our Octamax technology is a reaffirmation of IndianOil's commitment to Aatma Nirbhar Bharat. It validates our spirited journey from being a technology importer to a creator of cutting-edge refining technologies. Innovating this pioneering technology has helped IndianOil produce the country's first 100-Octane petrol at our Mathura Refinery to power high performing new generation automobiles. The launch of this high octane petrol grade has catapulted IndianOil into the league of select countries such as Germany, USA, Greece, Israel, etc., that offer 100-Octane petrol."

Accepting the honour on behalf of IndianOil, Director (R&D) said, "We are proud to receive this coveted award that recognises IndianOil's position as a technology licensor in the competitive refining research domain. Octamax® is a state-of-the-art indigenous process technology to produce petrol with exceptionally high anti-knock quality leading to better combustion efficiency & higher fuel saving benefits".

India's first pure green hydrogen plant commissioned in Jorhat

Oil India Limited (OIL) has taken the first significant step towards Green Hydrogen Economy in India with the commissioning of India's First 99.999% pure Green Hydrogen pilot plant, with an installed capacity of 10 kg per day at its Jorhat Pump Station in Assam on April 20, 2022. The plant was commissioned in a record time of 3 months.

Shri Sushil Chandra Mishra, Chairman & Managing Director, inaugurated the plant in the presence of Shri Harish Madhav, Director (Finance) and Shri Prasanta Borkakoty, Resident Chief Executive of the company. The plant produces Green Hydrogen from the electricity generated by the existing 500kW Solar plant using a 100 kW Anion Exchange Membrane (AEM) Electrolyser array. The use of AEM technology is being used for the first time in India.

Speaking on the occasion, Shri Mishra said that the company has taken an important step towards fulfilling the vision of our Prime Minister for an atmanirbhar India. This plant is expected to increase its production of green hydrogen from 10 kg per day to 30 kg per day in future. The company has initiated a detailed study in collaboration with IIT Guwahati on blending of Green Hydrogen with Natural Gas and its effect on the existing infrastructure of OIL. The company also plans to study use cases for commercial applications of the blended fuel.

GAIL awards contract to set up one of India's largest PEM based Green Hydrogen Project

In line with the National Hydrogen Mission, GAIL (India) Limited has awarded a contract to set up one of the largest Proton Exchange Membrane (PEM) Electrolyser in India. The project would be installed at GAIL's Vijaipur Complex, in Guna District of Madhya Pradesh, and would be based on renewable power.

The Project has been designed to produce around 4.3 Metric Tons of Hydrogen per day (approx. 10 MW capacity) with a purity of about 99.999 Volume %. It is scheduled to be commissioned by November 2023. In line with the vision of Atmanirbhar Bharat, the project has been awarded to a vendor having domestic value addition of more than 50 per cent.

Earlier, in January this year, GAIL had commenced India's first-of-it's-kind project of mixing Hydrogen into Natural Gas system. Hydrogen blended Natural Gas is being supplied to one of GAIL's Joint Venture (JV) company with HPCL- Avantika Gas Limited (AGL), which is a City Gas Distribution (CGD) company operating in Indore, Madhya Pradesh. Till date, GAIL has been successful in blending upto 2% (v/v) hydrogen in natural gas in the CGD network.

Pipeline Infrastructure Limited (PIL) and GAIL (India) Limited have inked a MoU for cooperation and collaboration towards development and strengthening of the Hydrogen based ecosystem in India

Pipeline Infrastructure Limited (PIL) and GAIL (India) Limited have inked a Memorandum of Understanding (MoU) on May 13, 2022 in New Delhi for cooperation and collaboration towards development and strengthening of the Hydrogen based ecosystem in India. Aayushi Agarwal - Assistant Vice President - Strategic Planning & New Initiatives – PIL and Mr. Ashu Singhal - Executive Director - (CSPA, RM & TQM) -GAIL signed the MoU in the presence of Mr. Akhil Mehrotra – MD & CEO – PIL and Mr. M.V. Iyer - Director, Business Development – GAIL.

