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

From the Desk of the

Director General

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

Dear Members,

As I look back at the last quarter, the global economy and particularly the energy sector has been witnessing several challenges since the outbreak of the Russia Ukraine crisis. The high levels of inflation with rising fuel, food, and fertilizer prices owing to heightened geopolitical tensions and global risks, is hurting the growth momentum globally. The global economy is still reeling from the pandemic and the current geopolitical conflict between Russia and Ukraine, as the IMF in its July, 2022 report has reduced the global GDP growth rate from 3.6% to 3.2% for 2022.

The average Brent crude oil spot price declined by 17% from USD 106/bbl in July 2022 to USD 87.5/bbl in September 2022 due to policy rate hikes by major central banks, and concerns of a slowdown in the Chinese economy that has impacted oil and fuel demand. Further, a challenging economic environment and recurring COVID lockdowns in China continue to weigh on market sentiment. According to IEA, world oil demand is forecasted at 99.7 mb/d in 2022 and 101.8 mb/d in 2023.

As far as India is concerned, the IMF has revised India's GDP growth forecast for the current fiscal year 2022-23 to 7.4 % due to factors such as rising inflation, geopolitical tensions and rapid policy tightening by the Reserve Bank of India (RBI). High inflation prompted the RBI to raise the repo rate to 5.40 % in August, 2022.

According to the recent World Oil Outlook 2022, publication by Organization of Petroleum Exporting Countries (OPEC), the oil demand in India is expected to reach around 5.14 million barrels per day in 2022 as compared to 4.77 million barrels per day in 2021. According to OPEC, India's demand for petroleum products will grow by 7.73 % in FY 2022-23, the fastest pace in the world. The demand for petroleum products in India is supported by the healthy economic growth, opening of the economy post COVID and easing of trade-related bottlenecks supporting both mobility and industrial sector activity.

Key Policy Developments in Oil & Gas Sector during July-September'2022

In the upstream segment, the Directorate General of Hydrocarbons (DGH) under the aegis of Ministry of Petroleum & Natural Gas (MoP&NG) had organized an Investors Meet in London on 7th - 8th July, 2022 to engage with prospective global investors and E & P companies. This event was organized to apprise the investors and the E&P companies about E&P opportunities in India, policy initiatives and incentive structures. The 2nd edition of the Investors Meet on opportunities in the Indian E&P sector was held in Houston, USA on 28th-29th September, 2022.

Further, in continuation of its zeal to accelerate the E&P activities, the Government had launched the OALP Bid Round-VIII, offering 10 blocks, for International Competitive Bidding on July 7, 2022. Successful award of Round-VIII Blocks would add a further 36,316 sq. km of Exploration Acreage and cumulative exploration acreage under OALP regime will be increased to 2,44,007 sq. km.

Amid rising concerns over global natural gas prices, the MoP&NG has set up an expert committee under noted energy expert Dr. Kirit Parikh, Chairman, Integrated Research and Action for Development (IRADe) to examine the issues of domestic natural gas pricing regime as per guidelines dated

25.10.2014 and 21.03.2016 (Marketing & Pricing Freedom for the gas to be produced from difficult fields).

On 10th August, 2022, MoP&NG had ordered the diversion of natural gas from industries to the city gas distribution sector to ease CNG and piped cooking gas prices that have increased significantly over the last few months. The higher allocation is expected to meet a major part of the demand for CNG to automobiles and piped cooking gas to household kitchens in the country.

Further, as the world is witnessing a transitional shift from traditional energy sources to cleaner energy solutions, the initiatives taken by the Government of India by extending the excise duty exemption to biofuels to encourage the blending of higher proportions of ethanol and components of vegetable oil with gasoline and diesel, is a welcome step towards energy sustainability.

The Union Cabinet chaired by the Hon'ble Prime Minister of India, Shri Narendra Modi has also approved India's updated Nationally Determined Contribution (NDC). As per the updated NDC, India now stands committed to reduce Emissions Intensity of its GDP by 45 % by 2030, from 2005 level and achieve about 50 % cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.

Events and Webinars organized by FIPI during July-September'2022

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

On 19th July 2022, FIPI jointly with bp India organized the bp Energy Outlook – 2022 edition at New Delhi. This Outlook was unveiled in a physical gathering and was attended by Shri Hardeep Singh Puri, Hon'ble Minister of Petroleum & Natural Gas and Housing & Urban Affairs; Shri Rameswar Teli, Hon'ble Minister of State of Petroleum & Natural Gas and Ministry of Labor & Employment; Shri Pankaj Jain, Secretary, MoP&NG; Mr. Spencer Dale, Group Chief Economist, bp plc and eminent CMDs of major oil and gas companies in the country. Mr. Spencer Dale, made a detailed presentation on the bp Energy Outlook 2022. He mentioned that there is a strong growth in the primary energy market in India led by renewables and natural gas and this growth is underpinned by increasing population and rapid industrialization. He also discussed the future of the energy sector and India's energy scenario in the ongoing energy transition.

On 30th July 2022, FIPI organized a webinar on "Basic Refining Economics and Relevance of Planning" exclusively for its Student Chapters wherein Mr. Sachin Singh, Senior Principal Consultant, Aspen Technology was the speaker. It was attended by 56 participants from FIPI Chapters at various institutes/Universities in India.

During August 03-04, 2022, FIPI participated for the first time at the Tanzania Energy Congress 2022 in Dar Es Salaam, Tanzania. FIPI was responsible for setting up the India pavilion on behalf of oil and gas industry wherein IOCL, BPCL, HPCL & GAIL participated as co-exhibiters. The Indian delegation portrayed the key areas of expertise such as increasing LPG penetration, exports of petrochemicals, including lubes, and developing CGD & CNG infrastructure across the country.

On 23rd August 2022, FIPI in association with EY organized a webinar on 'Recent Developments in Direct and Indirect Taxes Impacting Oil and Gas Sector'. The webinar witnessed an overwhelming response with participation of more than 300 professionals working across the oil and gas value chain.

On 9th September 2022, FIPI organized an open house with Shri Hardeep S Puri, Hon'ble Minister of Petroleum & Natural Gas and Housing & Urban Affairs at New Delhi. At the event, the Hon'ble Minister witnessed the contract exchange ceremony for 30 Discovered Small Fields (DSF) blocks under DSF bid round-III and 4 CBM blocks under special CBM bid round 2021 awarded to 14 Exploration & Production (E&P) companies. During the event, the Minister also unveiled the logo for India Energy Week (IEW) 2023, the Ministry's flagship event taking place from 6th- 8th February 2023 in Bengaluru, India.

FIPI in association with Great Lakes Institute of Management organized a three-day training program on "Project Finance and Environment, Social and Governance (ESG)" on September 28-30, 2022 at Varanasi. The program was attended by 39 mid to senior level executives from key oil & gas companies.

Ongoing FIPI Studies

FIPI is currently carrying out an industry study on 'Emerging Hydrogen Market and its Opportunities in India' for assessing the hydrogen market potential in India. The study aims to assess the options for hydrogen production, storage, transportation, demand from various sectors, cost economics, etc. and recommendations for developing a hydrogen economy in India. The study is being carried out by ICF as the Knowledge Partner.

Further, FIPI in collaboration with The Energy and Resources Institute (TERI), is carrying out a study on the "Scope and Role of Natural Gas in Mitigating Industrial Air Pollution". The study focuses on three Industrial clusters: three industrial clusters, namely Gurgaon (Haryana), Varanasi (UP) and Sangareddy (Telangana). The findings of this study will go a long way in increasing the acceptability of natural gas as a replacement fuel in industrial clusters among policymakers.

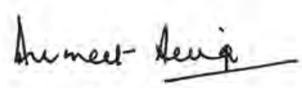
During the last quarter, FIPI has also conducted various Committee meetings with our industry members to discuss the relevant issues pertaining to the oil and gas sector and have been continuously working to address their issues with the concerned Ministry, Regulator, and other stakeholders from time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

Conclusion

FIPI strongly believes that the Indian oil and gas industry is taking significant strides towards being an integrated energy sector with an increased focus on clean energy fuels like bio-fuels, batteries and hydrogen etc. and thus playing a crucial role in transitioning India towards a cleaner and a sustainable form of energy.

I assure you that FIPI stands strong by the industry and will be at the forefront advocating for a supportive policy ecosystem for the larger growth and development of the nation.

I wish all readers and their families a happy festive season!



Gurmeet Singh

The Comparison of Valve Regulated Lead Acid (VRLA) and Lithium-Ion (LTO & LFP) Battery Technology for Offshore Oil & Gas Unmanned Platform Applications

Avinash Kumar
Offshore engineering Services

Oil and Natural Gas Corporation Limited

Abstract:

The future outlook of oil and gas is challenging owing to many factors. The most prominent of these are low oil prices, emergence of new hydrocarbon sources, increasing penetration of renewable energy, electric vehicle, strict carbon regulation, better energy storage technology. Up-stream oil and gas industry needs Industry 4.0 for digital transformation. This disruptive potential arising jointly development of Internet-of-Thing (IOT), artificial intelligence (AI), robotics, private LTE/4G network at offshore and other advanced technologies which requires considerable amount of reliable power at it's furthest and remotest well platforms in offshore. Valve Regulated Lead Acid (VRLA) battery has served till date but upcoming future power demands at unmanned for intelligent and real time Asset Management is need of hour for sustainable development of offshore up-stream business. In this technical paper we will compare new Li-ion (Lithium Titanate Oxide and Lithium Iron Phosphate) battery technology which will be the backbone for IOT, AI, robotics, automation, high speed data connectivity (surveillance, monitoring and control) of remote/isolated unmanned well platforms in offshore. This new battery technology not only will reduce the foot print, weight, and serve longer life but also meets a reliable power demands for future technologies in up-stream oil & gas industries.

Keywords: *Industry 4.0, Internet-of-Thing (IOT), Artificial Intelligence (AI), Robotics, Valve Regulated Lead Acid (VRLA), Lithium Titanate Oxide (LTO), Unmanned Well Platform*

I. Introduction

For last several decades battery energy storage solution for unmanned offshore platforms have not been updated and till date Indian oil and gas industries specially ONGC who is major operator in offshore is dependent on valve regulated lead acid (VRLA) batteries. VRLA has proven past tracks for energy storage solution but major issue is footprint, heavy weight, charging-discharging rate, self-life and frequent replacement (less charge-discharge cycle). Lithium titanate Oxide (LTO) and Lithium Iron Phosphate (LFP) is one kind of Li-ion cell/ battery chemistry, designed and developed by Li-ion cell manufacturers primarily for Electric Vehicle (EV) segments in industry. LTO & LFP cell technology has worth considering it's benefits comparing with VRLA battery technology. Slowly and gradually when Li-ion battery technology matured in EV market, Lithium Titanate Oxide (LTO) an LFP cell chemistry also established it's presence, LTO & LFP technology is proven and accepted in EV industries due to its highest life cycle (20,000 cycle), fast charging, huge current withdrawal capacity, stability and safest among other Li-ion chemistry due to presence of titanate inside. Cost effective, efficient and intelligent Asset Management (Specially offshore up-stream business) for ONGC is the prime objective of this paper.

II. Background

A. Solar + VRLA age (1970 to 2020)

Last 4-5 decades unmanned well platforms needs power for RTU/SCADA/Telemetry, Instrumentation/ sensors, Fire & gas detection system, Navigational

Aids etc. these are the basic requirements to operate any unmanned oil/gas well platforms in offshore. 1970's to 2020 we have survived with solar panels for power generation and VRLA batteries for power storage device to meet all power demands during nights, no-sun days. Last one decade digitalization, data communication and automation entered in all industry including up-stream oil & gas and now Industry 4.0 revolution is ahead. As the industry revolution is evolving power demands also increased accordingly. This new power demands cannot be met from 50 years old VRLA technology. Solar panels are still number one choice for power generation due to improved efficiency, static parts (no moving parts means negligible maintenance at unmanned platforms).

B. Maturity of EV market and Li-ion battery technology

This is the time now when Li-ion battery technology is proven itself in EV market for its safety, high energy density, and compact in size, lower weight, longer life and better charge-discharge rate as compared to VRLA batteries. This proven Li-ion battery technology can be adopted in offshore unmanned platform to meet its power demand (Existing and for future technologies).

Future power demand may be in the form of digitalization of offshore Asset, IOT, AI, Private LTE/4G in offshore these are the part of Industry 4.0 revolution for upstream companies to overcome the new challenges, improve there efficiencies, minimize the shutdowns or losses, able to take better and fast decisions. All these can be possible in future with continuous and reliable power supply with the help of matured battery technology that is Lithium Titanate Oxide (LTO) and Lithium Iron Phosphate (LFP) Li-ion chemistry.

III. Different Chemistries in Li-ion technology

Lithium Ion cell has 6 established chemistries in the market, these are primarily designed and developed for mobile, laptop, rechargeable appliances/toys, power tools later on demand came in plug in hybrid electric vehicle (PHEV), Electric Vehicles, Fork lifter, public transport, Railways, Trolly buses, on grid frequency regulation, off grid energy storage solution etc. Li-ion has proven a success stories in all the fields today, whether it is mobile, laptop or EV every energy demand are fulfilled by this technology. Following are some successful Li-ion chemistry in the market.

Table 1: Properties of Li-ion chemistries

Li-ion Chemistries	Target Application	Life cycle/Energy Density (Wh/kg)	Benefits
Lithium cobalt oxide (LCO)	Broad use, laptop	300-700/ 150-240	High specific energy
Lithium manganese oxide (LMO)	Hybrid EV, Cell phone, laptop	300-1000/ 100-150	High specific energy, good life span
Lithium nickel cobalt aluminum (NCA)	EV	300-1000/ 130-240	High specific energy, good life span
Lithium nickel manganese cobalt oxide (NMC)	EV, Power Tools, Grid Energy Storage	1000-4000/ 120-220	Good specific energy and specific power
Lithium Iron Phosphate (LFP)	Aviation, EV, Power tools, PHEV	1000-5000/ 100-150	Moderate density, temp range, long life
Lithium Titanate Oxide (LTO)	Aviation, EV, Power tools, PHEV	6000-20000/ 85-130	Safety, Rapid charging, Long life

Offshore oil and gas upstream industry (specially unmanned platforms ONGC) still not have experienced the Li-ion technology and its benefits. The main reason is Li-ion cell and battery manufacturer have not concentrated this niche market. Most of the products/battery modules available are either designed for EV, ESS, UPS, etc. whereas unmanned offshore platforms have certain conditions and design criteria before adoption of Li-ion as power storage. Offshore design of engineering services is working on the same with cell manufacturers and will come up with the solution soon.

Selecting a lithium titanate oxide (LTO) or lithium iron phosphate (LFP) chemistry for unmanned offshore application has a reason, these two chemistries are stable, safe, very high thermodynamic stability (Low risk of fire due to high thermal runaway capabilities as compared to other chemistries), very long life (20,000 charge discharge cycle life means more than platform design life), wide effective SOC (Available state of charge range is 0-100%), rapid charging and discharging capacity (highest C-Rate among other chemistry), no specific cooling is required and it's battery abuse tolerance (phase transformation capability of anode during internal short circuit unlike with graphite or carbon anodes).

Lets have to look at Valve Regulated Lead Acid (VRLA) batteries comparison with LTO/LFP. Lithium-ion batteries are more energy dense, lighter, and discharge rate is faster than VRLA. C-Rate is more than the ten times compare to VRLA.

Table 2: Properties of LTO, LFP and VRLA cells

Battery Chemistries	Target Application	Life cycle/Energy Density (Wh/kg)	Benefits
Lithium Iron Phosphate (LFP)	Aviation, EV, Power tools, PHEV	1000-5000/ 100-150	Moderate density, temp range, long life
Lithium Titanate Oxide (LTO)	Aviation, EV, Power tools, PHEV	6000-20000/ 85-130	Safety, Rapid charging, Long life
Valve Regulated Lead Acid (VRLA)	UPS, ESS	1500-2000/ 40-50	

Other comparison are as following

Table 3: Other comparison of LTO and VRLA

Chemistry	VRLA	LTO
Cost Comparison	X	2.5X
Charge rate	0.5C	7C
Discharge rate	1C	7C
Operating Temp.	10 to 30 degree C	-30 to 55 d.c.

As seen above VRLA initial costs is less compared to LTO or LFP but considering other factors like energy density two to three times more with LTO (space and weight is major consideration for offshore platform design, LTO can save both less than half of weight and volume compare to VRLA), cycle life which defines the life of battery, LTO stands more than 25 years a biggest reason for selection for unmanned offshore application and charge discharge rate (since solar panels are the only source of power generation LTO charges quickly when sun is available whereas VRLA take its own time 8-10 hrs) this technical benefits of LTO also make it first preference for remote unmanned platform application.

As on date unmanned offshore platforms are restricted with 24/48V DC power availability only. With Li-ion new technology it can be possible to provide single or three phase AC power which can be used for chemical dosing, valve actuation (opening or closing), night landing facilities, small maintenance jobs etc. within the cost of existing VRLA technology. VRLA has another drawback that is voltage drop due to 24/48 VDC system, this is the main reason where power cable size increases drastically and it invites for cable theft in offshore. Cable size can be reduced with higher voltage option and this can be possible with Li-ion technology. Lower cable size reduces cost, weight and laying/replacement feasibility in offshore.

A. Life Cycle calculation

Typical solar powered unmanned offshore platform is charging during day and discharging during night.

1 day = 1 charge/discharge cycle (Assumption)
1 year = 365 charge/discharge

VRLA capacity varies from 1500 to 2000 cycles
VRLA life = 2000/365 = 5.5 years (more years with reduced capacity, please refer graph)

LTO capacity – 15000 to 20000 cycles
LTO life = 15000/365 = 40 years (Platform design life is 25 years)

LFP capacity 5000 to 10000
LFP battery life = 5000/365 =13 years
Note: VRLA battery performance/capacity reduces after 5-7 years and replacement is required.

B. Typical Load analysis of unmanned

• System-I (RTU/SCADA): Existing energy demand is 20-22 KWhr per day (In future private LTE/4G)
• System-II (Instrumentation system): Existing energy demand is 9-10 KWhr (In future more sensors, dosing, actuators and automation may come)
• System-III (Fire and Gas system): Existing energy demand is 18-20 KWhr
• System-IV (Navigational Aid System): 100-200 Whr
(Actual load list data from solar powered HRP-III platform project)

These are the critical loads of unmanned and powered from solar + VRLA, but major issue arises when system getting nonfunctional due to VRLA battery life finished at 5-7 years. Replacement of VRLA battery bank in offshore is a major job.

C. Digitalisation of offshore Assets

This is the future of up-stream offshore oil and gas to improve and optimize it's offshore assets. Digital transformation of field data is the demand of time, it will impact the value chains. New technology will link physical and digital system. By connecting physical production assets with digital systems, operator can generate a real time data and analyze insights to make better decisions about their assets. Offshore operators can respond in real-time to unexpected events that might affect production.

Technology is readily available for digitalization of offshore assets but every technology needs reliable power. LTO and LFP Li-ion battery technology can meet the future power demands of offshore platforms.