L-R – Mr. Ashu Singhal - Executive Director - (CSPA, RM & TQM) - GAIL, Mr. M.V. Iyer - Director, Business Development – GAIL, Mr. Akhil Mehrotra – MD & CEO – PIL, Aayushi Agarwal - Assistant Vice President - Strategic Planning & New Initiatives – PIL and Mr. Neeraj Pasricha - Vice President – Regulatory & Business Support – PIL sign the MoU

The MoU aims at collectively exploring the feasibility, desirability and viability of Hydrogen as a source of energy and thus build a partnership between the companies. PIL & GAIL will explore various options for transportation using the existing natural gas pipeline and the end use of hydrogen.

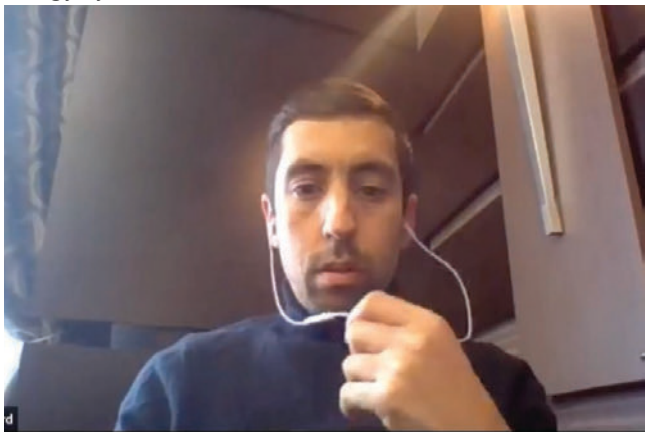
India as a nation is at a very nascent stage with respect to Hydrogen as an energy source. The focus of all the stakeholders including GoI, Industry Bodies, Industry peers and Consumers, should be on exploring production, transmission, and distribution of Hydrogen for making it viable to be able to contribute towards fulfilling India's COP26 commitment.

Events

Webinar on Sustainable Aviation Fuel

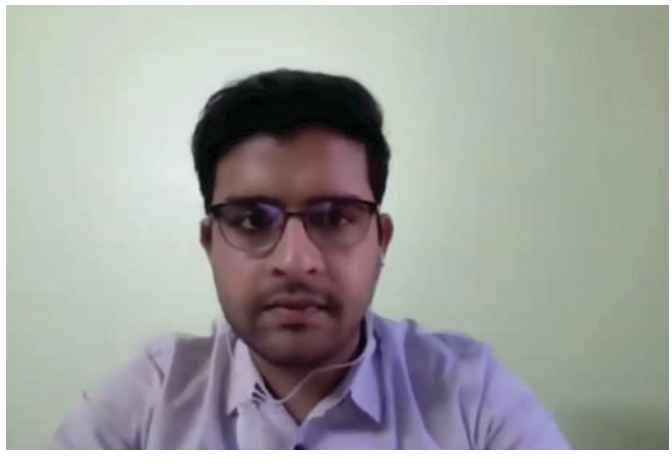
The Federation of Indian Petroleum Industry (FIPI) in association with Axens organized the webinar on Sustainable Aviation Fuel on 5th April, 2022. The webinar focussed on various technology pathways for Sustainable Aviation Fuel production. The webinar witnessed participation of more than 70 professionals working across the oil and gas value chain.

Mr. DLN Sastri, Director (Oil Refining & Marketing), FIPI started the session with the opening remarks. He mentioned that Government has laid down various initiatives like One nation one grid, Ethanol blending programme, SATAT (bio gas) scheme, FAME (EVs) scheme etc to ensure efficient, sustainable and clean energy system for India in future.



Mr. Yvon Bernard, Business Development Manager, Bio & renewables, Axens started with the presentation "Introduction to Axens biofuel technologies portfolio and Global context". He talked about the presence of Axens worldwide especially in refining and petrochemicals, gases and alternatives & renewables and said that Axens has over 3000 industrial units under license and over 500 modular units' references.

Mr. Harshit Agarwal, Deputy Country Sales Manager, Axens talked about Indian biofuels market scenario. He said that Axens have provided over 150 plus license units and 10000 tons of catalyst to all major oil and gas PSU's in India. He then mentioned about the biofuel market present in India and discussed the ethanol production and blending rates. He said that by 2018 there was focus on 2G and 3 G pathways of producing SAF or renewable diesel and hence the target of blending ethanol with gasoline was revised to 20%. He mentioned that the consumption of biofuel is low in the Indian market and discussed the steps that need to be addressed in case of biofuel market.



Mr. Maxime Vassieu, Technologist, Alcohol to jet team, Axens presented the pathway related to Alcohol to jet route. He highlighted the aviation fuel specifications containing synchronised hydrocarbons and discussed about the APJ-SPK (synthetic paraffinic kerosene) production steps.

Mr. Praveen Rai, Deputy Director, FIPI conducted the Q&A session and the panellists provided their views and opinions on various queries posted by our participants. Lastly, Mr. Siddhartha Saha, Country Head, Sales & marketing, Axens proposed the closing remarks.

Webinar on Energy Transition & Decarbonization - Role of LNG & Application of CCUS

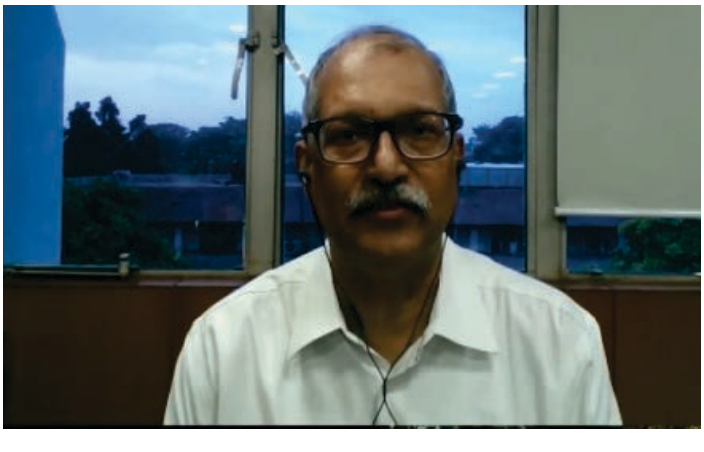
The Federation of Indian Petroleum Industry (FIPI) organized an exclusive webinar on 'Energy Transition & Decarbonization - Role of LNG & Application of CCUS' on 08th June 2022 over virtual platform. The webinar was aimed at understanding the role of Natural gas, LNG and CCUS in energy transition to pave a way forward for implementation of these concepts & technologies in the industry.

Commencing the proceedings of the webinar, Mr. Gurmeet Singh, Director General, FIPI extended a warm welcome to the speakers and participants. In his welcome address, he highlighted that with the following initiatives by the Government, India is already underway towards energy transition:

Accelerating the uses of renewable energy; Decarbonisation of transport and adoption of electric mobility; One nation one grid; Ethanol blending programme; SATAT (bio gas) scheme; FAME (EVs) scheme etc to ensure efficient, Sustainable and clean energy system for India in future; National Hydrogen Mission with the goal to make India a global hub for Green Hydrogen production and export.

Dr. A K Balyan, former MD & CEO Petronet LNG, in his presentation on the "Energy Transition & Role of LNG/ Gas" emphasised that use of energy today cannot be seen in isolation and the true cost of energy is more than just few dollars/cents. It is important to take into consideration the consequences of choosing an energy source as it has economic, political, social and environmental factors attached to it.

Dr Raj Deo Tewari, Chief Scientist R&D in Group Research & Technology, Petronas in his presentation on the "Important Role of CO2 Capture Utilization and Storage in the Energy Transition" emphasised that there is an urgency to significantly cut GHG emission to avoid the economic and human consequences of severe climate change.



At the end, Mr. T K Sengupta, Director (E&P), FIPI extended sincere gratitude and thanked all the two speakers Dr Raj Deo Tewari, and Dr. A K Balyan for giving their valuable time and for sharing their experiences on the Energy Transition & Decarbonization perspective focussing on CCUS & LNG. He also thanked all the participants for taking out their time and listening to the session.

NEW APPOINTMENTS

Dr. Pushp Kumar Joshi takes over as Chairman & Managing Director of HPCL

Dr. Pushp Kumar Joshi

Dr. Pushp Kumar Joshi has taken charge as Chairman & Managing Director of Hindustan Petroleum Corporation Ltd (HPCL), a Maharatna Company on May 8, 2022. Prior to this Dr Joshi was Director-HR of the Corporation from August 01, 2012. Dr. Joshi is also holding the Additional charge of Director - Marketing of HPCL.