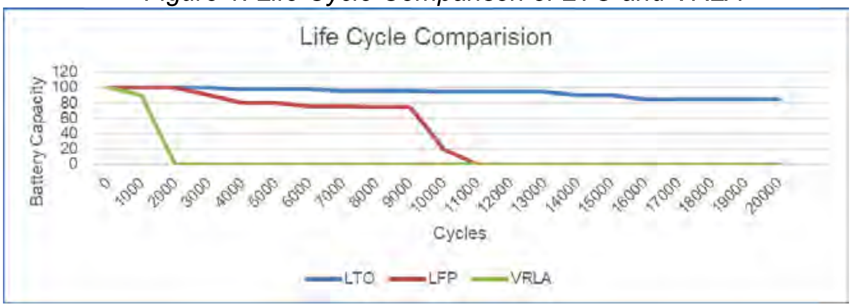
D. Some Common Mistakes

Remote unmanned offshore platforms are almost need a zero maintenance kind of technology, a single moving parts like a cooling fan inside any equipment may cause of failure of that system at unmanned. Micro wind turbines, thermo electric generators (TEG), combined cycle vapor turbine (CCVT), micro turbine all have the moving parts and need supervision and sometimes maintenance also. All are installed in Mumbai offshore field but none of them replaced solar panels, reason is simple it's a static power generating equipment. Again power non-availability at any unmanned is due to VRLA battery bank failure and not due to solar panels. Solar panels only need cleaning for better performance (uncleansed panels reduces output but generate 70-80% power of it's rated capacity)

Note: Solar panels installed in Mumbai offshore is the world highest efficient solar panels (credit goes to offshore engineering services). Offshore engineering services is working on Li-ion cell technology also and will come with the solution soon in future.

IV. Why Technology Matters for Offshore

Figure 1: Life Cycle Comparison of LTO and VRLA



Offshore oil and gas business is entirely different then onshore. Platforms have limited space, energy storage presently device such as VRLA batteries occupies complete battery room in unmanned whereas LTO / LFP Li-ion batteries can eliminate the separate battery room concept, footprint requirement of LTO/LFP is such that can be accommodate in electrical/Instrumentation room itself. The second factor is Li-ion does not release hydrogen or any such gases which is not with VRLA (separate room is mandatory for VRLA).

Weight is the third factor with VRLA, lead acid battery bank can never become portable but Li-ion battery bank can be portable/plug and play type and also replacement (which is not at all required for entire platform life of 25 years with LTO) is the big issue with VRLA. Offshore material handling involves crane, vessel and special care and time but new battery technology can eliminate all and provide highly reliable, efficient, cost effective solution for existing power demands and for future as well.

Offshore oil and gas fields are facing high speed data connectivity problem till date. Due to distance from shore and non-availability of subsea cables for data, unmanned as well as process complexes are dependent on satellite communication (bandwidth and data speed is restricted). Technology called private LTE/4G is available for remote mining and for offshore, private LTE/4G can connect our all remote assets with high speed data, voice and HD video call but challenge is to how to provide power to these private LTE/4G network in offshore. LTO/LFP Li-ion battery can solve all this kind of issues and offshore oil fields can be ready for IOT, AI etc. in near future.

Conclusion: There are several applications where VRLA may still be a viable option, particularly if it is onshore and payback period is shorter. New emerging and established lithium-ion battery technology has proven in EV market. Oil and gas up-stream especially offshore unmanned is the best suitable place of application for this new technology.

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On-Purpose Production of LPG: Emerging Alternatives

Sayanti Ghosh

Dr. Chanchal Samanta

Dr. Chiranjeevi Thota

Dr. Bharat Newalkar

Dr. Ravi Kumar Voolapalli

Bharat Petroleum Corporation Limited
Corporate R&D Centre

Introduction

Rapid urbanization and industrialization have demanded increased consumption of fossil fuels leading to excessive emission of CO_2 into the environment and causing climate changes. Thus, it is imperative to reduce our over reliance on fossil fuels by alternative sources of energy having lower carbon footprints. Governments around the world have taken major initiatives to reach the goal of carbon neutrality by introducing alternative fuels such as hydrogen, compressed biogas (CBG), renewable ethanol, methanol, DME, LPG, SAF etc in the energy mix.

Liquefied petroleum gas (LPG) offers high-octane number (≥ 95) which almost equates it to super grade leaded petrol, making it highly suitable for powering automotive engine. LPG contains a flammable mixture of hydrocarbon gases, specifically propane (C_3H_8) and butane (C_4H_{10}). It serves as convenient, portable energy source and easy to store and sold in gas cylinders. Under modest pressure or in cooler conditions, LPG transforms into a liquid state. Besides this, with a high heating or calorific value, LPG provides a high level of heat in a short lifetime. The specific calorific value of LPG is around 46 MJ/kg or 12.78 kWh/kg depending on the composition of LPG [1,2]. Owing to its unique properties, LPG is a versatile energy source that can be used in a wide variety of end applications (Figure 1). LPG is used everyday in several sectors as below

- In residential sector for cooking, water heating and lighting purpose.
- In agriculture to increase the production and the quality of farm products and power farm equipment such as irrigation pumps.
- In Petrochemical sector it serves as a petrochemical feedstock for olefins production.
- In Industry applications like heat treatment furnaces, direct firing of ceramic kilns, glass working, textile and paper processing and paint drying. LPG can also be used as back-up fuel for electricity generators, including hybrid renewable energy systems in remote locations.
- In transport sector as a low-emission alternative to gasoline and diesel for vehicles

It may be interesting to note more than 3 billon people use LPG from Asian mega cities to remote bases on Antarctica and LPG even powers the Olympic torch. That's why LPG is often referred to as the "world's most multi-purpose energy".

As per estimate by Grand View Research [3], the global LPG market size was valued at USD 116.41 billion in 2019 and is expected to grow at a compound annual growth rate (CAGR) of 4.4% from 2020 to 2027 to 164.36 billion USD. According to International Energy Agency (IEA), LPG demand is expected to reach nearly 375 MMT (million metric tons) by 2030. The major drivers for LPG consumption are increase in world population, rapid urbanization, government initiatives to use cleaner fuel, industrialization, and investments in developing countries. North America is dominating the market, making United States as the leading LPG exporter globally. During 2020, the country exported 47.1 million tons of LPG, witnessing a hike from 40.8 million tons in 2019.

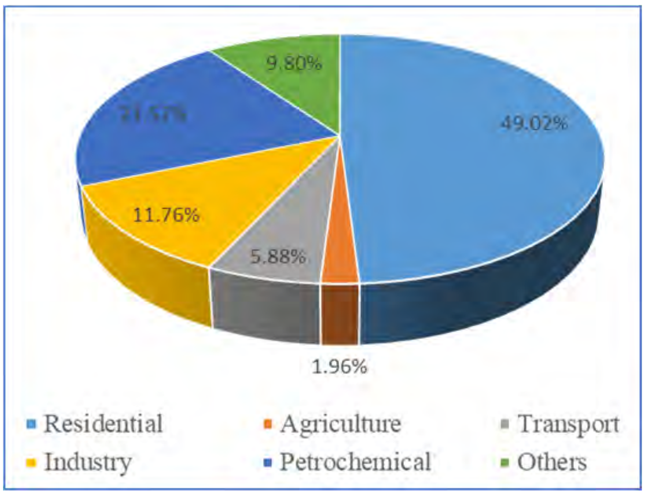

Figure 1. LPG global demand distribution among several sectors [Ref 3]

LPG demand scenario in India

A few years ago, many Indian households were deprived of LPG as a cooking fuel, and they relied on crude forms of cooking which in turn cause alarming household pollution and adversely affects the health of women & children leading to serious respiratory diseases/disorders. Thus, the government had launched various schemes like PAHAL and Pradhan Mantri Ujjwala Yojana (PMUY) to provide cleaner cooking gas (LPG) connection to the underprivileged section of the society. The rapid rise in population combined with LPG distribution in rural areas has resulted in an average growth of 8.4% in LPG consumption, making India the 2nd largest consumer of LPG in the world at 22.5 MMT. As per (oil) ministry's projections and forecasts, LPG consumption is expected to grow to 30.3 MMT by 2025 and 40.6 MMT by 2040. LPG demand has seen an increasing trend in India in the past 5 years [4].

As per data of Petroleum Planning and Analysis Cell (PPAC), India's LPG consumption has increased drastically from 19.6 MMT during FY 2015-16 to 27.5 MMT during FY 2020-21 (Figure 2). Some of important facts of Indian LPG market scenario is provided below:

• PSUs OMCs (IOCL, BPCL and HPCL) together have 30.95 crore active LPG customers.
• PSU OMCs have a total 203 bottling plants all over India with rated bottling capacity of around 21.74 million metric tons per annum (MMTPA).
• To cater LPG demand in the automotive sector, PSU OMCs have established a total 571 Auto LPG dispensing stations all over India.
• During April-Jun 2022, 48.33 lakh new domestic customers were enrolled by PSU OMCs

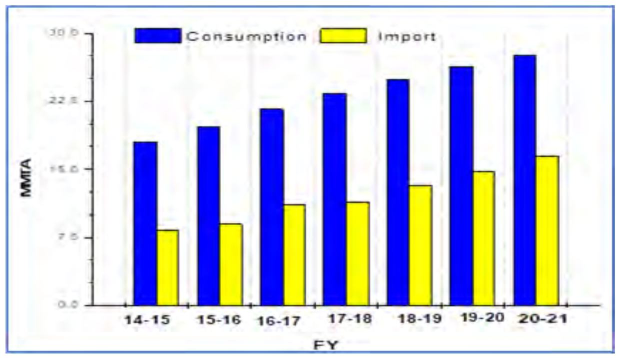

Figure 2. India's recent trends of consumption and import of LPG (source: PPAC)

With ease of storage, transportation and clen and efficient energy source, LPG is expected to create immense opportunities for the Indian and global market.

LPG product quality and storage

Domestic LPG cylinders used for cooking applications contain more butane than propane as compared to commercial LPG. The fuel value per kilogram of butane is higher than propane and it liquefies under much lower pressure than propane and thus, aids in safer handling. However, the high flammability of LPG poses various concerns associated with storage, high installation cost of LPG to liquefaction process and irregular domestic supply, leading to its market restraints. The typical properties of LPG are tabulated in Table 1.

Table 1: Properties of LPG

Properties	Value
Vapor pressure	124 psig at 21.1 °C; 192 psig at 37.8 °C; 286 psig at 54.5 °C
Specific gravity	0.509 at 15.6 °C
Initial boiling point	- 46.1 deg C at 1 bar
Dew point	- 43.3 deg C at 1 bar
Specific heat	2.462 kJ/kg at 15.6 °C
Lower limit of flammability	2.4 vol% gas in air
Upper limit of flammability	9.6 vol% gas in air
Latent heat of vaporization	185 Btu/lb; 430.3 kJ/kg
Gross heating value (liquid)	21,550 Btu/lb; 50,125 kJ/kg
Gross heating value (gas)	2,560 Btu/ft^3; 9,538 kJ/m^3

Source: Mckinsey & Company

Some of the important features of LPG are:

• LPG has a high heating or caloric value. LPG, as an energy source, provides a high level of heat in a short lifetime. The specific calorific value of LPG is around 46 MJ/kg or 12.78 kWh/kg depending on the composition of LPG. In comparison, wood has an energy content in the range of 14-18 MJ/kg or 3.89-5 kWh/kg (depending on the type of wood and the moisture content) while charcoal in the range of 27-33 MJ/kg or 7.5 - 8.34 kWh/kg (depending on the type of charcoal).

• LPG is a cleaner burning fuel because of the absence of sulphur.

• LPG is a convenient, portable energy source that is easy to transport and store and sold in gas cylinders. Under modest pressure or in cooler conditions, LPG transforms into a liquid state.

• LPG looks like water in its liquid form. One litre of liquid LPG expands to 270 litres of gaseous energy which allows a lot of energy can be transported in a compact container.

• For industry, LPG has a consistent quality. That means when it's used for gas engines in forklifts or industrial boilers, it's reliable and steady.

LPG production: Conventional routes

LPG is a by-product of natural gas, oil extraction and crude oil refining. Around 60% of LPG is separated from raw gas and oil during the extraction of natural gas and oil from the earth and balance 40% is obtained as a by-product from crude oil refining or made from waste or renewable vegetable oils (Source: world LPG association). Natural gas is composed of gases and liquids which are processed to separate ethane, propane, butane, and water, to meet the specifications of commercial natural gas. Interestingly, LPG produced from natural gas extraction is inexpensive than refining of crude oil and only requires a gas separation facility that can extract the desired gases to form LPG.

Table 2: Typical composition of natural gas (Source: Naturalgas.org)

Gas	Formula	Volume %
Methane	CH4	70-90 %
Ethane	C_2H_6	0-20 %
Propane	C_3H_8	
Butane	C_4H_{10}	
Carbon dioxide	CO_2	0-8 %
Oxygen	O_2	0-0.2%
Nitrogen	N_2	0-5 %
Hydrogen sulphide	H_2S	0-5 %
Rare Gases (Argon, Helium, Neon and Xenon)	Ar, He, Ne, Xe	Trace

LPG extracted from natural gas is estimated to be highest in North America, which contributes to the maximum percentage of LPG produced worldwide and expected to dominate the global LPG market in the coming years. LPG extracted is distributed through tankers or pipelines.

LPG derived from crude oil refineries produce 4 - 5 % of LPG which may decrease to as little as 1 % depending on the quality of the crude, the degree of sophistication of refinery and the market values of propane and butane compared to other oils products. Based on market demand, refiners tune the operating conditions to suit product slate. The major sources of LPG are obtained from the following refinery operations:

• ***Atmospheric distillation*** - All crude oils yield some amount of propane and butane when distilled. Typically, they leave the distillation tower in a wet gas stream that is sent to the saturated gas plant for separation of propane and butane from lighter gases (methane and ethane) that are then used for refinery fuel.

• ***Reformer*** - Reformers can yield approximately 5% (by volume) of both C3s and C4s in the conversion process.

• ***FCC*** – In FCC process large amounts of saturated and unsaturated C3s and C4s are produced, including propane, butane, propylene and butylene.

• ***Coker*** - Similar to the FCC, the coker conversion process generates mixed C3s and C4s containing saturated and unsaturated molecules. However, it is less common for coker C3s and C4s to have their olefins separated out.

With the emergence of EVs, CNG, LPG, H2 in the transportation sector, it is projected that demand growth of liquid transportation fuels viz. gasoline and diesel could gradually decrease in the mid to long term. As a result, refiners are seeking to integrate petrochemicals for sustaining operation and profitability. One of the key strategies for downstream petrochemical complex is to increase olefins production. Refiners are thereby modifying the existing FCC units to improve the yield of light olefins mainly propylene which also led to enhance LPG production. A list of modified FCC processes and products yield patterns is provided in Table 3.

Table 3: Product yields of conventional FCC and modified FCC based processes [5,6]

Parameters /Technology	FCC	DCC	PetroFCC	HS-FCC
Operating temperature (⁰C)	500	530	590	600
Contact time (s)	2-5	10	2-5	0.5-1.0
Cat/oil Ratio	5	15	10	25
Product Yield (wt %)				
LPG	25	40	30	40
Gasoline	55	25	25	38
Propylene	8	18	22	19

UOP's petro FCC and Axen/S&W's HS-FCC process involve changing in hardware of reactor system along with proprietary catalyst to increase propylene selectivity. Deep catalytic cracking (DCC) technology developed by SINOPEC uses entirely ZSM-5 based catalyst system for propylene maximization with high severity condition. INDMAX FCC technology developed by Indian Oil Corporation Limited R&D in partnership with M/s Lummus Technology is a modified FCC process to maximize light olefins/LPG production in refinery (Figure 3). The proven process can produce propylene, ethylene and butylene in refineries directly from heavy residues. This technology can be adopted in any grassroot refinery and petrochemical complex or revamp of an existing FCC/RFCC unit with minor hardware modifications along with INDMAX catalyst to enhance light olefin generation from low value heavy feedstocks. INDMAX technology employs proprietary catalyst system having higher metal tolerance, higher selectivity towards light olefins and lower dry gas yield.

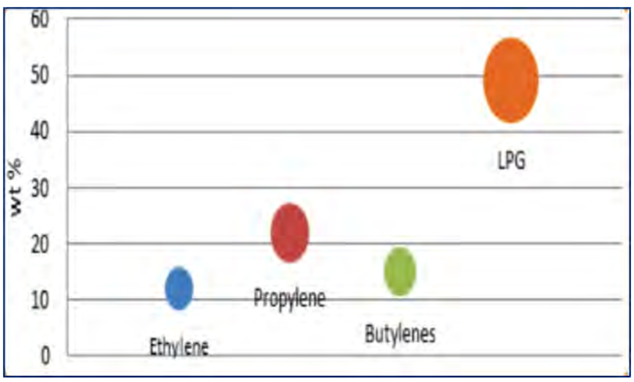

Figure 3. Typical light olefins and LPG yields, wt % of feed (Source: INDMAX Technology)

Emerging challenges and alternatives for LPG

With the advent of "Shale gas", many countries are building new gas crackers. In fact, because of the relative cost competitiveness of gas crackers, prospect for new naphtha/gasoil crackers has weakened significantly. As a result, USA and Western European countries has lost significant C3-C4 olefins output during the last decade. Therefore, it is anticipated that operation load of the existing stream cracker will be going down on a mid and long-term basis. Thus, companies around the world are coming up with alternative on-purpose production routes based on using C3 and C4 feedstocks. For example, a significant amount of propylene is now being produced through various on-purpose production routes. On-purpose propylene production processes such as Propane Dehydrogenation (PDH), Methanol-to-Olefins (MTO), Methanol-to-Propylene (MTP) and Olefin metathesis technologies are gaining attention to fill the gap for the growing demand of propylene. It can be noted that during 2013, the world propylene demand was around 80 MMTPA and only 11% contribution came from on-purpose production routes.

The scenario changed significantly during 2020 where propylene demand increased to 125 MMTPA and nearly 25 % of this production came through the on-purpose production routes. PDH has emerged as a major on-purpose production route and this is gradually shifting application of propane as a chemical feedstock for propylene production than its conventional use as LPG. There are 28 operating PDH units are currently running with world's largest propylene production capacity of 750 KTA. INEOS, one of the Europe's largest petrochemicals companies, is constructing one of the largest PDH unit (750,000 tons/year capacity) based on Catofin technology at Antwerp, Belgium which is expected to come on stream in 2023.

As LPG is a well-established fuel with distribution infrastructures are in place, the most innovative companies are using groundbreaking technology to rekindle fuels and on-purpose production of LPG from renewable sources. In response to the high global demand for LPG, more advanced, ecofriendly, and cost-effective strategies must be developed with urgency to keep the supply above the demand, and this provides an exciting area of opportunity.

LPG can be synthesized from the following pathways as shown in Figure 4:

- Direct synthesis from syngas
- Indirect synthesis from syngas via methanol or DME
- Indirect synthesis from CO2 via methanol or DME
- Hydroprocessing of vegetable oils
- Pyrolysis of biomass

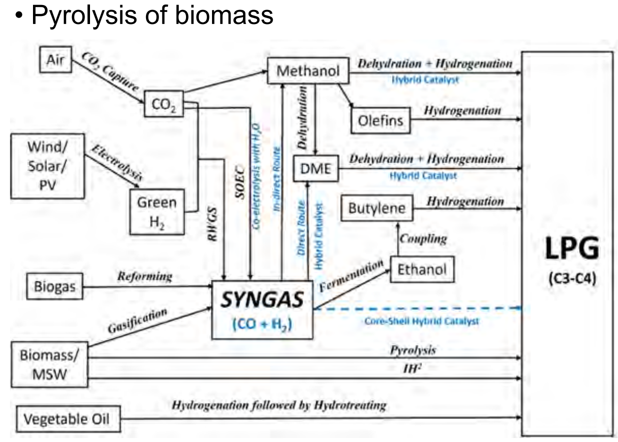

Figure 4. Various indirect and on-purpose synthetic routes for LPG

LPG production from syngas

LPG can be essentially synthesized from syngas via two fundamental pathways: (i) Direct conversion route through Fischer-Tropsch (FT) process and (ii) Indirect conversion route through Methanol to Hydrocarbon (MTH) also known as the multi-stage process.