During his career, he had held key portfolios in Human Resources functions viz. Executive Director – HRD and Head – HR of Marketing Division.

Dr. Pushp Kumar Joshi is a Doctorate in Human Resource Management, Post Graduate in Human Resource Management from XLRI, Jamshedpur and Bachelor of Law from Andhra University.

Dr. Joshi had been part of the Board of Directors of HPCL since 2012. During his tenure in the Board, HPCL became a Maharatna Company and achieved the landmark Profit After Tax of 10,000 crore in FY 2020-21. In addition, Mumbai Refinery Expansion Project, Joint Venture Bathinda Refinery Project & numerous infrastructure projects in Marketing, which exponentially increased the Refining and Marketing capacities of HPCL, have been executed over the years. HPCL is also in the process of executing the Visakh Refinery Upgradation Project, Green Field Refinery cum Petrochemical complex at Barmer, Rajasthan, etc.,

As Director – HR, Dr. Joshi has been responsible for overseeing the design and deployment of key Human Resource policies and strategies while leading Human Resources practices that are employee-oriented and aimed at building high performance culture.

Ms. Pomila Jaspal takes over as Director (Finance) of ONGC

Ms. Pomila Jaspal has taken over as Director (Finance) of ONGC on 19 April 2022. Prior to this, Ms. Jaspal served as Director (Finance) in Mangalore Refinery and Petrochemicals Ltd (MRPL) - Schedule 'A' CPSE and subsidiary of ONGC, since October 2019. She has also served as Director on the Board of ONGC Mangalore Petrochemicals Limited (OMPL), Petronet Mangalore Hassan Bangalore Limited (PMHBL) and ONGC Petro Additions Limited (OPaL).

Pomila Jaspal

Ms. Jaspal is a fellow member and gold medallist of the Institute of Cost Accountants of India. She is a recipient of the Late Mrs Dhanpati Goel Gold Medal from the Institute. She has obtained a degree in B.Com. (Hons) from MCM DAV College, Chandigarh, and M.Com. from the Punjab University.

She has 36 years of experience across varied segments of the oil & gas industry, encompassing operating, regulatory and policy aspects of upstream and downstream industry. She was instrumental in the merger of OMPL with MRPL, paving the way for synergy and integration benefits for the ONGC Group.

As Director (Finance) of MRPL, she focused on the restructuring of the borrowing portfolios leading to a lower effective rate of interest. She steered MRPL's maiden Non-Convertible Debenture (NCD) issue worth Rs 3,000 crore and also ventured into the commercial paper market at the opportune time that could generate funds at very competitive rates. In addition, she also facilitated the settlement of many issues on merit under Sabka Vishwas Scheme for Indirect Tax, as well as under Vivad Se Vishwas Scheme for Direct Tax.

Dr. Manas Kumar Sharma takes over as Director (E&D), OIL

Dr. Manas Kumar Sharma

Dr. Manas Kumar Sharma took charge as Director (Exploration & Development) of Oil India Limited (OIL), India's second largest national exploration & production company on 20.04.2022. Dr. Sharma was serving OIL as Executive Director (Basin Manager-Shelf) prior to his appointment as Director (E&D), where he was involved in various E&P activities within the operational areas in Assam and Arunachal Pradesh of OIL.

A skilled geoscientist and operational manager, Dr Sharma carries with him more than 30 years of experience in the oil and gas industry, he has first hand knowledge & experience in the subsurface & surface domain, both in the working as well as in the senior management level.

Dr. Sharma has conceptualized action plan for various exploration activities leading to identification of prospects for continued hydrocarbon exploration, appraisal of discoveries as well as formulation of revitalization plan for existing brown fields within Operational Areas in Assam and Arunachal Pradesh. He is also instrumental in establishing Industry-Academia collaboration with Universities in the Northeast, which has helped in better understanding of the Assam & Assam-Arakan Basin for carrying out extensive exploration activities by OIL in the Northeast.