The major drawbacks of FT process are that it follows the Anderson-Schulz-Flory (ASF) rule, where a wide range of hydrocarbons with different chain lengths are distributed (Fig 3). The ASF model is used to describe statistically distributed products. According to this model, the molar fraction (Mn) of the hydrocarbon product with a ***carbon number*** of n is only dependent on the chain growth probability (α), which is a function of the rates of chain growth and chain termination, by the following equation:

$$M_n = (1-\alpha)\,\alpha\, n-1$$

Based on the ASF distribution, lighter (C_1–C_4) hydrocarbons are expected with a higher selectivity at a smaller α value, while higher selectivity of heavier (C_{21+}) hydrocarbons can be obtained at a larger α value. However, as shown in Figure 5, the middle distillate products, which are usually the target products in most of the traditional FT process, cannot be obtained with high selectivities. For example, the maximum selectivity of diesel-range (C_{10}–C_{20}) hydrocarbons is approximately 39% (α = 0.89).

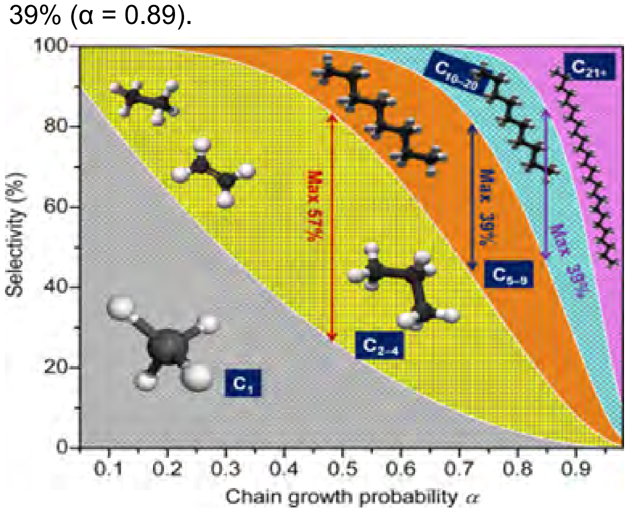

Figure 5: Product selectivity in FT synthesis as a function of the chain growth probability (α). The selectivity is expressed as the molar percentage of a particular range of products on a carbon basis [7].

Thus, direct conversion of syngas through FT process offers low LPG yield and very high costs associated with subsequent separation process, making direct LPG synthesis from syngas through the FT synthesis process less economically attractive and hence less ideal for on-purpose production of LPG. Therefore, designing a more effective catalyst for the direct synthesis of LPG from syngas is a fundamental area that acutely demands innovative research strategies. The most promising catalysts reported for direct conversion of syngas to LPG is tabulated in Table 4.

Table 4. Catalyst systems for direct conversion of syngas to LPG [8,9]

S. No.	Catalyst system	Type	Reaction conditions	CO conversion (%)	LPG selectivity (%)
1	$Cu/ZnO/ZrO_2/Al_2O_3$@H-β Zeolite Capsule	core-shell hybrid catalyst	T = 350 °C P = 30 bar	54.8	26
2	Pd/SiO_2-Y Zeolite	core-shell hybrid catalyst	T = 350 °C P = 50 bar	14.1	34.4

As syngas production is an energy intensive process, the obvious promising option would be production of LPG from CO_2, which is widely available as by-product in many processes. Thus, very recently, fruitful efforts have been made in CO_2 hydrogenation to LPG. This not only aids in increased selectivity of LPG as a product but also reduces the carbon footprints that could further accomplish the net zero targets.

Table 5. Catalyst systems for direct conversion of CO_2 to LPG [10]

S.No.	Catalyst system	Type	Reaction conditions	CO_2 conversion (%)	LPG selectivity (%)
1	CuZnZr / SAPO-34	Hybrid	T = 350 °C P = 20 bar	12.4	86
2	In_2O_3 / SSZ-13	Hybrid	T = 350 °C P = 30 bar	11.7	90
3	PdZn/ ZrO2 /SAPO-34	Hybrid	T = 350 °C P = 50 bar	40	>50 C3 selectivity
4	Zr-modified Cu-Zn catalyst with Pd-modified beta	Hybrid	T = 260 °C P = 20 bar	25	75

Challenges associated with direct conversion of syngas to LPG

From the viewpoint of energy production, the direct route of LPG production from syngas has more potential compared to the indirect synthesis, owing to low energy cost, low investment scale and facile heating recycle of tail gas. However, it is very challenging to execute direct synthesis of LPG over one multi-functional catalyst system as it comprises of various catalytic active sites. The major drawbacks are listed below:

- LPG directly synthesized from syngas over a hybrid catalyst shows a good initial activity and selectivity for synthesis of LPG. However, its stability remains compromised due to deactivation under CO_2 and water at high temperature.
- The Pd-based hybrid catalyst shows higher stability and activity than Cu-based catalyst. However, high catalyst cost is caused by high content of Pd in methanol catalyst would obstruct commercial application of this new process.
- A general strategy of physical mixing methanol synthesis catalyst and a noble metal-modified zeolite for a hybrid catalyst have been commercially applied. Unfortunately, it is difficult to control distribution of active sites over these hybrid catalysts.

- Presently, the core-shell metal-based catalyst with zeolite capsule has been widely reported as efficient catalysts in tandem catalytic reactions, such as syngas to iso-paraffins and syngas to DME. However, typical tandem reactions are restricted to not more than two steps.

Indirect conversion of syngas

The indirect conversion of syngas involves multiple steps. These are (a) conversion of syngas into methanol and (b) methanol to hydrocarbons. This process generates considerably more LPG and less by-products due to the establishment of the two successive but independent processes. The first step requires a hydrogenation catalyst which converts syngas-to-methanol whereas the second step relies on a zeolite catalyst which then transforms the formed methanol to desired hydrocarbons. Researchers have also explored a dual bed mechanism where the tandem reactions involved have been reported. Furthermore, contact of reactant gas with different and interspaced catalysts come with side reactions which reduces product yield. Therefore, combining two independent reactions into one operational unit which can eliminate interruptions in product generation is more economical and attractive.

Table 6. Typical reactions involved in indirect syngas conversion to LPG

S.No.	Reaction	Catalyst	Operating conditions
1	Syngas to methanol $CO + 2H_2 \rightleftarrows CH_3OH$	Cu-based catalyst $Cu/ZnO/Al_2O_3$	T = 220-300 °C P = 50-100 bar
2	Methanol dehydration to DME $2CH_3OH \rightleftarrows CH_3OCH_3 + H_2O$	γ- alumina or ZSM-5	T = 200-250 °C P = 10-20 Bar
3	DME to light olefins	SAPO-34 or modified ZSM-5	T = 350-450 °C P = 10-15 Bar
4	C3- C4 light olefins to C3 –C4 paraffins/isoparaffins	Ni, Pt, Pd based catalyst	T = 150-200 °C P = 10-15 bar

Methanol to Propylene (MTP) Process

Methanol to propylene (MTP) is a commercial an on-purpose technology for production of olefins especially propylene from various carbon sources such as coal, natural gas or biomass through methanol. The process has been developed by M/s Lurgi and the olefins are used as feedstock for a variety of petrochemical processes. The MTP process involves dehydration of methanol to DME followed by olefins synthesis which produces propylene with selectivity as high as 70% using modified ZSM-5 catalyst. The commercial project with olefin production of nearly 100,000 ton per year based on Lurgi's process has been constructed in Iran. Besides propylene, the said process can produce LPG via product fractionation (Fig 6.).

In a typical commercial MTP process, 5000 tons/day of methanol produces 519000 tons/year of propylene, 143,000 tons/year gasoline along with 54000 tons/annum of LPG [11].

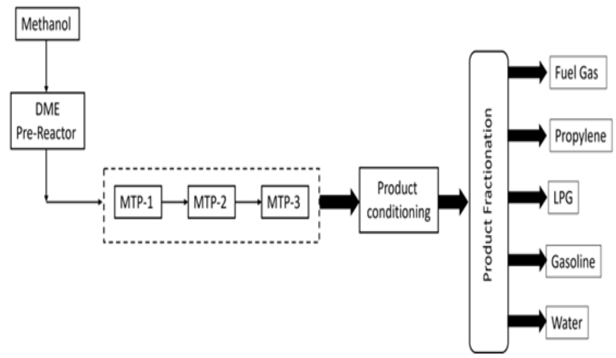

Figure 6. Schematic of Lurgi MTP process

Several leading companies such as BASF and Haldor Topsoe, Mitsubishi are working on the development of direct conversion of syngas to dimethyl ether (DME) which in turn can be used for the production of olefins from DME via commercial methanol to olefins (MTP) process where methanol is converted to DME and then DME is fed into MTP reactor. Since direct conversion of syngas to DME overcomes equilibrium conversion limitation is faced by syngas to methanol conversion reaction, direct conversion to syngas to DME followed by DME conversion to light olefins along with LPG production would inherently lower the capital and operational cost since less numbers of reactor system and process steps would be required.

Bio-LPG: Emerging Green alternative

Bio-LPG is nothing, but propane produced from renewable feedstocks like plant and vegetable residuals. It is also referred as renewable propane or bio- propane and is commonly derived product from biomass via Hydrotreating, Dehydrogenation and Fermentation.

The only difference between LPG and Bio-LPG lies in the type of source even though the chemical composition remains the same. Bio-LPG is a co-product of the biodiesel production process where the feedstocks undergo a series of complex treatments and feedstock is combined with hydrogen in the presence of a catalyst. During the refining process, a variety of waste 'off-gases' are produced that contain propane or Bio-LPG. This co-product is then purified to make it identical to conventional propane. Presently, the demand for Bio-LPG is increasing owing to the following merits:

- Cleaner alternative.
- Equivalent calorific value as that of fossil fuels.
- Obtained from a wide range of feedstocks.
- Reduces hazardous emissions such as CO and NO_2.
- Compatible with conventional LPG fueled appliances, boilers and FTLs.
- No additional hardware required.
- Easily deliverable to remote areas.
- It is identical in use and performance to conventional LPG.
- It is an ideal energy solution to reduce carbon footprint, as it reduces CO2 emissions up to 80%.

Bio-LPG can be produced in a number of ways depending on the feedstock and process. Currently, the main production method is the renewable or hydrotreated vegetable oil (HVO) biodiesel production process. This also generates a by-product of Bio-LPG. During the refining process, a variety of waste 'off-gases' are produced that contain propane or Bio-LPG. For every ton of biodiesel, 50 kg of Bio-LPG is generated from this off-gas stream. This co-product is then purified to make it identical to conventional propane.

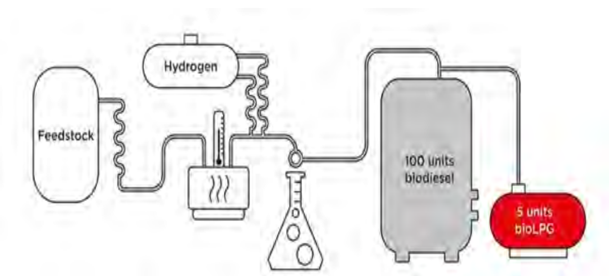

Figure 7. Schematic of Bio-LPG production along with Biodiesel

Like biogas, Bio-LPG is also well-established overseas. Around 460,000 tons of Bio-LPG are being produced globally each year as a by-product during the manufacturing of renewable diesel, sustainable aviation fuels and other biofuels.

Europe and United Kingdom are investing significantly in strategizing the transition to Bio-LPG. Neste initiated the world's first large-scale renewable propane production facility in Rotterdam, Netherlands with production capacity of 40,000 tonnes per year and Calor (parent organization SHV Energy) being exclusive supplier, has the vision to supply only Bio- LPG by 2040. Meanwhile, Repsol in Spain is producing 250,000 tons of hydrobiodiesel, biojet, bionaphtha, and bio propane/Bio-LPG.

Recent developments in Bio-LPG

- Montalto Estate in Ireland switch to Calor bioLPG 100% renewable energy
- BrookLodge & Macreddin Village in Ireland and the UK switch to Calor BioLPG 100% renewable energy
- La-Roche-Posay became the first industrial site in France to use Bio-LPG in 2018
- Circle K to sell 100% Bio-LPG cylinders in all its stores in Sweden from April 2020

A number of companies active in bio-LPG production and marketing are Neste, SHV Energy, Renewable Energy Group, Inc, AvantiGas, Diamond Green, Eni, Total, Irving Oil, Repsol, Preem AB.

Advanced gas & liquid-based processes to Bio-LPG are technically challenging and not well-established commercially. This is anticipated to cause uncertainty in the Bio-LPG market. But these chemical processes hold promising potential to use cellulosic and waste-feedstock on a large scale to produce significant volumes of bio propane. Manufacturers can capitalize on this business opportunity, since these processes help to break down large and complex molecules of biomass into smaller and simpler molecules that can be synthesized for the production of fuels. As such, the market for Bio-LPG is expected to expand at an explosive CAGR of ~83% during the years 2020 to 2030.

On-purpose production of Propane from Glycerol

Approaches for converting of a low-value product like glycerol derived from various renewable sources to propane, act as a renewable liquefied petroleum gas [12]. The various catalytic routes for converting glycerol to bio propane is shown in Figure 8.

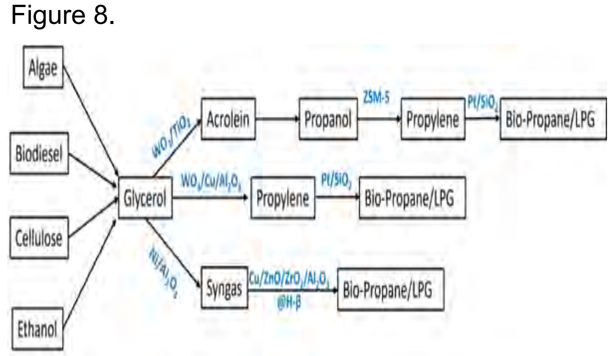

Figure 8. Catalytic routes for glycerol to bio propane

The conventional route is a multistep step reaction route involving a combination of hydrogenation-dehydrogenation steps with different catalyst systems. Glycerol is converted to acrolein at temperature of 270 °C and 1 bar pressure using WO_3/TiO_2 catalyst, subsequently to propanol and finally to bio propane. However, successful attempts are made to reduce the reaction steps. A two- step process of converting glycerol to propylene at 240 °C, 1 bar pressure in presence of $WO_3/Cu/Al_2O_3$ catalyst followed by hydrogenation to bio propane seems to be a viable route.

Summary and Future outlook

Production and uses of carbon neutral fuels will play an important role to reduce CO_2 emission and combat climate change. In the emerging energy transition scenario, renewable LPG could become a significant substitute of petroleum-based fuels. Renewable LPG could find greater applications in various industrial sectors as well as domestic cooking fuel due to its clean burning properties. Although LPG production from natural gas liquid is going to remain the primary source, contribution of on-purpose production from various renewable sources would increase. LPG production from FCC units would increase as refiners there will be more petrochemicals integration as demand for liquid transportation fuel is expected to decrease in mid to long term.

In the medium term, bio-LPG production as a co-product of biodiesel/bio-ATF process could partly meet the required demand. However, in the long-term, LPG production from captured CO_2 and green hydrogen may play significant role once both CO_2 capture technology and green hydrogen production become cost effective. As India is a significant importer of LPG, production of LPG from waste through gasification of biowaste can provide a mid-term solution. India is also taking significant steps in developing green hydrogen ecosystem and the efforts are underway in developing cost-effective carbon capture technologies, which can provide an eco-system for on-purpose LPG production from CO2 and H2 through methanol intermediate. LPG production through syngas generated through co-electrolysis of CO2/H2O using SOEC could play a significant role and can provide carbon neutral attractive alternative route for on-purpose LPG once the technology gets maturity.

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City Gas Distribution (CGD): Driving India's Gas Demand

Sujay Sarkar
Sr. Asst. Director (Gas)

Deepak Srivastav
DGM (BD-Gas), IOCL,
CGD Helpdesk

Naresh Gupta
DGM (Mktg.), GAIL,
CGD Helpdesk

Federation of Indian Petroleum Industry

Climate change is already having visible effects on the world. According to the Intergovernmental Panel on Climate Change (IPCC) — the United Nations body established to assess the science related to climate change — modern humans have never before seen the observed changes in our global climate, and some of these changes are irreversible over the next hundreds to thousands of years. Warmer temperatures are changing weather patterns, increasing the sea levels and disrupting the normal balance of nature over time. This poses many risks to human beings and all other forms of life on Earth.

Providing access to energy while addressing global climate change is one of the greatest challenges of the 21st century. The transition of today's energy infrastructure needs to reduce emissions, minimize environmental impacts while ensuring energy security, economic security, human security and development in ways that enable the global community to overcome the unprecedented global health and economic crises.

Today, Natural gas is considered as the world's fastest-growing fuel, which meets more than 24% of the global energy demand. Gas has been considered as a "bridging fuel" that can play an essential role in facilitating the transition to a low-carbon economy, complementing a significant increase in the utilisation of renewable energy sources. Gas will keep playing a crucial sustainable role in supporting energy transition because they offer high efficiency, flexibility of use, availability on-demand, secure, abundant, safe, and affordable energy access. Going forward, it is expected to catch up with oil & coal and emerge as the main hydrocarbon component of a more sustainable energy mix because of the three primary reasons:

- the abundance of gas resources will help to ensure that there is sufficient energy to meet the world's growing needs. The world has proven reserves equivalent to 52 times its annual consumption (at consumption levels and excluding unproven reserves- as of 2017).
- the world wants energy security, and gas can help with that too.
- the world needs its energy to be sustainable and lower-carbon energy future, and gas has a unique role to play in that regard.

Natural gas also has the potential to meaningfully contribute to at least four of the seventeen Sustainable Development Goals (SDGs) of the United Nations: viz.,

(i) Goal 3 'Good health and well-being for all ages' through the reduction of urban air pollution by using piped natural gas (PNG) for residential, commercial & industrial, fertilizer, steel, etc. and compressed natural gas (CNG) & LNG for transport;

(ii) Goal 7 by providing access to affordable and clean energy;

(iii) Goal 9 by helping build and promote resilient and sustainable infrastructure, industry and innovation; and

(iv) Goal 13 to combat climate change by contributing to decarbonization.

India is the 3rd largest energy consumer globally after China and the USA and ranks among the top 14 in gas consumption in quantity terms. Natural gas's share in India's total primary energy consumption was 6.3% in 2021 as compared to the world's average share of 24.4%.

Table 1: Top 15 gas consuming countries globally in 2021

Top 15 Gas consuming countries globally in 2021		Gas Consumption (in BCM) 2021	Share of gas in Primary Energy 2021 (%)	Contribution in World's gas consumption 2021 (%)
1	US	826.7	32.0%	19.8%
2	Russian Federation	474.6	54.6%	11.4%
3	China	378.7	8.6%	9.1%
4	Iran	241.1	71.2%	5.8%
5	Canada	119.2	30.8%	2.9%
6	Saudi Arabia	117.3	39.0%	2.8%
7	Japan	103.6	21.0%	2.5%
8	Germany	90.5	25.8%	2.2%
9	Mexico	88.2	46.8%	2.1%
10	United Kingdom	76.9	38.6%	1.8%
11	Italy	72.5	41.1%	1.7%
12	United Arab Emirates	69.4	55.2%	1.7%
13	South Korea	62.5	17.9%	1.5%
14	India	62.2	6.3%	1.5%
15	Egypt	61.9	58.7%	1.5%
	World	4167	24.40%	

Source: BP Statistical Review of World Energy 2022, Statista

The use of natural gas is expected to be supported by increasing demand in fast-growing emerging economies- as they continue to industrialize and reduce their reliance on coal. Growth in liquefied natural gas plays a central role in increasing emerging markets' access to natural gas.

- BP Energy Outlook 2022

Natural, low- and zero-carbon gases and gas infrastructure key to an achievable transition toward a sustainable and secure energy future for all. Natural gas, together with decarbonised and low or zero-carbon gases, will play a critical role in supporting the decarbonisation initiatives.

- IGU, Global Gas Report 2022

Faster development and implementation of clean energy transition policies, especially in mature gas markets, would ease price competition and help emerging markets access supplies that can contribute to short-term improvements in carbon intensity and air quality.

- IEA, Gas Market Report, Q3-2022

Increasing natural gas usage can help India overcome many challenges like achieving development objectives, providing energy security, fulfilling its mitigation efforts on the climate change front, etc. In addition, it can play a crucial role in India's transition towards a low-carbon clean fuel-based economy. The sector-wise consumption of natural gas (domestic gas and RLNG) for FY 2021-22 is highlighted in table no.2.

Table 2: Sector-wise consumption of natural gas in FY 2021-2022

Sectors	Qty (MMSCM)	Share (%)
Fertilizer	18079	30.4%
CGD	12128	20.4%
Power	8930	15.0%
Refinery	5313	8.9%
Petrochemical	2759	4.6%
Others	12309	20.7%
Total	**59518**	**100%**

Source: PPAC, Natural Gas Monthly Report, May 2022

The target of a 15% gas share by 2030 in the energy mix remains a top priority, and the Ministry of Petroleum and Natural Gas (MoP&NG), along with the Petroleum and Natural Gas Regulatory Board (PNGRB), is focusing on developing the country's natural gas infrastructure in a mission mode. To achieve the 15% target, various initiatives have been taken, which inter alia include the following (PIB, July'22):

(i) Expansion of National Gas Grid to about 35,000 Km
(ii) Expansion of City Gas Distribution (CGD) network to 295 Geographical Areas (GAs)
(iii) Setting up of Liquefied Natural Gas (LNG) Terminals
(iv) Freedom to establish and operate LNG Stations in any GA or anywhere else to increase the share of LNG in India's energy mix
(v) Unified Tariff Regulations to make natural gas affordable in far-flung areas
(vi) Promoting Ease of Doing Business
(vii) Marketing and Pricing freedom for natural gas
(viii) Sustainable Alternative Towards Affordable Transportation (SATAT) initiatives to promote Bio-CNG

India has a high potential of gas demand and it has embarked on a massive expansion of CGD networks to develop large-scale nation-wide infrastructure for making Piped Natural Gas (PNG) available to Domestic, Commercial & Industrial consumers and Compressed Natural Gas (CNG) to transport consumers. As a result, the CGD sector has been emerging as one of the fastest-growing sectors in the country, and with the various initiatives taken by the government of India to bolster city gas demand, the CGD sector is poised to take centre stage as a priority sector in the country. A snapshot of the gas sector growth focusing on the CGD segment over the last 5 years and the aspirational targets by 2030 is highlighted in the tables no. 3 & 4:

Table 3 : Gas sector infrastructure growth & target- CGD focussed

	2015-16	2021-22	2030 (P)
Gas Consumption	130 MMSCMD	163 MMSCMD	500+ MMSCMD
Gas share in energy mix	~6%	6.3%	15%
CGD gas consumption	17 MMSCMD	33 MMSCMD	-
% Share of CGD in total gas consumption	13 %	20.4 %	-
LNG regasification capacity	21 MMTPA	42.5 MMTPA	70 MMTPA
Gas Pipeline Network	~12,400 KM	~18,000 KM	~35,000+ KM
CGD Entities	15	40+	-
CGD GA's covered	64	295	Pan India coverage
No. of CNG Stations	1053	4433 (Mar'22)	~17,700
No. of LNG Stations	NIL	1	1000
No. of domestic PNG	~31 lakhs	~93 lakhs (Mar'22)	~12.33 crores (As per MWP)

Source: PPAC, PIB, Industry reports

Tabke 4: Year wise CGD infrastructure growth

	Segments	As on 31st Mar'18	As on 31st Mar'19	As on 31st Mar'20	As on 31st Mar'21	As on 31st Mar'22	As on 31st July 22
PNG	Domestic	~42.80 lakhs	~50.43 lakhs	~60.68 lakhs	~78.20 lakhs	~93.02 lakhs	~97.40 Lakhs
	Commercial	26,131	28,046	30,622	32,339	34,854	35,626
	Industrial	7,601	8,823	10,258	11,803	13,215	13,833
CNG	CNG Stations	1,424	1,730	2,207	3,101	4,433	4,664
	CNG Vehicles	~30.90 lakhs	~33.47 lakhs	~37.10 lakhs	~39.55 lakhs	~44.09 lakhs	~46.21 lakhs

Source: PPAC, Vahan

CGD is one of the biggest infrastructure initiatives happening in the country. Once the network comes out, it will transform how energy is delivered in the country. Providing PNG connections and establishing CNG stations is part of the development of the CGD network, and the same is carried out by the entities authorized by PNGRB. The CNG Stations and PNG connections are being provided by authorized entities as per timelines prescribed by PNGRB from time to time.

- After completion of the 11A city gas distribution (CGD) round, 295 Geographical Areas (GAs) have been authorized, which inter alia cover 98% of India's population and 88% of its GAs.
- As on June 30, 2022, total 96.34 lakh PNG (Domestic) connections have been provided and 4629 CNG (Transport) stations have been established by the authorized entities.
- As per Minimum Work Programme, CGD entities authorized upto 11A round, have to provide 12.33 crore PNG connections and establish 17,700 CNG stations by 2030, including in rural and urban areas.

To promote the expansion of CGD networks across the country, various Ministries have issued guidelines for increased penetration of CNG/PNG in their jurisdiction, and a few of them are (PIB, Mar'21):

(i) Public Utility Status granted to CGD Projects by Ministry of Labour and Employment.
(ii) Ministry of Defence has issued guidelines for use of PNG in its residential areas/unit lines
(iii) Department of Public Enterprises has issued guidelines to Public Sector Enterprises (PSEs) to have the provisions of PNG in their respective residential complexes.
(iv) Ministry of Housing and Urban Affairs has directed to CPWD and NBCC to have the provisions of PNG in all Government Residential Complexes
(v) Department of Promotion of Industry & Internal Trade notified amended rules 2018 to ease out process to set up CNG dispensing facilities at existing OMC Retail Outlets.
(vi) Allocation of domestic gas to Compressed Natural Gas (Transport) / Piped Natural Gas (Domestic) in no cut category.

With the growth in initiatives taken by the government in the CGD sector, various CGD entities including public and private have entered the market, and have come forward to establish CGD networks in different geographical locations across the country. The amount of investment in CGD has also grown multi-fold with new areas opened for bidding. An investment of $USD 60 billion is lined up in developing gas infrastructure in the country, including gas pipelines, city gas distribution (CGD) networks, and LNG regasification terminals (PIB, 2020). The capital expenditure planned by the CGD entities, both public and private for FY 22-23 and FY 23-24 is to the tune of Rs. 46,000+ crore for developing CGD networks across the country.

Government has identified LNG as a transport fuel as a priority area considering the potential of manifold benefits in terms of reducing vehicular pollution, saving in terms of import bill and wide ranging benefits that may accrue to fleet operators, vehicle manufacturers and other entities in the gas sector. The LNG stations are at various stages of developments and are being established by country's Oil & Gas majors, CGD entities either as a standalone basis or in partnerships. These are being put up at the nation's Golden quadrilateral and major National highways where LNG is to be made available for heavy vehicles and buses.

The expansion of the natural gas infrastructure and CGD sector, in particular, is leading to various opportunities across the natural gas value chain. India has limited capacity to meet the estimated growing demand for equipment and spare parts of the CGD sector, and thus provides opportunities for setting up new facilities and expanding existing capacities in the country. In addition, augmentation/ creation of the manufacturing facilities under "Make in India" campaign will create huge direct and indirect employment opportunities across various states of the country.

With all this, the CGD sector is showing signs that it could be a potential game-changer in increasing the gas share in the primary energy mix and to play a remarkable role in India's economy.

Overcoming the major challenges:

1. Permission-related issues:

To create CGD infrastructure, the CGD pipeline network must be laid along National/State highways/ village roads/ district roads and within the jurisdiction of municipal/panchayat bodies. In general, permissions from Land owning agency/ Civic agency/ Municipal Corporation, Fire department and from state divisions of PESO, NHAI, Railways, MoUD, MoRTH, MoEF&CC etc are required. This requires a lot of time to obtain permissions from multiple departments causing delays in the execution of works and in the overall development of the natural gas value chain.

In order to expedite the process of various permissions, CGD Helpdesk- A centralised digital Helpdesk has been created at FIPI as per the directives of MoP&NG, which was put into operation in December 2020. The basic idea behind creating the CGD Helpdesk is to exhaustively address all common issues that need to be escalated at a higher level for speedy resolution by the intervention of MoP&NG. Within six months of its creation, the visible impact was seen as many pending issues for more than six months were resolved, and all stakeholders have appreciated the noble initiative of MoP&NG.

To give a perspective towards the performance of the CGD Helpdesk portal, around 56% of more than 650 issues uploaded (Central & State level) till August 31, 2022, have been successfully resolved, out of which about 60% of issues were pending for more than six months. Moreover, due to enhanced sensitisation, the newly uploaded issues have been noticed to take less time to resolve. After such unquestionable performance, the CGD Helpdesk has become a name to reckon with in the CGD industry.

The CGD Helpdesk has not limited itself up to merely the resolution of issues but has also been instrumental in conducting various State level meetings for the awareness of greener fuel and organising a CGD equipment vendors & suppliers virtual conference in April 2022, which was 1st of its kind and was attended by more than 50 vendors and suppliers from all over the country. CGD Helpdesk is well on its way to play a pivotal role in developing Vendors, Suppliers, and specifically skilled Manpower to build a robust ecosystem for faster and smoother growth of the CGD Sector in the country.

The success of CGD Helpdesk can be evaluated by the fact that a similar Helpdesk portal for CBG Plant operators is also being envisioned to help expedite the commissioning of around 5000 plants all over the country.

2. Gas Pricing Issue:

The government had notified "New Domestic Natural Gas Pricing Guidelines, 2014" on October 25, 2014. The pricing mechanism is formula based and has been worked out considering the volumes and prices prevailing at major international markets such as Henry Hub, National Balancing Point, Alberta and Russia. The prices are notified after every six months in accordance with the said guidelines.

The domestic gas prices have witnessed an increasing trend since October'21 and the prevailing price for the six months starting October 01, 2022 has been fixed at $8.57 per mmBtu from $6.10 per mmBtu earlier. This is the highest price for procuring natural gas since the introduction of the New Domestic Gas Pricing Guidelines in November 2014 and this current high gas prices reduce the price competitiveness of CNG and PNG vis-à-vis alternate fuels.

Amid rising concerns over global natural gas prices, the government has begun a review of the pricing formula for domestically-produced gas. The Ministry has set up a committee under noted energy expert Dr. Kirit Parikh to review the current gas pricing formula to ensure "a fair price to the end consumer".

Further, in an attempt to boost natural gas consumption under CGD and increase gas availability, the Ministry has also prepared a mechanism for a uniform base price for gas.

The uniform base price formula will be based on regasified LNG, compressed biogas, and domestically produced gas. The idea of bringing in a uniform base price is to meet the increasing demand for the gas required for CGDs, which domestic gas sources cannot just meet. Uniform base prices will help increase the availability of gas from different sources and meet the gas requirements of the CGDs.

A lot has been done in the past for the CGD sector in the policy perspective, and a lot still needs to be done, and it is imperative that all the stakeholders in the value chain respond jointly towards the sector's progress. Some of the roadblocks facing the CGD sector which requires immediate attention & joint representation in voicing the sector's concerns with various ministers and regulator are as follows:

- Single Window Clearance System
- Creation of Modal CGD/CNG Policy at Central/ State levels
- PLI scheme for CNG/CGD/Bio-CNG/LNG-related Equipment
- Taxation-related issues, etc.

Conclusion:

The changing climate and rising air pollution causing serious health hazards have forced countries to look for less carbon-emitting, environment-friendly fuels. Natural gas fits the requirement well, and the demand for natural gas is expected to rise continuously. It has set the stage for a gas boom.

Under the visionary leadership of the Hon'ble of Prime Minister, India has laid down the blueprint of a gas-based economy, and the government is working relentlessly to achieve the milestones. The government has initiated various programs and schemes to develop CGD infrastructure and networks and push the sector's growth to ensure gas supply to more areas.

The expansion of the natural gas infrastructure and CGD sector, in particular, is leading to various opportunities across the gas value chain. With all this, the CGD sector has been emerging as one of the country's fastest-growing sectors and will play a remarkable role in India's economy.

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Indigenous Development of Green Hydrogen Technologies: Collaborative Efforts at ONGC Energy Centre



Dr. Ashwini Nirukhe
Research Scientist-Hydrogen Program

Saroj Chaudhary
GM-Chemistry, Project Manager-Hydrogen Program

Dr. D. Parvatalu
Domain Expert-Hydrogen Program

Oil and Natural Gas Corporation Limited
ONGC Energy Centre

1. Introduction

Hydrogen being clean, non-polluting, renewable, and versatile source is considered as a promising energy carrier. Its abundance in different forms, high energy density, clean combustion, and convertibility into electricity or useful chemicals makes Hydrogen more popular and globally accepted. It can be produced from variety of feed stocks using diverse pathways and finds application in different industrial sectors viz. chemical, petrochemical, agricultural, metallurgy, food processing, plastics, electronic, and energy (Martinez-Burgo et al, 2021). As of now, 95% of hydrogen produced around the world is 'Grey hydrogen', produced from fossil fuels. However, 'Green Hydrogen' can be produced by breaking down water molecules (H_2O) into oxygen (O_2) and hydrogen (H_2) by electrolysis or thermochemical splitting, provided the electricity used to power the process is entirely from renewables.

Government of India has initiated several National missions towards Research, Development and Demonstration (RD&D) activities to provide energy security to the nation (India Country Status Report on Hydrogen and Fuel Cells, 2020). With respect to the India's commitment to a net zero emissions target by 2070, National Hydrogen Energy Mission (NHEM) was launched by the government in August 2021 to transform India into an energy independent nation by 2047. India is gearing up for meeting imminent energy transition with the help of renewables where water and hydrogen are the lead players.

Recently, India has published its Green Hydrogen Policy in February 2022 as first initiative under the National Hydrogen Mission to promote production and utilisation of green hydrogen and green ammonia (Report by NITI Aayog, 2022 and Green Hydrogen Policy, 2022). Both the Government and public sectors in India are supporting RD&D projects on different aspects of hydrogen economy including production, storage and utilization for stationary power generation and for transport applications.

In line with the ongoing rapid developments in encouraging and promoting hydrogen economy by the Government of India, ONGC Energy Centre (OEC) has initiated RD&D activities for indigenous development of Green Hydrogen Economy. This article enlightens the advances made by OEC in developing Green Hydrogen Eco-system by following a collaborative consortium mode with various national Centres of excellence with focus on large scale green hydrogen generation to develop cost effective indigenous technology.

2. Green Hydrogen by Thermochemical Water Splitting

Water being the abundant resource on the earth has attained more importance in the Green Hydrogen Economy. However, the method of hydrogen production decides the environmental impact and energy efficiency. Direct thermal decomposition of water into hydrogen and oxygen requires temperatures in excess of 2500°C (Chao, 1975).

However, thermochemical water splitting/ decomposition, or more commonly called "thermochemical cycles" is an emerging and promising technology for large-scale production of hydrogen due to reduced temperature requirement. A thermochemical cycle uses two or more intermediate compounds in a sequence of chemical and physical processes to split water molecules into hydrogen and oxygen at much lower temperature than thermal decomposition. The intermediate compounds are recycled internally, creating a closed loop that consumes only water and produces hydrogen and oxygen. These possess many advantages such as no requirement of product gas separation, moderate operating temperatures between 600 and 1200K, minimum or very low power input requirement and can be solar and nuclear driven. They use both thermal energy and electricity through a sequence of thermochemical and electrochemical reactions.

Although over 200 possible thermochemical cycles have been proposed in the past (McQuillan et al., 2002 and Lewis et al., 2003 and 2006), very few have progressed beyond concepts and theories to working demonstrations showing practical feasibility of the processes. In recent years, numerous organizations and researchers worldwide i.e. from USA (General Atomics, Savannah River National Laboratory, Argonne National Laboratory (ANL)), Canada (University of Ontario Institute of Technology (UOIT), Atomic Energy of Canada Limited (AECL), UNENE (University Network of Excellence in Nuclear Engineering), Japan (Japan Atomic Energy Agency, JAEA), France (Commissariat à l'Energie Atomique, CEA), Korea (KAERI), South Africa, China, and others are focusing particularly on the iodine-sulfur (I-S), hybrid sulfur and copper-chlorine (Cu-Cl) cycles. Currently, these cycles are at different stages of development globally and are yet to be commercially proven (Norman et al., 1982, Naterer et al., 2011, Gabriel et al., 2022). To further complement these ongoing efforts, India has also taken the initiatives.

3. Research, Development and Demonstration (RD&D) by ONGC Energy Centre (OEC) in Green Hydrogen Production

ONGC Energy Centre (OEC) has been developing highly efficient clean and green indigenous hydrogen generation technologies using thermochemical water splitting from a concept to commercialization using renewable, thermal power and water. Among various possible options of thermochemical cycles with regard to the choice of likely process routes for development, OEC has chosen two processes i.e. Copper-Chlorine (Cu-Cl) cycle and Iodine-Sulfur (I-S) cycle due to relatively low temperature requirement of 550°C and 900°C respectively. These cycles possess opportunities for efficient integration with other energy systems, in particular, nuclear or solar power. However, the process was complex and required multi-disciplinary approach to develop suitable technology.

In order to accomplish cost effective hydrogen production using thermochemical cycles at commercial scale, the overall development was planned through different stages viz. Proof of concept, lab engineering scale, pre-pilot and pilot scale demonstrations leading to commercial production. OEC has been following a collaborative consortium approach in bringing up these technologies on a fast track mode to meet the large hydrogen requirements anticipated in near future in a techno-economically feasible way.

3.1. Copper-Chlorine (Cu-Cl) Cycle

OEC in collaboration with Institute of Chemical Technology (ICT), Mumbai has been developing hydrogen production using thermochemical Cu-Cl cycle. The originally proposed cycle by Argonne National Laboratories, USA was modified to the process represented in Fig. consisting six steps. The cycle starts with hydrogen generation (Step-1) where copper and hydrogen chloride gas reacts to produce cuprous chloride (CuCl) and hydrogen. Step-2 is the electrolysis of cuprous chloride to give cupric chloride ($CuCl_2$) and copper which is reactant to hydrogen generation reaction followed by drying of aqueous cupric chloride. Further, hydrolysis of $CuCl_2$ (step-4) produces cupric oxide (CuO) and hydrogen chloride (HCl), a reactant to hydrogen generation reaction and decomposition of $CuCl_2$ (Step-5) produces cuprous chloride (CuCl) and chlorine gas. The last step is the oxygen generation (Step-6) wherein copper oxide reacts with chlorine to produce cuprous chloride (CuCl) and oxygen. The cuprous chloride from hydrogen generation, decomposition and oxygen generation will be sent to electrolysis.