An alumnus of Dibrugarh University, Dr. Sharma is a Ph.D and M Tech in Applied Geology.

Mr. Sanjay Jindal assumes charge as Director (Finance) of EIL

Mr. Sanjay Jindal has assumed charge as Director (Finance) of Engineers India Limited (EIL), a Navratna PSU on June 10, 2022.

Mr. Sanjay Jindal is B.Com (Hons.) from Delhi University and a member of the Institute of Cost & Management Accountants of India (ICMAI). Mr. Jindal had joined EIL in 1992 and has rich and versatile experience of more than 29 years. He has handled entire spectrum of Finance and Accounts functions, especially Facilitating Project execution from Bidding to Contract closure, Project Financing, investments, taxation, implementation of Internal Financial Control Systems, Financial Reporting etc.

Mr. Jindal has also served as Chief Financial Officer of Ramagundam Fertilizers and Chemicals Limited, a Joint Venture company promoted by EIL and National Fertilizers Limited.

Sanjay Jindal

STATISTICS

INDIA: OIL & GAS

DOMESTIC OIL PRODUCTION (MILLION MT)

		2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	
									% of Total
Onshore	ONGC	...	5.9	6.0	6.1	6.1	5.9	5.8	38.6
	OIL	3.2	3.3	3.4	3.3	3.1	2.9	3.0	19.7
	Pvt./ JV (PSC)	8.8	8.4	8.2	8.0	7.0	6.2	6.3	41.7
	Sub Total	**17.8**	**17.6**	**17.5**	**17.3**	**16.2**	**15.1**	**15.1**	**100**
Offshore	ONGC	16.5	16.3	16.2	15.0	14.5	14.2	13.6	93.5
	OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pvt./ JV (PSC)	2.5	2.1	1.9	1.9	1.5	1.1	1.0	6.5
	Sub Total	**19.1**	**18.4**	**18.1**	**16.9**	**16.0**	**15.4**	**14.6**	**100.0**
Total Domestic Production		36.9	36.0	35.7	34.2	32.2	30.5	29.7	100.0
	ONGC	22.4	22.2	22.2	21.0	20.6	20.2	19.5	65.5
	OIL	3.2	3.3	3.4	3.3	3.1	2.9	3.0	10.1
	Pvt./ JV (PSC)	11.3	10.5	10.1	9.9	8.4	7.4	7.3	24.4
Total Domestic Production		**36.9**	**36.0**	**35.7**	**34.2**	**32.2**	**30.5**	**29.7**	**100.0**

Source : PIB/PPAC

REFINING

Refining Capacity (Million MT on 1st January 2022)

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

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

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

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

Hindustan Petroleum Corp. Ltd.	
Mumbai	7.50
Visakhapattnam	8.30
Total	**15.80**
Other PSU Refineries	
NRL, Numaligarh	**3.00**
MRPL	**15.00**
ONGC, Tatipaka	**0.07**
Total PSU Refineries Capacity	**141.92**

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

Total Refining Capacity of India 249.2 (5.00 million barrels per day)
Source : PPAC

CRUDE PROCESSING (MILLION MT)

PSU Refineries	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)
IOCL	58.01	65.19	69.00	71.81	69.42	62.35	67.66
BPCL	24.10	25.30	28.20	30.90	31.53	26.22	29.84
HPCL	17.20	17.80	18.20	18.44	17.18	16.42	13.97
CPCL	9.60	10.30	10.80	10.69	10.16	8.24	9.04
MRPL	15.53	15.97	16.13	16.23	13.95	11.47	14.87
ONGC (Tatipaka)	0.07	0.09	0.08	0.07	0.09	0.08	0.08
NRL	2.52	2.68	2.81	2.90	2.38	2.71	2.62
SUB TOTAL	**127.03**	**137.33**	**145.22**	**151.04**	**144.71**	**127.50**	**138.08**

JV Refineries	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)
HMEL	10.71	10.52	8.83	12.47	12.24	10.07	13.03
BORL	6.40	6.36	6.71	5.71	7.91	6.19	7.41
SUB TOTAL	**17.11**	**16.88**	**15.54**	**18.18**	**20.15**	**16.26**	**20.44**