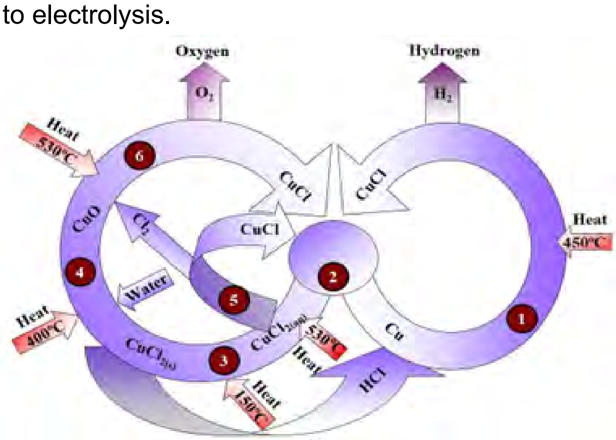

Fig. 1. Closed-loop Cu-Cl thermochemical cycle

Initially, the proof of concept was established in Phase-I by developing a new route for Cu-Cl cycle (patented in seven countries) with no additional energy requirement. All the reactions were experimentally demonstrated with conversions of ~90%. Based on the proof of concept, a metallic set up was developed for 25 LPH hydrogen production with indigenous sources. Individual metallic reactors and a series of electrochemical cells/stacks of different capacities were developed and tested for prolonged durations. The performance of different anodes, viz. graphite, Platinum (Pt) / MMO coated on titanium was evaluated for electrolysis. Incremental innovations with and novel designs were developed and implemented for process improvement. After satisfied performance of individual reactors, interconnectivity of reactors with one another was established to form the closed loop of Cu-Cl cycle and systems were continuously operated.

In order to address engineering challenges, the facilities for performance evaluation of indigenously developed membranes for electrochemical and gas separation were established and performance of membranes was evaluated. For the development of corrosion resistant materials for plant level operations, the facilities for performance evaluation of different materials in high temperature molten salt media were established. After standardizing the procedure, several metallic and non-metallic materials were screened in molten salt environment at 550°C up to 1000h. After completion of work at each stage, the gaps were identified with respect to challenges.

The performance checks of existing systems for prolonged period, bridge the gap studies to address all the engineering challenges of the Cu-Cl cycle and data generation in progress.

3.2. Iodine-Sulphur (I-S) Cycle (Closed Loop)

RD&D on iodine-sulfur (I-S) thermochemical cycle was initiated by OEC in collaboration with Indian Institute of Technology, Delhi. The reactions in the I-S cycle are shown in Fig. 2. The first one is the Bunsen section, an exothermic reaction, which proceeds spontaneously in the temperature range 298-393K and produces two acids: H_2SO_4 and HI, however, the other two reactions are the thermal decompositions of those acids formed. Sulfuric acid (H_2SO_4) decomposition is an endothermic reaction, which is composed of two stages, i.e. gaseous H_2SO_4 decomposes spontaneously into H_2O and SO_3 at 673-773K and then SO_3 decomposes into SO_2 and O_2 at about 1073-1173 K in the presence of catalyst. HI decomposition is slightly endothermic reaction, releases hydrogen and takes place in the temperature range 573-723K.

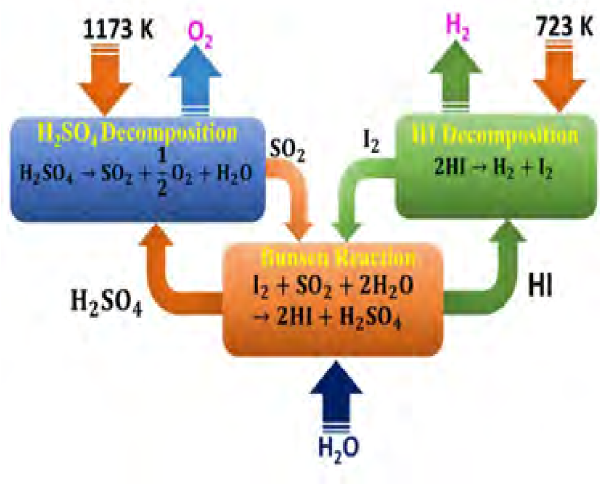

Fig. 2. Closed-loop I-S thermochemical cycle

During the studies, fundamental studies on the three reactions of I-S cycle i.e. Bunsen reaction, HI decomposition reaction, and sulfuric acid decomposition reaction were completed. The issues of separation, concentration and purification sulfuric acid were also addressed.

In H_2SO_4 decomposition section, a cost-effective, high performing and highly stable non-Pt- based catalyst system was developed and tested. Designed, fabricated pilot scale metallic reactor system equivalent to 150 LPH of H_2 generation in-house. Performance of selected catalyst under lab stage was evaluated further in this reactor at 900 ±50°C and 10-15 bars and found to be highly satisfactory. Mechanistic studies on catalytic decomposition of H2SO4 were completed. In HI decomposition section, a highly performing transition metal based catalyst system which is stable for over 100 h was developed and yields conversion being close to equilibrium values at 500-550°C.

In Bunsen section, the reaction kinetics and separation characteristics of H_2SO_4 and HIx phases were studied through electro-dialysis and electro-electro-dialysis (EED) technique for HI enrichment and established at lab scale with minimum cross-contamination levels across membrane and without any side reactions. Model codes were developed in Simulation work to address scaling up and issues related to integration with the remaining sections of the cycle. In HI section, new catalysts were developed giving near equilibrium conversion and their long-term stability was also tested.

Presently, the data generation from the integrated closed loop I-S process for hydrogen production in all quartz/glass assembly set-up is in progress in view of scale up.

3.3. Iodine-Sulphur (I-S) Cycle (Partially open-loop)

Generally, natural gas processing involves deep removal of hydrogen sulphide (H_2S), a hazardous pollutant, and post-treating. Presently, H_2S is largely converted to elemental sulfur and water using industrial processes such as the Claus process, however, it would be more useful and economical to convert H_2S to sulfur and H_2 instead (Spatolisano et al., 2022 and De Crisci et al., 2019).

As large-scale H_2 production processes from H_2S decomposition have not yet been developed, a low temperature alternate route of thermochemical hydrogen production through partially open-loop I-S process utilising H_2S was explored by OEC in collaboration with CSIR-IIP, Dehradun. This is an offshoot of closed-loop I-S cycle and involves three main steps as shown in Fig. 3 starting from H_2S: (1) H2S Incineration (2) Bunsen Reaction (3) HI Decomposition. This process does not involve the H_2SO_4 decomposition unlike closed-loop I- S cycle. Instead produced H_2SO_4 can be marketed to the fertilizer plants. Therefore, this arrangement makes the cycle a partially open loop.

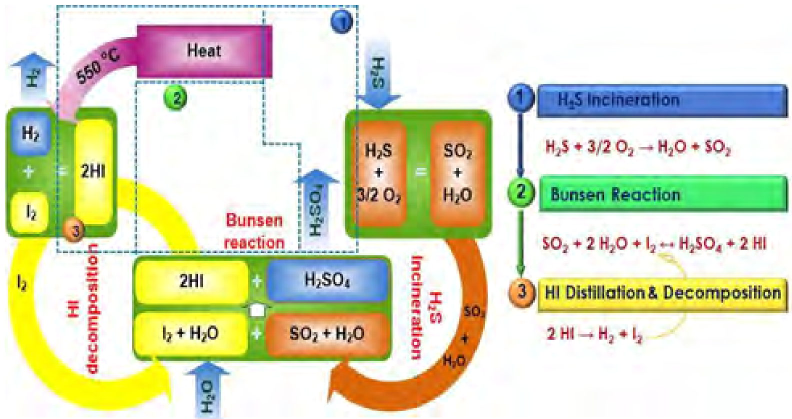

Fig. 3. Partially open-loop I-S thermochemical cycle

The H_2S incineration occurs at temperatures of 1073-1373K in presence of O_2 to yield H_2O and SO_2. This SO_2 will then reacts exothermically with I_2 and H_2O in the Bunsen reaction to produce two acids: H_2SO_4 and HI. There are two immiscible liquid phases: the H_2SO_4 phase, consisting primarily of H_2SO_4 and H_2O; and the HIx phase that contains mainly HI, I_2 and H_2O. The Bunsen reaction is highly exothermic, and for it to spontaneously proceed in the liquid phase, excessive H_2O is required. Another reactant, I_2, also needs to be put in excess to separate the mixture of H_2SO_4 and HIx phases into two immiscible aqueous phases (a liquid- liquid equilibrium phase separation process). Therefore, purification of H_2SO_4 and HIx phases is also required. The next step is the HI decomposition, an endothermic catalytic reaction, releases hydrogen and requires lower temperatures (573-723K).

During the studies, the proof of concept in quartz systems has been established in Phase-I. Although H_2S incineration is a well-established process, to generate process 'know how' to address some critical issues in view of open-loop S-I cycle, H_2S incineration was studied in the laboratory scale H_2S incinerator designed/fabricated based on the simulation and data obtained from Sulphur Recovery Unit (SRU) of the refinery with complete combustion.

During the studies, the Bunsen reaction was optimized to reduce cross-contamination and achieve maximum purification of HIx and H_2SO_4 phases. The complete purification of H_2SO_4 phase and HIx phases was achieved. In HI section, the catalyst was tested with the HI collected as the distillate after distillation and showed exceptional performance. Presently, the integration of various sub-sections are in progress now based on which a pilot scale metallic system is planned.

In both the partially open loop and closed loop I-S cycle, the iodine section constituting HIx concentration, HI decomposition and H_2 separation from HI decomposition possess significant challenges in terms of complexity and material handling. In order to reduce the temperature requirement of HI section of I-S cycle, feasibility of HI decomposition using electrochemical approach is also being explored.

4. Summary

OEC has established the processes viz. close-loop Cu-Cl cycle and close/open loop I-S cycle so far at lab / lab engineering scale and is in the process of scaling up at ONGC premises for process intensification using in-house designs and indigenous fabrications in an effort to move forward for realizing ultimate commercialization goals. Despite challenges in indigenous development of such technologies for the first time in India that are even yet to be commercialized elsewhere in the world, OEC has made significant strides in the development of these processes, including the supporting technology like membranes, catalysts, electrodes, design of corrosion test methods for screening / materials of construction, indigenous sources of fabrication, etc., and earned several national and international patents for the developed products and processes. Overall, efforts are being made by OEC for cost effective green hydrogen ecosystem on a fast track mode to meet the large hydrogen requirements anticipated in near future in a techno-economically feasible way.

Acknowledgements

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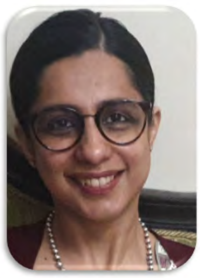
A Discussion on the Challenges in the Road to Net Zero



Jessica Singh
Chief Manager
(Corporate Planning & Economic Studies)

Sachin Srivastava
Chief Manager
(Corporate Planning & Economic Studies)

Indian Oil Corporation Limited

Abstract:

This article is intended to catalyze a discussion on the varied and daunting challenges that need to be addressed to reach the goal of a Net Zero world. Broadly, these are technological, financial, and socio-economic. However, over and above these, are the challenges of governance. In this article we discuss the governance challenges in the context of India's current federal structure and its energy governance systems and protocols. In the end, we put forth suggestions that could be adopted for effective governance which can regulate the pathway to Net Zero.

I. Introduction

At the 26th Conference of Parties (COP26), India committed to a net-zero emissions target by 2070[i]. Today, majority of the countries have taken up Net Zero Commitments and for each of these, this is bound to bring about intimidating policy challenges. In India, these challenges are expected to be more pronounced, as its Net Zero Target intersects with the contemporaneous economic growth and social transitions including a demographic and urban transition[ii]. The emergence of discourse globally on "just transition' and "orderly transition" is a manifestation of wide ranging, economy wide impacts that Net Zero ambitions in particular, and energy transition in general, is expected to have.

In this article we discuss on the various including many especially daunting ones, that need to be addressed to reach the goal of a Net Zero world. Broadly these are technological, financial, socio-economic, and over and above these, are the challenges of governance. We discuss the governance challenges in the context of India's current federal structure and its energy governance systems and protocols. In the end, we propose suggestions that could be adopted for effective governance towards Net Zero.

II. India on the Eve of the Net Zero Journey

India is the 3rd biggest energy consumer and the 3rd biggest carbon emitter in the world.

India's energy demand has been growing rapidly and stood at 929 mtoe in 2019 (falling marginally to 880 mtoe in 2020). Currently, India's energy mix is dominated by coal, with it accounting for 44% of its energy mix. This is followed by oil which meets its 26% of energy demand. Share of Natural Gas in the Indian energy mix is low at 6% as compared to the world average of 20%. Nearly 85% of the oil demand and 54% of gas demand is met through imports.

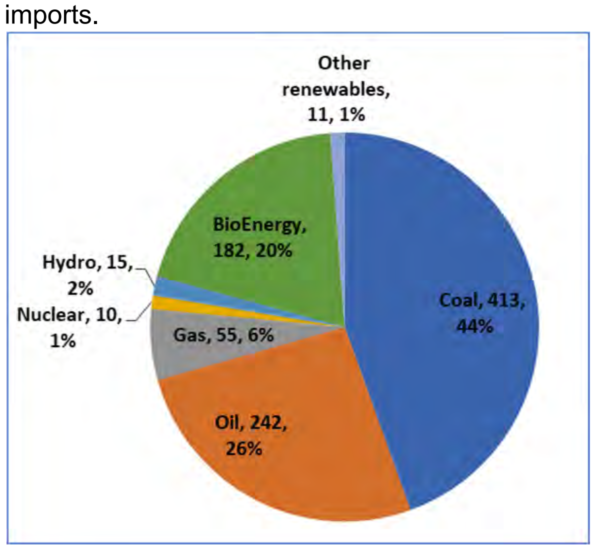


Fig. 1: India's Total Primary Energy Demand
Source: WEO 2020

India is set to drive global energy demand over the long term given India's long term energy demand growth trajectory. Megatrends underpinning this are an expanding economy, rising population, urbanization, industrialization, emerging middle class, and a young population in contrast to ageing societies of advanced economies. Moreover, in India there is also a pressing need to bridge the energy access deficit (in line with United Nation's Sustainable Development Goals). Despite being the third largest energy consumer in the world, its per capita energy consumption levels are abysmally low. At 0.6 toe per person India stands not only well below the world average of 1.7 toe per person, but also below the Non-OECD average of 1.3 toe per person-pointing towards a conspicuous energy access deficit.

India's Performance on Nationally Determined Contributions: India, Nationally Determined Contributions (NDCs) 2015 were subsequently raised at COP 26 with greater commitment, the table below details India's progress on its NDCs:

India's Original NDCs	Progress in NDCs
40 % of installed power capacity from non-fossil fuels by 2030	41.6% (168 GW as on 31.7.22) India's nuclear energy-based installed electricity capacity stands at 6.78 GW
Reducing the emissions intensity of GDP by 33 to 35 per cent by 2030 from 2005 level	Emission intensity of its GDP reduced by 21 per cent between 2005 and 2020.
Additional 'carbon sink' of 2.5 to 3 billion tons of CO2 equivalent through additional forest and tree cover by 2030	India's forest and tree cover increased from 802 thousand km2 in 2017 to 807 km2 in 2019. The net change in the carbon stocks of forests was +42.6 Mt or 156.2 MtCO2 equivalent between the assessments of 2017 and 2019.

Table 1: India's NDCs and their Present Status

India's Updated NDCs in line with COP26 announcements (updated by GoI in Aug 2022):

- India now stands committed to reduce Emissions Intensity of its GDP by 45 percent by 2030, from 2005 level
- Achieve about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.

III. Challenges in achieving Net Zero

Net Zero as an end target can be achieved through multiple pathways, but the optimal pathway would be one that while achieving net zero, addresses not only the challenge of technology but also the challenges of financing, socio-economic outcomes and of governance.

• ***Technological Challenge:***

First and foremost, Net Zero targets have an inherent technological challenge. Across pathways and agencies, what is amply clear is that radical technological transformations are fundamental to meeting Net Zero Targets. In addition to established technologies like energy efficiency and renewables, many new technologies such as advanced batteries, CCUS, Hydrogen, Carbon Dioxide Removal (CDR), Geo-engineering etc., which have not yet been commercialized will be critical to achieving net zero targets. So will be the need of finding innovative (less carbon intensive) production pathways for heavy industries like steel, cement and chemicals. Many of these technologies despite the zeitgeist of sustainable finance, continue to face funding gaps in R&D, which further exacerbates the scale of the technological challenge.

• ***Financing Challenge:***

The financing challenges for a Net Zero world are daunting too. For instance, an analysis by McKinsey & Co.[iii], estimates that investment in new infrastructure to meet global climate goals would be to the tune of $9.2 trillion per year through 2050. Currently, global energy sector investment (on both low carbon and fossil fuels) is $5.7 trillion annually. Meeting Net Zero targets would not only require reallocation from fossil fuels to low carbon fuels, but also an additional investment (60% more that today) of $3.5 trillion annually which is roughly equivalent to the size of Germany's economy (Germany GDP at Market Exchange rates 2019: $ 3.85 trillion). Developing countries like India would have to spend much higher proportions of their GDP on Net Zero investments. For instance, India's required investment is estimated to be 10.7% of GDP (2021-2050), while for Europe and UK this is much less at 6.5% of GDP.

And, these are just mitigation costs, the challenge of climate change would also impose adaptation costs which is reckoned by climate scientists to be of a much higher order. Climate finance, i.e., money flowing from developed countries (both from public and private sources) to developing countries for adaptation and mitigation, set at $100 billion currently, is not only paltry but also remains underachieved. This highlights the daunting task of getting the required capital for meeting Net Zero goals especially for developing countries like India.

Reallocation and raising of high level of capital will have to address concerns of technological uncertainty of investment, manage risk/return trade-offs and direct capital flows to developing countries. Along with this, lie the associated and often unanswered questions of who pays for the transition- government or businesses, whether funds are raised through taxes or debt or equity and will it be developing countries or developed countries who pay for it. These financing choices would in turn influence (i) the pace of the transition, (ii) its achievements and (iii) its socio-economic consequences. For instance:

"India's climate actions have so far been largely financed from domestic resources. However, providing new and additional financial resources as well as transfer of technology to address the global climate change challenge are among the commitments and responsibilities of the developed countries under UNFCCC and the Paris Agreement. India will also require its due share from such international financial resources and technological support."

Union Cabinet, India's Updated NDCs, PIB (Release ID: 1847812)

(i) Public funding in form of subsidies and investment in infrastructure for EVs would be critical to achieving the scale of EV penetration required for meeting Net Zero Targets. A shift to EVs for instance in India would require demand creation, which would not only require cost parity and availability of models but also charging infrastructure. And, only in a market where there is demand would auto makers come out with models. And, for creating this demand, it may be required of the Government to invest and subsidize. If left to market forces and private investment alone, investment could be below the desired levels leading to underachievement of targets.

(ii) If developed economies don't raise the bar of their financing commitments, financing of transition for developing countries would be a daunting task that could suppress the transition itself.

(iii) Finally, taxation of public to raise resources for the transition such as carbon tax, could affect consumer spending and hence economic activity and job creation. The allocation pattern of tax revenues so generated would be a crucial determinant of whether the transition is (or not) aligned with the growth imperative.

• ***Socio-Economic Challenge:***

The figure given below (Figure 2) compares total carbon emissions with GDP per capita for the twenty largest emitters of Carbon Dioxide in the world. Nine out of these twenty countries have a GDP per capita, below the threshold value of $ 25000. This graphical presentation captures the quintessential dilemma that the large developing countries face: to either prioritize spending on development of their economies or on meeting climate goals.

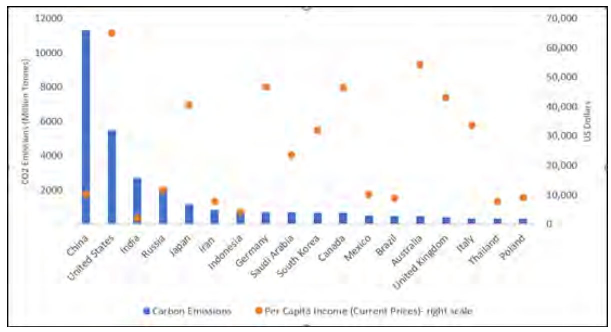


Fig. 2 Carbon emissions versus GDP/Capita (2019)
Source: Data from BP Statistical Review of World Energy 2022&IMF World Economic Outlook April 2022

Net Zero transition is expected to reduce employment and economic activity in fossil fuel sectors. The coal sector is the most labor-intensive form of fossil fuel extraction; in India for instance, the sector employs a workforce of at least 2.6 million people. Net Zero transition along with industry wide changes such as automation pose a real risk to jobs in the coal mining sector. Mine closures run the risk of causing deep and long-term impact on local communities, reducing economic activity, causing discontent among the people and social dislocation. In case of India, this risk is highly potent for the coal belt of India, where economic activity and employment is driven by the coal sector. Similarly, shift towards electrification of transport poses similar risks to automobile and refining sectors- important pillars of India's manufacturing base.

Another challenge associated with energy transition is that despite the wide-ranging disruptions that will accompany the transition, it is of paramount importance to ensure that energy access is maintained at all places at all times. Accordingly, a concurrent goal for the global economy is to achieve *100% access to modern energy to all by 2030* as part of the Sustainable Development Goals (SDGs)[iv]. Moreover, given the basic nature of energy demand, it is vital to ensure supplies at affordable prices for smooth functioning of economies and for meeting energy requirements of their residents. In the latter half of 2021 (prior to the Russia-Ukraine war), we were in midst of an energy crisis, with prices of gas, coal and electricity soaring to unprecedented levels, and we saw Europe struggling for gas supplies and glaring power shortages in many provinces in China. This was in part, on the demand side due to harsher weather conditions. It was also due to disruptions in renewable energy supplies due to unexpected weather changes such as low wind speeds affecting wind output in North Sea and drought in parts of China affecting hydropower output. Such situations could only become more frequent with the Net Zero Transition as reliance on renewable energy increases. Further, increased occurrence of extreme weather events, has been found to be related with the rising carbon levels in the atmosphere, increasing the likelihood of such situations going forward.

Another aspect of the transition that brings forth its own set of challenges and risks is that renewable energy and battery technologies- the bellwethers of the net zero transition are highly metal intensive. In 2021, we witnessed, prices of crucial energy transition metals such as aluminum, copper, nickel, lithium, and cobalt rise to unprecedented levels and these have continued their rise well into 2022. Rising demand, disrupted supply chains and concerns around tightening supply due to the current geopolitical condition have accounted for the price rise. The falling cost of solar & wind power and batteries have been fundamental to their growing adoption and remain crucial to their future growth. In 2022, for the first-time battery costs are expected to rise according to Bloomberg NEF, reversing a secular trend of falling cost. Runaway inflation in crucial energy transition metals has emerged as a major challenge in the path to net zero. Companies and countries are scrambling for getting access to these crucial resources. All routes such as through investments in resource rich geographies, through diplomacy and through focus on finding & raising domestic production are being adopted- marking the crucial role of these metals in the future world order . Another aspect related to these transition metals, is that of working conditions and human rights of workers engaged in their mining, which in some cases have been flagged to have been compromised. Case in point is that of use child labour in cobalt mining in Democratic Republic of Congo (DRC), which presently accounts for 70% of world cobalt production.

It is in the backdrop of these wide socio-economic ramifications of the net zero transition that the need for ensuring that the transition is just and orderly, acquires increased importance.

Box 1: Russia-Ukraine Conflict & Net Zero Challenges

The ongoing Russia-Ukraine conflict and the resultant sanctions and high prices of fossil fuels especially gas and many transition metals has come as an additional challenge in the context of global net zero goals.

For one, the world is set to burn more coal this year, which is at loggerheads with net zero transition (at least in the short-term context). Global carbon emissions are now on course for new highs in 2022.

There has been an increase in investment fossil fuel infrastructure in Europe, such as LNG import terminals across Europe and restart of coal power plants and permission to restart mining operations in many European countries. This seems to be an U-turn from Europe’s plans prior to the war.

In the backdrop of the worst energy crisis of a generation, with countries scrambling for fossil fuel energy supplies and citizens facing runaway energy price inflation, countries with plans of introduction of carbon pricing such as Philippines have been forced to put these on a back burner. However, high fossil fuel prices effectively mean higher carbon price on fossil fuels and hence may induce substitution away from these.

The current crisis could also therefore lead to focus on energy efficiency and quicker deployment of renewables capacity, at least for those Asian nations which are heavily dependent on energy imports. On the other hand, all-time high prices of some metals required for renewable energy are adding to cost pressure in wind turbines, large-scale battery storage, and other renewable infrastructures.

The current crisis could also be a turning point for global nuclear industry. The events of Three Mile Island in Pennsylvania in 1979; Chernobyl in 1986; and Fukushima in Japan in 2011 led to a movement in most parts of the world that forced the governments to abandon the development of nuclear projects. Current high energy prices and the need to cut carbon emission is forcing countries to reconsider their stances on nuclear energy. European Union in August decided thar that nuclear energy could be promoted if there were enough safeguards. Under the commission’s plan, new nuclear plants that show they can safely handle toxic nuclear waste could be counted as green investments until 2045. In Asia, newly elected leaders of the Philippines, Japan, and South Korea, empowered by shifting public opinion, are also pushing ahead with plans to restart reactors and build new nuclear plants to ease power shortages.

IV. The Overarching Governance Challenge

Over and above these and encompassing all these challenges, is the Governance challenge. Climate Change is said to be "all-of-society and all-of-government problem"[vi]. It entails governance challenges at global, national and local levels and also requires a never-before-seen coordination, as the world collectively tries to limit global temperature rise while working within a finite and shrinking carbon budget. Far greater interagency coordination both vertically & horizontally would be the cornerstone of transition governance. According to Mckinsey (2021)[vii], the pace, scale, and systemic nature of the required transition likely means:

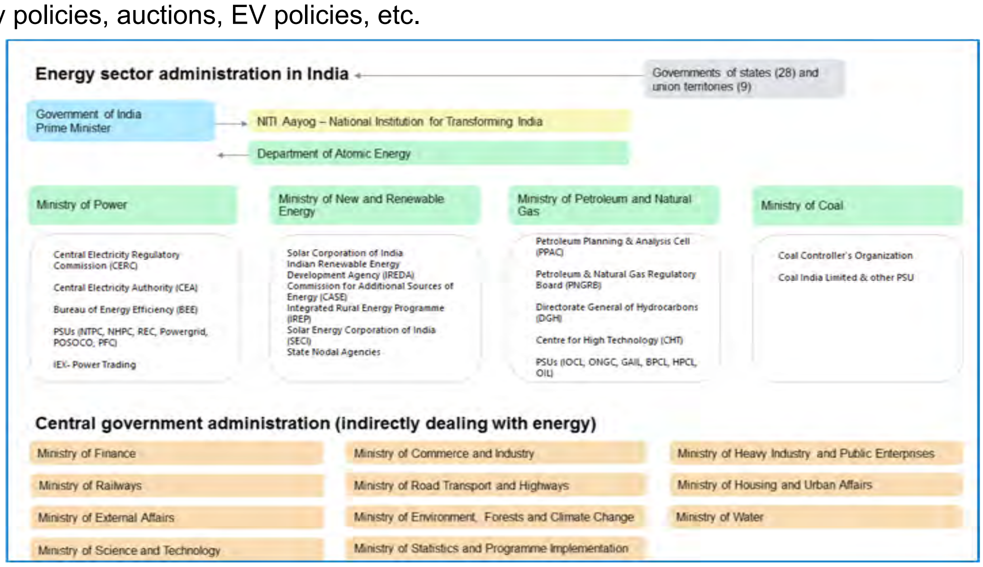
• That many of today's institutions may need to be revamped, and new institutions may need to be created to enable best-practice sharing, drive capital deployment at scale, manage uneven impacts across stakeholders, and spur collective action. These institutions include standard-setting organizations, global platforms for collective action (including partnerships across public and private sectors), local chapters of larger organizations, and civil society institutions.

• Further institutional needs will also undoubtedly emerge. As with technological innovation, adapting or creating organizations committed to net zero will likely gain momentum as the transition proceeds—and engender resistance.

> *"Achieving net zero requires operationalization in varied social, political and economic spheres. There are numerous ethical judgements, social concerns, political interests, fairness dimensions, economic considerations and technology transitions that need to be navigated, and several political, economic, legal and behavioural pitfalls that could derail a successful implementation of net zero."*
>
> Fankhauser, S., Smith, S.M., Allen, M. *et al.* The meaning of net zero and how to get it right
> *https://www.nature.com/articles/s41558-021-01245-w*

Looking at the governance set-up in India, India has a Federal System of Governance, with Constitutional division of powers between the State and Central Governments. Many areas related to energy such as agriculture, land, mines and minerals (with conditions), gas etc. fall under State legislation, while Center is responsible for fewer (although important) areas such as atomic energy and mineral resources, oil and petroleum, and a few aspects of mines and minerals. In addition to this, areas such as forests and electricity fall under the concurrent list, which is governed by both State and Center. This presents a major governance challenge as "while financial and bureaucratic capabilities are concentrated in the center, the locus of climate decisions lies largely in the states because they steer energy choices and respond to climate impacts"[viii]. Further, at the national level, currently India does not have one single ministry in charge of energy policy. The Government of India (GoI) has at least five ministries with responsibilities for energy: The Ministry of Power (MoP), the Ministry of Petroleum and Natural Gas (MoPNG), the Ministry of New and Renewable Energy (MNRE), the Ministry of Coal (MoC) and the Department of Atomic Energy (DAE). In addition, state governments also play a crucial role in energy governance and policies. For instance, electricity being a concurrent subject, the responsibility of distribution rests with States, it is the state power/energy departments that drive state-level policies in areas such as pricing, renewable energy policies, auctions, EV policies, etc.

Fig. 3 Energy Sector Governance Structure, Source: Adapted from IEA



This energy governance structure is associated with many challenges, which are expected to only magnify in the context of working towards net zero target:

a. Conflicting Statements & Plans

There is a broad consensus on the need to move away from excessive dependence on fossil fuels for sound economic and geopolitical reasons, and here the government is betting more on renewables for decarbonizing India's economy. However, targets set by one Ministry can often be found in conflict with the targets of the other and this leads to a potential scenario where there could be underachievement of targets of both the Ministries due to lack of co-ordination. There are CPSEs under the Administrative control of different Ministries like Petroleum and Natural Gas, Coal, Power, etc. while other CPSEs in the energy sector report to MNRE. Fundamentally, national resources are being used for the creation of assets by these entities under the guidance of their Administrative Ministries which may not align with the overall objective of the Government.

b. Overlapping Jurisdiction

In many areas problem of overlapping jurisdiction is faced. Looking at policy instruments applicable for Renewable Energy for instance, apart from Ministry of Renewable Energy (MNRE) several other Ministries and State Level Departments are involved. This makes the adoption and dissemination of Renewable Energy difficult.

	Name of Instrument	Primary responsibility	Objective of Intervention
1	Fiscal interventions		
a.	Capital Subsidy	MNRE	Provide a subsidy to bring down upfront investment costs
b.	Indirect Taxes - Cess, Exemption from VAT/ Sales Tax & Electricity Duty, Exemption from Import/ Excise Duty, Accelerated Depreciation (AD)	Ministry of Finance, State Governments	Lower the gap between RE based power and conventional power
c.	Direct Tax exemptions/ Tax Holidays	Ministry of Finance	Provide direct tax exemptions which incentivize RE based power generation
d.	Interest Subsidies	MNRE	Provide a subsidy on interest to reduce cost of capital and in turn life cycle cost of projects
2	Production Subsidies (GBI)	MNRE	Provide an incentive for production of power
3	RE Funds	State Governments and State Nodal Agencies	Provide low cost funds to promote investments in RE
4	Demonstration Projects and R&D Grants	MNRE	Showcase technology development with the aim of inviting investments
5	Carbon Trading	Ministry of Environment and Forests	Provide a financial incentive for carbon mitigation, thereby encouraging clean power generation
6	State RE Policies (including issues such as development of transmission networks to connect RE projects, and wheeling & banking, Third Party Sale)	State Governments	Provide a policy framework for encouraging RE investment in the state

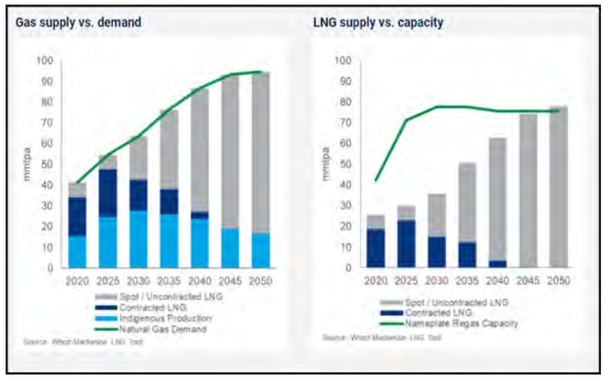
Source: compiled from various sources

Fig 4. Cases of Overlapping Jurisdiction in Indian Renewable Energy context

c. Risk of Stranded Assets:

The country today has a multitude of plans for infrastructure expansion in the gas sector, renewable energy sector, bioenergy, and electric charging, plans and investments are afoot even in the oil sector across upstream, midstream, and downstream. Along with this, the latest has been the adoption of National Hydrogen Mission. Moreover, currently, India has 34.5 GW of coal power capacity under construction.

This approach does pose a risk of any new infrastructure especially in the fossil fuels sector getting stranded as technology advancements continue and more competitive options become available for use. This risk is not only relevant for the coal and oil refining sectors but also for India's Natural Gas Sector, where currently a massive wave of investment is taking place.



The risk of stranded gas assets could be especially true if the bridging period to Net Zero, where the prospective role of gas is etched out, is shorter than expected. The creation of a Pan-India gas grid to move towards a gas based economy and conversion of LPG consumers to Piped Gas is shifting the base of hitherto urban LPG consumers. However, with increased and better power availability, energy efficient electric induction cooktops could see a rise in their adoption, especially in urban areas and that could in turn affect Piped Gas in the medium to long term. In addition to this, India's LNG Re-gas sector today itself is mired with low utilization rates, and despite 50% expansion in gas demand in this decade the trend of underutilization is expected to continue, especially in the context of the current energy crisis. In case gas prices remain elevated for a longer duration, as is currently being anticipated by some analysts, it could lead to permanent demand destruction for gas and lead to stranded gas assets. Further, even in case of renewables, high global metal prices coupled with increase in custom duty on solar PV and parts of wind generator imports (imposed prior to the crisis to promote domestic PV manufacturing) are adding to the cost pressures and in case metal prices remain elevated for a longer duration, it could impact the growth of renewables in a price-sensitive market such as India.

V. Way Forward

- At a very fundamental level, given the pervasive nature of the climate change challenge, it is pertinent that *climate imperatives get embedded as a set of umbrella processes in government's decision making at all levels* and across ministries & departments. At the same time, while taking decisions on actions and pathways for Net Zero, pathways should be congruent with economic and social goals both in the short term and over the long term.

• Talking about ***energy administration*** in India, the current energy multifarious structure of governance spread across ministries and national and sub-national governments has a number of challenges associated with it at present and these are bound to get exacerbated with the Net Zero Transition. This points to the need for having a holistic approach to energy administration as has been voiced by experts for some time now. For instance, Kelkar Committee Report on Roadmap for Reduction in Import Dependency in the Hydrocarbon Sector by 2030 (2014) had voiced this concern in regard to energy security objectives of the country- "In India, multiple ministries and agencies are currently involved in managing energy related issues, presenting challenges of co-ordination and optimal resource utilization, hence undermining efforts to increase energy security." More recently, draft of National Energy Policy by Niti Aayog in 2017 emphasized that "In view of the fact, that energy is handled by different Ministries that have the primary responsibility of setting their own sectoral agenda, an omnibus policy is required to achieve the goal of energy security through coordination between these sources." ***Some of the suggested tenets of an omnibus energy governance structure could be:***

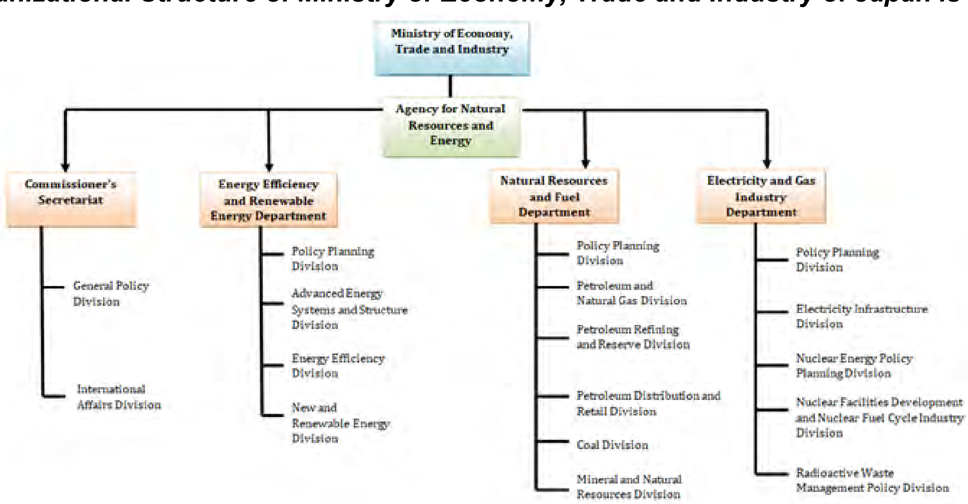
✓ A National Energy Policy with decadal targets up to 2070
✓ A Nodal agency approving public funded mega energy infrastructure projects in alignment with the National Energy Policy
✓ A National Level Energy Think Tank and Projection agency that forms the basis for informed and research backed changes in energy sector targets and plans along with an integrated energy data platform. In the US, the Energy Information Administration (EIA) that collects, analyzes, and disseminates independent and impartial energy information to promote policymaking and efficient markets is one such example.
✓ An Omnibus Ministry or a mechanism that enhances and nurtures synergy between ministries. For example, in Japan, Ministry of Economy, Trade & Industry is responsible for total Energy & Environment Policy for Integrated Planning. India can also take a similar approach to meet the energy challenge, which is of fundamental importance in meeting India's growth story.

Box 2: Omnibus Ministry of Japan

Japan's Ministry of Economy, Trade, and Industry is an Omnibus Ministry under which there is an Agency for Natural Resources and Energy and which is responsible for Japan's policies regarding energy and natural resources. The Agency coordinates with various departments in policy formulation and implementation, such as Energy Efficiency and Renewable Energy Department, Natural Resources and Fuel Department, and Electricity and Gas Industry Department.