Pvt. Refineries	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21 (P)	2021-22 (P)
NEL	19.11	20.92	20.69	18.89	20.62	17.07	20.16
RIL	69.50	70.20	70.50	69.14	68.89	60.94	63.02
SUB TOTAL	**88.61**	**91.12**	**91.19**	**88.03**	**89.51**	**78.01**	**83.19**

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21 (P)	2021-22 (P)
All India Crude Processing	**232.90**	**245.40**	**251.90**	**257.25**	**254.38**	**221.77**	**241.70**

Source : PIB Release/PPAC

CRUDE CAPACITY VS. PROCESSING

	Capacity On 01/01/2022 Million MT	% Share	Crude Processing 2021-22 (P)	% Share
PSU Ref	141.9	56.9	138.1	57.1
JV. Ref	19.1	7.7	20.4	8.5
Pvt. Ref	88.2	35.4	83.2	34.4
Total	**249.9**	**100**	**241.7**	**100**

Source: PIB/PPAC

POL PRODUCTION (Million MT)

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)
From Refineries	227.9	239.2	249.8	257.4	258.2	229.3	250.2
From Fractionators	3.4	3.5	4.6	4.9	4.8	4.2	4.1
Total	**231.2**	**242.7**	**254.4**	**262.4**	**262.9**	**233.5**	**254.3**

DISTILLATE PRODUCTION (Million MT)

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)
Light Distillates, MMT	67.1	71.0	74.7	75.4	76.8	71.4	76.5
Middle Distillates , MMT	118.3	122.5	127.5	130.8	130.2	110.7	120.2
Total Distillates, MMT	188.8	196.9	206.8	211.1	211.7	186.3	200.7
% Distillates Production on Crude Processing	**79.9**	**79.1**	**80.6**	**80.5**	**81.7**	**82.4**	**81.7**

Source: PIB/PPAC

PETROLEUM PRICING

OIL IMPORT - VOLUME AND VALUE

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)
Quantity, Million Mt	202.9	213.9	220.4	226.5	227.0	196.5	212.0
Value, INR ₹000 cr.	416.6	470.2	565.5	783.2	717.0	469.8	899.3
Value, USD Billion	64.0	70.2	87.8	111.9	101.4	62.2	120.4
Average conversion Rate, INR per USD (Calculated)	65.1	67.0	64.4	70.0	70.7	75.5	74.7

OIL IMPORT - PRICE USD / BARREL

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)
Brent (Low Sulphur - LS-marker) (a)	47.5	48.7	57.5	70.0	61.0	44.3	80.7
Dubai (b)	45.6	47.0	55.8	69.3	60.3	44.6	78.1
Low sulphur-High sulphur differential (a-b)	1.8	1.7	1.6	0.7	0.6	-0.3	2.7
Indian Crude Basket (ICB)	46.17	47.56	56.43	69.88	60.47	44.82	79.18
ICB High Sulphur share %	72.28	71.03	72.38	74.77	75.50	75.62	75.62
ICB Low Sulphur share %	27.72	28.97	27.62	25.23	24.50	24.38	24.38

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

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)
Gasoline	61.7	58.1	67.8	75.3	67.0	47.5	89.7
Naphtha	48.5	47.1	56.3	65.4	55.1	43.9	79.9
Kero / Jet	58.2	58.4	69.2	83.9	70.4	45.8	87.3
Gas Oil (0.05% S)	57.6	58.9	69.8	84.1	74.1	50.0	90.2
Dubai crude	45.6	47.0	55.8	69.3	60.3	44.6	78.1
Indian crude basket	46.2	47.6	56.4	69.9	60.5	44.8	79.2

CRACKS SPREADS ($/ BBL.)