India could consider some of these design elements for its Omnibus Ministry. Taking cue from this structure, India could start with rationalization of the structure by bringing electricity related Power Ministry and MNRE together.

The Organizational Structure of Ministry of Economy, Trade and Industry of Japan is as under:



• Further, talking broadly about climate governance, insights from Dubash et al May 2021, & Dubash et al June 2021, wherein the authors suggest a climate governance structure for India seem potent-

- The approach to climate governance should be embedded in law such as UK's Climate Change Law (2008)
- Need for enhanced policy and technical capacities within Government ministries and departments to consider climate linkages
- An Executive Committee on Climate Change (ECCC) backed by the authority of Prime Minister's Office
- Setting up of a law backed new non-executive institution, which the authors call the Low-Carbon Development Commission (LCDC). Some of the suggested salient features of LCDC by the authors are:
    - ✓ Multi stakeholder commission
    - ✓ Generate analytically backed, policy relevant research
    - ✓ Independent status with accountability to Parliament like National Human Rights Commission
    - ✓ To serve as interface with research institutions, government bodies and stakeholders from industry, labor, civil society & media to obtain information, compile analysis and foster deliberation
    - ✓ Could serve as a point for engagement with state inputs, could help generate center-state alignment on low-carbon development pathways and provide a set of guidelines toward the long-term creation of a climate-ready federal system. The Finance Commission, an independent expert body at the center of India's fiscal federalism, has played a similar center-state coordination role successfully for decades by virtue of its extensive consultations, rigor, and apolitical nature.

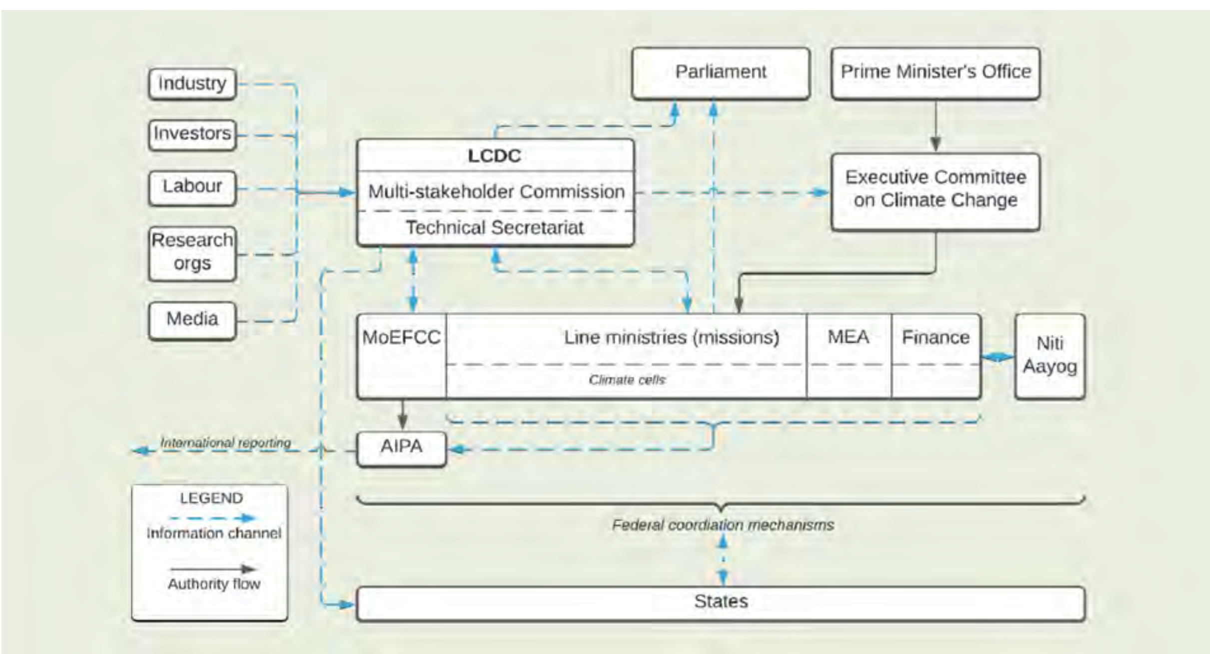


Fig. 5 Proposed Climate Governance Architecture

Source: Dubash, NK, A.V. Pillai, and P. Bhatia. 2021 "Building a Climate-Ready State: Institutions and Governance for a Transformative Low Carbon Development. Policy Brief, Initiative for Climate, Energy, and Environment. New Delhi: Centre for Policy Research. May 2021

In the end, one would agree that even with the best of revamping of governance models and embedding of climate into policy decision making, there would still be limitations as to what governance and coordination alone can achieve. An ideal scenario would require not only policy decisions based on net zero principles, but also individual decisions based on that i.e., net zero principles getting embedded in decision making of each and every economic agent (consumers and producers). And it is here that the fundamental role of carbon pricing as an efficient tool that complements climate governance could come in.

Economist describe, Climate Change as a problem of market failure , consumption & production of goods and services entail carbon emissions, however, under current market mechanisms the cost of this pollution is not accounted for in the price of goods and services. A carbon price or tax puts a price on each unit of carbon emitted and thereby sends a price signal that cause a market response across an entire economy, creating incentives for emitters to shift to less carbon intensive ways of production and ultimately resulting in reduced emissions. When set appropriately and with wide enough coverage, it can change "everyone's behavior – from multinational corporations to individuals" .Further, the revenue generated from carbon tax can be used to invest in green alternatives, cushion low-income households from cost impacts, thereby not only easing the Governance challenge but also addressing the financial & socio-economic challenges.

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Disclaimer: The views expressed are personal and not representative of those of Indian Oil Corporation Limited

i It remains unclear whether India's target covers all greenhouse gas (GHG) emissions or CO2 emissions only. India has not yet submitted a long-term strategy (LTS) to the UNFCCC as of 12 November 2021.
ii https://iopscience.iop.org/article/10.1088/1748-9326/aacc74
iii Mckinsey 2021: https://www.mckinsey.com/business-functions/sustainability/our-insights/the-net-zero-transition-what-it-would-cost-what-it-could-bring#
iv SDG 7 of "Ensure access to affordable, reliable, sustainable and modern energy for all"

v Recently, the U.S. invoked the 1950 Defense Production Act (DPA), with the aim of strengthening domestic supplies of battery raw materials including lithium, nickel, cobalt, graphite, and manganese. The Presidential executive order announcing the move argues that "action to expand the domestic production capabilities for such strategic and critical materials is necessary to avert an industrial resource or critical technology item shortfall that would severely impair the national defense capability." Soaring prices for battery raw materials, driving up the cost of electric vehicles, have highlighted those risks. The order mandates the Secretary of Defense to help increase domestic production for these critical materials by supporting a range of activities, including feasibility studies for new mining and processing projects, and modernisation to increase productivity at existing facilities. The DPA was used dozens of times during 2020-21, as the Trump and then Biden administrations attempted to increase production of urgently needed medical supplies including Covid tests and personal protective equipment.

vi Dubash et al May 2021
vii Solving-the-net-zero-equation-nine-requirements-for-a-more-orderly-transition
viii https://cprindia.org/briefsreports/unlocking-climate-action-in-indian-federalism/
ix In 2022-23, GoI removed the exemption in Basic Customs Duty on solar PV and parts of wind generators, which are highly import reliant and the base rates were also increased
x The 2008 Climate Change Act is the foundation of United Kingdom's approach to reducing emissions and preparing for the impact of climate change. The Act consisted of legally binding emissions targets for 2050. The Act balances the primacy of the government and parliament in making decisions with the use of independent advisers in interpreting science and evidence. The Act is widely credited with having contributed to reducing the country's gross greenhouse gas emissions by 26% between 2010 and 2019, while the economy grew by 17% in the same period. The Act has served as a model for the development of climate legislation in a number of countries, including Denmark, France, Germany, Ireland, Mexico, New Zealand and Sweden. The specifics of these laws vary between countries, but in all cases the laws involve setting interim targets on the pathway to a long-term goal and independent evidence-based advice.
xi " Climate change is a result of the greatest market failure that the world has seen": Nicolas Stern-author of the landmark Stern Review, 2007
xii Zero Carbon Commission on UK emissions pricing. Interim Report, June 2020

194R- New Withholding Provisions on Benefits/Perquisites



Neetu Vinayek
Partner

Hiten Sutar
Director

Milan Kapadia
Senior Consultant

Ernst & Young LLP

1. Backdrop

► Companies across O&G value chain adopt strategies/campaigns for increasing their business presence. As a part of these campaigns various incentives plans and marketing strategies are formulated to reach out to customers/distributors. These include loyalty points, incentives on achieving sales targets, provision of infrastructure facilities, etc. These incentive plans are very common and is part of day-to-day business run by these companies.

► Till now, there was no obligation on O&G companies to ascertain whether the expenditure would result in a benefit or perquisite in the hands of any person. However, from 1 July 2022, a mandatory requirement has been inserted in the Income-tax Act, 1961 ('the Act') is to ascertain whether any payments would result in any benefit or perquisite in the hands of an Indian resident and if yes, payer is required to withhold taxes on such benefit or perquisite. Non-compliance of such provisions would result in denial of tax-deductible expenditure as well as interest and penalty under the provisions the Act.

► The applicability of new withholding tax provision under section 194R along with its impact and implications are discussed hereunder

2. Applicability of section 194R

► The provisions of section 194R applies when:

► Any person provides benefit or perquisite;
► Such benefit or perquisite arises from exercise of business or profession of recipient;
► The recipient is a resident of India; and
► The value of benefit or perquisite or aggregate value of such benefit or perquisite qua the payer and recipient exceeds INR 20,000 in the relevant Financial Year.

► If above conditions are fulfilled, then the payer is required to deduct taxes @ 10% on the value of benefit or perquisite provided. Such taxes are to be deducted 'before' providing the benefit or perquisite. Further, the provisions of section 194R shall be applicable only if the benefit or perquisite is provided in favour of a resident. However, a person who provides the benefit may be a resident or non-resident.

► The provisions of section 194R are not applicable to individual/HUF whose total sales, gross receipts or turnover in the financial year immediately preceding the financial year in which the benefit or perquisite is provided did not exceed INR 1 crore in case of business and INR 50 lakhs in case of profession.

► As per first proviso to section 194R(1) of the Act, where the benefit or perquisite provided is wholly or partly in cash and partly in kind and such part in cash is not sufficient to meet the TDS liability in respect of such benefit or perquisite then the person responsible for providing such benefit or perquisite, before its release should ensure that the TDS required to be deducted has been paid.

► Considering far-reaching implications of section 194R of the Act, a high degree of ambiguity prevailed on the applicability of the said provisions. Accordingly, the Central Board of Direct Taxes ('CBDT') vide Circular No 12 of 2022 dated 16 June 2022 and Circular No 18 of 2022 dated 13 September 2022 has issued certain FAQs to address the prevailing ambiguities.

3. Impact of Section 194R and CBDT Circulars – Key considerations

► Few key considerations applicable to below categories of taxpayers within O&G sector are discussed as under:

A. Business Associates
B. Dealers/ Distributors
C. Service Agents

A. Business Associates

i. Waiver of Loan

► Waiver of loan used for capital asset is per se a benefit or not was very controversial on account of conflicting decisions given by the Indian judiciary. In the case of CIT vs. Ramaniyam Homes (68 taxmann.com 289), the Madras HC dealt with the taxability of waiver of loan under one-time settlement scheme and held that such waiver is a benefit received by the debtor and hence taxable under the Act. However, in case of Mahindra and Mahindra (93 taxman.com 32), the Supreme Court held that waiver of loan is not taxable under the Act.

► With the introduction of section 194R and CBDT circulars, it has been clarified that waiver of loan may be an income to the person who had taken the loan and accordingly the provisions of section 194R would be applicable to such waiver of loan.

► The above clarification put an anomaly in cases under the Insolvency and Bankruptcy Code ('IBC'), where waiver or haircut was agreed by the lender bank. It could be seen that such waiver or haircut is for the benefit of bank itself as they could recover some amount from the debtor which may not have been possible due to insolvency of debtor. Thus, the primary objective of IBC is for benefit of the lender bank rather than benefit to debtor.

► However, subjecting such transaction to tax under section 194R would put extra cost on the bank as this would require payment of tax in addition to the haircut already taken by such bank and accordingly, CBDT issued clarifications exempting banks and other specified entities from the provisions of section 194R.

► Although, this was a welcoming clarification issued by CBDT, ambiguities still prevail in case of loans given by a Company to its sister concerns. For example, a company operating in an O&G sector gives a loan to its sister concern for doing Exploration and Production ('E&P') activities and if such E&P business fails on account of high risk prevailing in the O&G sector, due to which the lender company waives of the loan then whether the provisions of section 194R shall apply should be duly clarified. If such provisions apply then it could be a scenario whether the lender has to deduct and pay taxes of 10% out of its own pocket which may not be recoverable. Further, the entity which has received the benefit of loan waiver would contend that the loan was taken for building its capital base and thus such waiver would constitute a capital receipt and should not be considered as taxable. Deduction of taxes on loan amount in this scenario would result into cash blockages and would be adverse to the business operations.

B. Dealers/Distributors

a. Business meetings/conferences

► Companies are required to hold business meetings/conference in the regular course of business to educate their customers/dealers regarding new products, obtaining orders from customers, imparting training to dealers/distributors, etc. During such business meetings/conference, certain benefits or perquisites such as airline tickets, overstay facilities, leisure activities etc are provided to the distributors/dealers. At times, there are certain benefits or perquisite which are provided in a group activity during such business meetings/conference.

► To address the aforesaid issues, CBDT clarified that expenditure incurred on dealers/ distributors for overstay facilities provided prior to the dates of conference or beyond the dates of conference would be considered as benefits or perquisites for the purpose of section 194R. However, stay facilities provided for one day prior to the date of conference till a day immediately following the conclusion of conference would not qualify as benefit or perquisite.

► It is also clarified that expenditure attributable to leisure component may be regarded as benefit or perquisite even if it is incidental to business meetings or conference. Thus, the CBDT circular opines to deduct TDS under section 194R on such leisure component.

► In case benefits or perquisites are provided in a group activity then the value of benefit or perquisite needs to be allocated to each participant of the group using a reasonable allocation key. However, instances may arise when it is practically difficult to allocate the expenses incurred for a group as a whole. For example – Company paying Mediclaim premium for its dealers/distributors. In this case, each company needs to devise a strategy as to how it would compute deduction under section 194R.

b. Incentives on achieving sales target

► To incentivize dealers/distributors for achieving sales target, Companies often float various promotional schemes for its dealers/distributors. For instance, a company may provide flat discount on the invoice amount to its dealer/distributors who purchase stock exceeding specified quantity or providing credit note of certain % of the purchase value if the purchases exceed a specified quantity, cash incentives in the form of credit notes and such credit notes can be adjusted against future invoices.

► Sometimes, promotional schemes are floated in such a way that it provides benefit or perquisite to the dealer/distributor in the form Mobile or Gold coin or any other asset etc.

► CBDT while clarifying this issue opined that if the dealer/distributor opts for credit note which is adjusted against subsequent invoices then a position may be taken that no tax is required to be deducted under section 194R on account of practical difficulties faced by the seller.

► However, if the dealer/distributor opts for a Mobile or Gold Coin or any other asset then the said incentive can trigger the provisions of section 194R.

c. Reward points

► Companies may run a loyalty/reward point scheme for its dealer/distributors where notional reward points are credited to dealers based on goods purchased by them. The said reward points may be subsequently redeemed / encashed in various forms such as shopping vouchers, electrical appliances etc

► Since the reward points are redeemed in the form of shopping vouchers/electrical appliance, the provisions of section 194R shall be applicable. However, a question may arise that if the reward points are credited prior to 1 July 2022 and are redeemed post 1 July 2022 then whether provisions of section 194R will apply.

► Similarly, if Company makes a provision for liability of accumulated reward points as at 31st March based on the estimates then whether the provision of section 194R would apply on such provision. It is necessary that a position is taken on these issues by the companies by suitably reading / modifying existing dealer reward policy. Else the tax department can hold the payer company to be non-compliant and adverse action may be taken against them.

d. Providing Billing software/POS terminals to customers/other assets

► Many a times, Companies in O&G sector provide billing software/POS terminals/other assets to its customers on a returnable basis after a considerable period of time. These billing software/ POS terminals/other assets are utilised for specific activities and are not given with a view to provide benefit or perquisite to the customers. By using the data from such billing software/POS terminals/other assets it helps company to carry out business analytics and thus a view can be taken that such billing software/POS terminals/other assets are given for the benefit of the Company.

► CBDT circular provides for deduction of TDS under section 194R on receipt of items which are capital in nature. However, if a product is utilised for the purpose of rendering of services and is returned back then it will not be treated as benefit for the purpose of section 194R.

► As such, by providing billing software/POS terminals/other assets, no benefit or perquisite arises to the customer. Further, since the billing software/POS terminals/other assets are given to the customers on returnable basis, a view may be taken that provisions of section 194R do not apply.

C. Service Agents

e. Reimbursement of expenses

► Any expenditure which is the liability of one person carrying on business or profession is met by another person qualifies as benefit or perquisite provided by the second person to the first person.

The CBDT circular clarifies that if invoices for Out-of-Pocket Expenses ('OPE') are in the name of service provider and such expenses are reimbursed by the service recipient then it qualifies as benefit or perquisite on which provisions of section 194R applies. On the other hand, if invoices are in the name of service recipient and are being reimbursed then provisions of section 194R are not applicable.

► To give an example, to carry out drilling operations in India, it is very common to import drilling rigs from abroad. Companies in the O&G sector usually appoint a C&F agent who acts on behalf of the importer for obtaining the necessary approvals from custom authorities. While obtaining such approvals, the C&F agent may incur certain expenses on behalf of the importer for which reimbursement is claimed by the agent from the importer. A question would arise whether tax under section 194R is to be deducted on such reimbursements, if yes, this would result in huge cash blockage for the agents.

► Various representations were made before the CBDT to provide additional clarifications/ guidelines in relation to the reimbursement of expenses claimed by the Pure Agent who claims reimbursement on actuals and GST credit on such expenses is also available to the service provider instead of Pure Agent.

► To address this issue, CBDT has clarified that if the service provider has incurred OPE while acting as Pure Agent as per the GST Valuation Rules, 2017 then provisions of section 194R shall not apply to such reimbursement.

► It is further clarified that where OPE is part of consideration in the invoice for professional fees and tax has been deducted on gross consideration (including OPE) under section 194J then the provisions of section 194R would not be applicable.

4. Implications of non-deduction of TDS under section 194R

► In a case, where the taxpayer fails to deduct TDS under section 194R then for such failure it would result into levy of interest and penalty. However, a question arises whether disallowance of expenditure will be triggered for such failure?

► In this regard, CBDT has clarified that the taxpayer needs to disallow and add back the expenditure representing the benefit or perquisite provided while computing the income under the Act if taxes are not deducted under section 194R and to get relieved from its obligation of deduction of taxes under section 194R on such benefit or perquisite.

► In view of above clarifications, the taxpayer may not be able to claim the expenditure if TDS under section 194R is not deducted.

5. Way forward

► While CBDT has come up with 2 Circulars providing clarifications and additional guidelines for implementing the provisions of section 194R, it seems that ambiguities persist which can result into unwarranted litigation.