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)
Gasoline crack							
Dubai crude based	16.1	11.1	12.0	5.9	6.7	2.9	11.7
Indian crude basket	15.6	10.6	11.4	5.4	6.5	2.6	10.5
Diesel crack							
Dubai crude based	12.0	12.0	13.9	14.8	13.8	5.5	12.2
Indian crude basket	11.5	11.4	13.4	14.2	13.6	5.2	11.0

DOMESTIC GAS PRICE ($/MMBTU)

Period	Domestic Gas Price (GCV Basis)	Price Cap for Deepwater, High temp High Pressure Areas
April 16 - September 16	3.06	6.61
October 16 - March 17	2.50	5.30
April 17- September 17	2.48	5.56
October 17 - March 18	2.89	6.30
April 18 - September 18	3.06	6.78
October 18 - March 19	3.36	7.67
April 19 - September 19	3.69	9.32
October 19 - March 20	3.23	8.43
April 20 - September 20	2.39	5.61
October 20 - March 21	1.79	4.06
April 21 - September 21	1.79	3.62
October 21 - March 22	2.90	6.13
April 22 - September 22	6.10	9.92

Source: PIB/PPAC/OPEC

CGD INFRASTRUCTURE

		As on 31st March 2019	As on 31st March 2020	As on 31st March 2021	As on 31st March 2022	As on 30th Apr 2022 (P)
PNG	Domestic	50,43,188	60,68,415	78,20,387	93,02,667	94,12,909
	Commercial	28,046	30,622	32,339	34,854	35,031
	Industrial	8,823	10,258	11,803	13,215	13,320
CNG	CNG Stations	1,730	2,207	3,101	4,433	4,462
	CNG Vehicles	33.47 lakhs	37.10 lakhs	39.55 lakhs	44.09 lakhs	44.66 lakhs

Source: PPAC/Vahan

MAJOR NATURAL GAS PIPELINE NETWORK As on 31.03.2022

Nature of Pipeline		GAIL	GSPL	PIL	IOCL	AGCL	RGPL
Operational	Length	9,602	2,695	1,459	143	107	304
	Capacity	167.2	43.0	85.0	20.0	2.4	3.5
Partially commissioned#	Length	4,519			166		
	Capacity						
Total operational length		**14,121**	**2,695**	**1,459**	**309**	**107**	**304**
Under construction	Length	5,404	100		1,265		
	Capacity		3.0				
Total length		**19,524**	**2,795**	**1,459**	**1,574**	**107**	**304**

Nature of pipeline		GGL	DFPCL	ONGC	GIGL	GITL	Others*	Total
Operational	Length	73	42	24				**14,449**
	Capacity	5.1	0.7	6.0				**333**
Partially commissioned#	Length				1,131	365		**6,180**
	Capacity							-
Total operational length		**73**	**42**	**24**	**1,131**	**365**	**0**	**20,629**
Under construction	Length				1,1201	1,666	3,550	**13,186**
	Capacity						149.0	-
Total length		**73**	**42**	**24**	**2,332**	**2,031**	**3,550**	**33,815**

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

Source: PPAC/PNGRB

EXISTING LNG TERMINALS

Location	Companies	Capacity (MMTPA) As on 01st June 22	Capacity Utilisation (%) April 2022
Dahej	Petronet LNG Ltd	17.5	77.3
Hazira	Shell Energy India Pvt Ltd	5.2	17.3
Dabhol*	Konkan LNG Ltd	5	50.7
Kochi	Petronet LNG Ltd	5	19.4
Ennore	Indian Oil LNG Pvt Ltd	5	10.0
Mundra	GSPC LNG Ltd	5	12.6
Total Capacity		**42.7 MMTPA**	

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

Member Organizations

S No	Organization	Name	Designation
1	Antelopus Energy Pvt Ltd	Mr. Suniti Bhat	Chief Executive Officer
2	Axens India (P) Ltd.	Mr. Siddhartha Saha	Managing Director
3	Baker Hughes, A GE Company	Mr. Neeraj Sethi	Country Leader
4	Bharat Oman Refineries Ltd.	Mr. Abhairaj Singh Bhandari	Chief Executive Officer
5	Bharat Petroleum Corporation Ltd.	Mr. Arun Kumar Singh	Chairman & Managing Director
6	BP Group	Mr. Sashi Mukundan	President, bp India & Senior Vice President, bp group
7	Cairn Oil & Gas, Vedanta Limited	Mr. Sunil Duggal	Group CEO, Vedanta Ltd.
8	Chandigarh University	Mr. Satnam Singh Sandhu	Chancellor
9	Chennai Petroleum Corporation Ltd.	Mr. Arvind Kumar	Managing Director
10	Chi Energie Pvt. Ltd	Mr. Ajay Khandelwal	Director
11	CSIR-Indian Institute of Petroleum	Dr. Anjan Ray	Director
12	Decom North Sea	Mr. Will Rowley	Interim Managing Director
13	Dynamic Drilling & Services Pvt. Ltd.	Mr. S. M. Malhotra	President
14	Engineers India Ltd.	Ms. Vartika Shukla	Chairman & Managing Director
15	Ernst & Young LLP	Mr. Rajiv Memani	Country Manager & Partner
16	ExxonMobil Gas (India) Pvt. Ltd.	Mr. Monte Dobson	Chief Executive Officer
17	FMC Technologies India Pvt. Ltd.	Mr. Housila Tiwari	Managing Director
18	GAIL (India) Ltd.	Mr. Manoj Jain	Chairman & Managing Director
19	GSPC LNG Ltd.	Mr. Anil K. Joshi	Chief Executive Officer
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.	Dr. Pushp Kumar Joshi	Chairman & Managing Director
23	HPCL Mittal Energy Ltd.	Mr. Prabh Das	Managing Director & CEO
24	HPOIL Gas Private Ltd.	Mr. Arun Kumar Mishra	Chief Executive Officer
25	IHS Markit	Mr. James Burkhard	Managing Director
26	International Gas Union	Mr. Luis Bertran	Secretary General
27	IIT (ISM) Dhanbad	Prof. Rajiv Shekhar	Director
28	IMC Ltd.	Mr. A. Mallesh Rao	Managing Director
29	Indian Gas Exchange Ltd.	Mr. Rajesh Kumar Mediratta	Managing Director & CEO
30	Indian Oil Corporation Ltd.	Mr. S.M. Vaidya	Chairman
31	Indian Strategic Petroleum Reserves Ltd		Chief Executive Officer & MD
32	Indraprastha Gas Ltd.	Mr. Sanjay Kumar	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	Mr. Rahul V. Karad	Executive President
41	Mangalore Refinery & Petrochemicals Ltd.	Mr. M. Venkatesh	Managing Director
42	Megha Engineering & Infrastructures Ltd.	Mr. P. Doraiah	Director
43	Nayara Energy Ltd.	Mr. Tony Fountain	Chairman
44	Numaligarh Refinery Ltd.	Mr. Bhaskar Jyoti Phukan	Director (Tech.) & MD (I/c)
45	Oil and Natural Gas Corporation Ltd	Dr. Alka Mittal	CMD (Addl. Charge) & Director (HR)
46	Oil India Ltd.	Mr. Sushil Chandra Mishra	Chairman & Managing Director
47	Petronet LNG Ltd.	Mr. Akshay Kumar Singh	Managing Director & CEO
48	Pipeline Infrastructure Ltd.	Mr. Akhil Mehrotra	Chief Executive Officer
49	Rajiv Gandhi Institute of Petroleum Technology	Prof. A.S.K Sinha	Director
50	Reliance BP Mobility Ltd.	Mr. Harish C. Mehta	Chief Executive Officer
51	Reliance Industries Ltd.,	Mr. Mukesh Ambani	Chairman & Managing Director
52	SAS Institute (India) Pvt Ltd.	Mr. Noshin Kagalwalla	CEO & Managing Director-India
53	Schlumberger Asia Services Ltd	Mr. Vinay Malhotra	Managing Director
54	Scottish Development International	Mr. Kevin Liu	Head of Energy Trade, Asia Pacific
55	Secure Meters Ltd.	Mr. Sunil Singhvi	CEO - Energy
56	Shell Companies in India	Mr. Nitin Prasad	Country Chair
57	Siemens Limited	Mr. Gerd Deusser	CEO (Siemens Energy - India)
58	SNF Flopam India Pvt. Ltd	Mr. Shital Khot	Managing Director
59	South Asia Gas Enterprise Pvt. Ltd.	Mr. Subodh Kumar Jain	Director
60	THINK Gas Distribution Pvt. Ltd.	Mr. Hardip Singh Rai	Chief Executive Officer
61	TotalEnergies Marketing India Private Ltd.	Ms. Ahlem FRIGA-NOY	Country Chair
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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