► In order to avoid getting into prolonged litigation it is advisable to do the following exercise:

- ► Deep dive into various existing business promotion strategies floated by the Company to understand whether these provides any benefit or perquisite to the receiver
- ► To analyse the implication of section 194R before implementing any new business promotion strategies
- ► Develop a mechanism to identify expenses incurred on which the provisions of section 194R may trigger
- ► To avoid litigation, deduct TDS under section 194R on a conservative basis where conflicting views exists.

Oil & Gas in Media

IndianOil becomes the first Oil Marketing Company to produce and market AVGAS 100 LL in the country

"We are undergoing a remarkable transformation which is almost revolutionary. We are reducing dependence on imported fuels by promoting biofuel blending, green hydrogen and introduction of electric vehicles.", stated Shri Hardeep Singh Puri, Minister of Petroleum and Natural Gas & Housing and Urban Affairs while addressing at the launch of AVGAS 100 LL. Shri Hardeep Singh Puri in the presence of General (Dr.) V. K.Singh (Retd.) Minister of State for Civil Aviation and Road Transport and Highways, launched AVGAS 100 LL, special aviation fuel meant for piston engine aircrafts and Unmanned Ariel Vehicles. Currently India is importing this product from European countries. The launch event hosted by Indian Oil at Hindan Airforce Station witnessed participation by senior officials from Indian Airforce, senior officials from MoPNG and MoCA and officials from Flying Training Organizations (FTOs).

Highlighting the importance of launch of indigenous AV GAS 100 LL, the Minister for Petroleum and Natural Gas mentioned that the launch of indigenous AV GAS 100 LL is important to serve the needs of a thriving aviation industry with increase in footfall on airports, rise in number of aircrafts and Flying Training Organisations (FTOs) in trainee aircrafts for pilot training in future. As the demand for air transport in India is expected to increase manifolds in the future, there is going to be a huge demand for trained pilots also. And for this, the number of FTOs is also expected to increase significantly, he added.

Speaking about the launch of indigenous AV GAS 100 LL, Gen. (Dr.) V.K. Singh (Retd.) Minister of State for Civil Aviation, and Road Transport and Highways said that Ministry of Petroleum & Natural Gas under the leadership of Shri Hardeep Puri has put efforts in launch of indigenous AV GAS 100 LL which we were importing before. Under Prime Minister's Atmanirbhar Bharat vision IOCL has come up with AV Gas 100 fuel which was imported so far at huge cost. It will ensure that all our flight schools and all other smaller aircrafts that use AV Gas 100 LL are able to buy this from indigenous sources and save money. It will make huge difference to us in terms of exporting it to areas and countries which need AV Gas 100 LL fuel, he added.

Shri Shrikant Madhav Vaidya, Chairman, Indian Oil said,"Indian Oil is proud to introduce this specialised fuel by leveraging our refining strength and in-house expertise. In fact the indigenous fuel is superior compared to the imported grades. AV Gas market is expected to grow from the current \$ 1.92 billion to \$ 2.71 billion by 2029. We plan to set up a new facility soon to target export opportunities, besides catering to the domestic demand. I am confident that the superior quality we offer, combined with competitive pricing, will give us a significant edge in the global market and open a new chapter in India's journey of self-reliance."

The move towards AatmaNirbhar Bharat:

At present AVGAS 100 LL is completely imported product. The domestic production of AVGAS 100 LL produced by Indian Oil at its Gujarat Refinery will make flying training more affordable in India. This product which fuels the aircraft operated by FTOs and Defense forces, is being imported for decades by India. Indian Oil's R&D, Refineries and Marketing teams have achieved this feat of indigenous production and have offered price advantage to the industry.

IndianOil: Leading the Change

Principal grade of Aviation Gasoline, AVGAS 100 LL is designed for use in turbo charged reciprocating piston engines aircrafts, mainly used by FTOs and defence forces for training pilots.

AV GAS 100 LL produced by IndianOil's flagship refinery at Vadodara has been tested and certified by Directorate General of Civil Aviation (DGCA), the statutory body of the Government of India to regulate civil aviation in India. It is a higher-octane Aviation fuel meeting the product specifications with superior performance quality standards, as compared to imported grades.

The indigenous availability of AV GAS 100 LL will help reduce dependence on imports and address the associated logistical challenges. Country will be able to save precious foreign exchange with the inhouse availability of this product.

This will also benefit more than 35 FTOs across India. With the domestic availability of this product, Ministry of Civil Aviation is considering opening more training institutes in the country. Seeing the increase in aviation traffic, requirement of trained Pilots is expected to increase.

BPCL signed an MoU with M/s Petrobras

In a landmark development to diversify crude oil sourcing for the energy security of the country, particularly in the context of current geopolitical situations, BPCL signed an MoU with M/s Petrobras, the national oil company of Brazil, on 25th September 2022.

The signing of the MOU will strengthen future crude oil trade relationships between the two companies and explore potential crude import opportunities by BPCL, on a long-term basis.

The MoU was signed in Brasilia by Shri Arun Kumar Singh, C&MD BPCL, and Mr. Caio Paes de Andrade, CEO Petrobras, in presence of Shri Pankaj Jain, Secretary, MoPNG, Indian Ambassador to Brazil, and other officials from MoPNG.

Through its fully-owned subsidiary, Bharat PetroResource Limited, BPCL has a stake in the upstream sector in an ultra-deepwater hydrocarbon block in Brazil, owned and operated by M/s Petrobras. The field development plan and final investment decision are expected to be declared soon.

ONGC signs 6 Contracts for Discovered Small Fields in Offshore during DSF-III, 2 Contracts under CBM bid round-2021

Joint Secretary (Refineries) Sunil Kumar and ONGC CMD RK Srivastava (right) exchanging the signed contracts

Oil and Natural Gas Corporation (ONGC) has signed 6 contracts for Discovered Small Fields (DSF) in the Offshore under DSF-III bid round, with 3 each for fields in the Arabian Sea and Bay of Bengal. These include 4 contract areas as sole bidder and 2 contract areas in partnership with Indian Oil Corporation Limited (IOCL).

The Energy Maharatna also signed 2 Contracts for Fields under Special CBM Bid round-2021 blocks in Jharkhand and Madhya Pradesh.

In the Special CBM bid round-2021 under OALP, as per provisions of the RSC, a total estimated expenditure commitment is indicated by the Contractor to the Government of India. For the 2 CBM blocks awarded to ONGC, the total investment commitment is to the tune of USD 5.94 million. In the 6 DSF-III blocks awarded to ONGC (2 under JV with IOC) an investment of USD 1894.5 million is planned towards development in the blocks.

The contracts were exchanged in the presence of Hon'ble Minister of Petroleum & Natural Gas Shri Hardeep Singh Puri, by ONGC CMD Rajesh Kumar Srivastava on 9 September 2022 in New Delhi. ONGC Director (Offshore) Pankaj Kumar was also present.

The DSF-III bid round 2021 was launched by Government of India on 10 June 2021. A total of 75 fields (Nomination & PSC Regime) under the Discovered Small Field Policy were clubbed in 32 Contract Areas (11 Onland and 21 Offshore) for offer under DSF-III. ONGC participated in the bidding and subsequently won 6 contract areas. These include 4 contract areas as sole bidder and 2 contract areas in partnership with Indian Oil Corporation Limited (IOCL).

The CBM special bid round 2021 was launched by Government on 22 September 2021 and concluded on 31 May 2022 with a total of 15 blocks under offer. ONGC participated in the bidding of 2 blocks and won 2 blocks one each in Jharkhand and Madhya Pradesh.

HPCL enters into the Delhi retail market with the launch of its first HaPpyShop

Hindustan Petroleum Corporation Ltd. unveiled its branded store "Happy Shop" in the National Capital on 17th August 2022. The store was inaugurated at Servicircle outlet, Mathura Road by HPCL's Chairman and Managing Director, Sh. Pushp Kumar Joshi in the presence of ED – Retail, Mr. Sandeep Maheshwari and other Senior Officials and citizens of the locality. In pursuit of enhancing customer experience on a continuous basis, HPCL is ever expanding the bouquet of services being offered to its esteemed customers. "Happy Shop" is the latest offering in this series, which marks its push into non-fuel retailing in a big way. Here, HPCL has gone in for the "Harmonized Retail" approach that will have an amalgamation of online and physical stores to provide a superior shopping experience to its esteemed customers.

The "You need it, we have it" kind of product range in the Servicircle store (Mathura Road) is meticulously selected to suit the tastes and preferences of the local neighborhoods. The store will stock home utility products including food, toiletries, healthcare products, bakery products, groceries, vegetables and more – available to customers at competitive prices. It is also equipped with advanced digital technology to give a seamless shopping experience to the customers. Along with the experience of physical store, it has the option of online shopping with a door delivery model. Customers will be able to browse & shop the merchandise on HPCL's "HP Pay App" (available on IOS & Play store) and have goods delivered to their homes. The services will be available 24X7.

While inaugurating the Delhi "Happy Shop", Sh. Pushp Kumar Joshi said, " The store would endeavor to make a significant difference to the experience of the customers and live up to our motto of 'Delivering Happiness'. The customer response to our retail venture has been very encouraging. HPCL is set to accelerate the growth of "Happy Shop" network in the country would be setting up 20 such stores in the current fiscal."

Shri Hardeep Singh Puri dedicates 166 CNG stations across 14 states

Taking a significant step towards building a Natural Gas-based economy as envisioned by Hon'ble Prime Minister Shri Narendra Modi, Minister of Petroleum and Natural Gas & Housing and Urban Affairs Shri Hardeep Singh Puri dedicated 166 Compressed Natural Gas (CNG) stations to service of the community on 15th July 2022. These CNG stations have been set up by GAIL (India) Limited and nine of its group City Gas Distribution (CGD) companies in 41 Geographical Areas (GAs) across 14 states.

The stations were dedicated via video link by Shri Puri at a function in the presence of Minister of State for Petroleum and Natural Gas & Labour and Employment Shri Rameswar Teli, Secretary, Ministry of Petroleum & Natural Gas Shri Pankaj Jain and senior officials of the Ministry and Oil and Gas companies.

Sh. Puri congratulated GAIL and all the participating CGD entities for the expansion of CNG station network. He stated that these CNG stations commissioned at the cost of Rs 400 Crorewill further strengthen the gas-based infrastructure and availability of cleaner fuel in the country. He further stated that as compared to 2014 when there were about 900 CNG stations, currently the number of CNG stations have crossed 4500, and will be ramped up to 8000 in the next two years. The number of PNG connections have also now crossed 95 lakhs as compared to about 24 lakhsin the year 2014. Sh. Puri emphasized that rollout of CNG on such a scale is expected to incentivise market for CNG vehicles and will have exponential impact in terms of manufacturing, skill development and employment generation. These CNG stations will provide direct employment to about 1000 persons.

Minister of State for Petroleum and Natural Gas & Labour and Employment Shri Rameswar Teli also congratulated the team and stated that the Government is taking a series of measures to encourage greater use of environment- friendly fuel across the Country.

Sh. Puri also visited exhibition on Promotion of CNG and LNG based Clean Mobility Technology Vehicles organized by SIAM. During the interaction, he emphasized on the need to reduce vehicular emission through adoption of cleaner fuel and technology in automotive sector. He stressed on the need for enhanced coverage of CNG and LNG vehicles and requested the automotive companies to ensure availability of CNG/LNG vehicles on pan India basis.

After the completion of ongoing CGD development in GAs awarded under the 11th& 11th A CGD bidding round of Petroleum and Natural Gas Regulatory Board, 98% of India's population and 88% of its geographical area will have access to Natural Gas.

The dedication ceremony is an important step in expanding availability of environment friendly and convenient fuel Natural Gas to the transport sector, households and Industry in the country. Natural Gas in also safer and economical as compared to most conventional fuels.

Hon'ble Prime Minister has set an ambitious target of expanding the share of Natural Gas in the primary energy mixto 15% to usher in a gas-based economy. The development of a gas-based economy is expected to play a key role in achieving India's target of net zero by 2070.

Events

Training program on Project Finance and Environment, Social and Governance (ESG)

The Federation of Indian Petroleum Industry (FIPI) in association with Great Lakes Institute of Management organized a three-day training program on “Project Finance and Environment, Social and Governance (ESG)” on September 28-30, 2022 at Radisson Hotel, Varanasi. The program was attended by 39 mid to senior level executives from Indian Oil Corporation Ltd, Bharat Petroleum Corporation Ltd, Hindustan Petroleum Corporation Ltd, GAIL India Ltd, Oil & Natural Gas Corporation, ONGC Videsh Ltd, Oil India Ltd, and Reliance Industries Ltd.

The training program commenced on the 28th September with the opening remarks of Mr. Vivekanand, Director (Finance, Taxation and Legal), FIPI. Mr. Vivekanand welcomed the participants and the distinguished faculty members comprising of Dr. Ahindra Chakrabarti, Professor of Finance, Great Lakes Institute of Management, Dr. Chanchal Chatterjee, Professor of Finance, IMI Kolkata, Mr. Arjay Kumar Mishra, Consultant – ICRIER and Mr. Ruchir Agarwal, CGM (CF & T), IOCL. He highlighted the growing importance of project finance for companies as against balance sheet finance. He also explained the difference between project finance and balance sheet financing. He shared his personal experience in handling project finance matter for a major multi-billion-dollar international project. He also highlighted the increasing importance of ESG consideration for financing by oil and gas companies.

The training program ended in the evening on 30th September with the valedictory session. During the session, Mr. Vivekanand, Director (Finance, Taxation and Legal), FIPI awarded the participants with a certificate for successfully completing the three-day training program on Project Finance and Environment, Social and Governance. During his closing remarks, Mr. Vivekanand reemphasized importance of Project Finance in Mega projects like LNG in Oil & Gas sector. He also informed the participants about “India Energy Week (IEW),” erstwhile known as Petrotech, that is going to be held at Bengaluru International Exhibition Centre on February 6th-8th, 2023. The training program concluded with a vote of thanks by Mr. Praveen Rai, Deputy Director (Economic Policy & Planning), FIPI to all participants, companies that nominated their executives, and the faculty.

Events

Open House with Hon'ble Minister of Petroleum & Natural Gas and Housing & Urban Affairs

The Federation of Indian Petroleum Industry (FIPI) organized an open house with Shri Hardeep Singh Puri, Hon'ble Minister of Petroleum & Natural Gas and Housing & Urban Affairs on 9th September 2022 at Hyatt Regency, New Delhi. At the event, the Hon'ble Minister witnessed the contract exchange for 30 Discovered Small Fields (DSF) blocks under DSF bid round-III and 4 CBM blocks under special CBM bid round 2021 awarded to 14 Exploration & Production (E&P) companies. During the event, Minister also unveiled the logo for India Energy Week (IEW) 2023, the Ministry's flagship event taking place from 6th-8th February 2023 in Bengaluru, India.

The event commenced with Shri S.C.L. Das, DG DGH highlighting the key features of DSF and CBM rounds through a short presentation and their importance in helping India to reduce its dependence on imports while meeting the energy demand. DSF and CBM policies are also in-line with Government's thrust to promote domestic oil and gas production through a host of investor-friendly policy initiatives to attract new players and expedite the monetization of the hydrocarbon production from these fields.

Further Contract(s) were exchanged between Shri Sunil Kumar, Joint Secretary (Refineries) MoP&NG on behalf of Ministry of Petroleum & Natural Gas and the Business Leaders from the winning companies of the DSF bid round-III and special CBM bid round 2021.

Shri Pankaj Jain, Secretary MoPNG, made a presentation during the event and highlighted the growth opportunities in India's Oil & Gas sector, growth of the Indian economy and from being the 5th Largest Economy in the world presently to become 3rd Largest by 2030. He also mentioned the fact that with increase in population and rise in per capita energy consumption, demand for hydrocarbons is expected to rise in the future. In the coming years, India is expected to remain a growing energy demand center and will hold a significant share in the global energy consumption as it is one of the top five energy consuming nations with 3rd largest CNG vehicle fleet and 4th largest auto market globally.

During the event, the Hon'ble Minister unveiled the logo for India Energy Week (IEW) 2023, the Ministry's flagship event taking place from 6th-8th February 2023 in Bengaluru, India. In the Open House following the Contract Exchange and logo launch ceremony, the Hon'ble Minister highlighted that Government of India has taken several measures to minimize and mitigate the volatility of global crude oil and gas prices. Fuel price rise in India have been contained as compared to the exponential rise in the developed countries. Most of the developed nations have witnessed significant inflation rise in gasoline price, while in India gasoline price has been relatively stable due to excise duty cuts by the government.

On India Energy Week 2023, the Hon'ble Minister stated that it would be a flagship event of the Ministry, and also the first major Energy event once India takes over G20 Presidency. The event will provide an unprecedented opportunity for regional and international leaders and CEOs to come together for strategic policy and technical knowledge sharing for energy justice and energy transition.

1,000 exhibitors from over 50 countries will participate in the exhibition at India Energy Week that will host national pavilion representations from 15 countries. India Energy Week will feature exhibitors including NOCs, NECs, IOCs and IECs, international service providers, EPC contractors, technology, service companies, utility companies, and financial organisations, from across the oil, gas, alternative and renewable energy value chain. The strategic conference will host ministers and global business leaders to actively discuss the successful development and growth of the industry, promote strategic partnerships, investment opportunities and enhance industry collaboration. 20 ministerial and global business leader sessions will examine the key pillars driving India's energy transition and influence the future of the industry, both regionally and globally.

Contract(s) were exchanged between Mr. Sunil Kumar, Joint Secretary (Refineries) MoPNG on behalf of Ministry of Petroleum & Natural Gas and the Business Leaders from the winning companies of the DSF bid round-III and special CBM bid round 2021

A section of participants

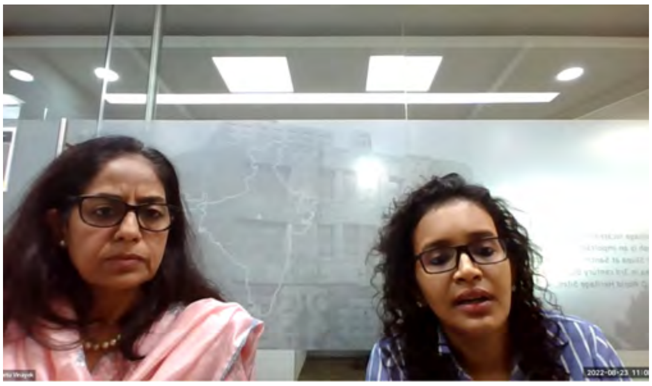
The event concluded with a question-and-answer round between the Hon'ble Minister and the media personnel.

Webinar on Recent Developments in Direct and Indirect Taxes Impacting Oil and Gas Sector

The Federation of Indian Petroleum Industry (FIPI) in association with EY organized the webinar on 'Recent Developments in Direct and Indirect Taxes Impacting Oil and Gas Sector' on 23rd August, 2022. The webinar focussed on recent developments in direct and indirect taxes on the oil and gas sector. The webinar witnessed an overwhelming response with participation of more than 300 professionals working across the oil and gas value chain.

Mr. Gurmeet Singh Director General, FIPI made the opening remarks. In his address, he covered global and domestic macro scenario in oil and gas sector. He further said that FIPI, on behalf of member companies, has been taking up industry points on taxes with appropriate authorities in the Government such as bringing exempted hydrocarbon fuels into the GST ambit, issue of cess levied recently on oil. While welcoming EY team, he observed that participants will be immensely benefited from hearing the subject-matter experts.

Ms Uma Iyer, Partner EY- Indirect tax, made presentation on 'Recent Developments in Indirect Taxes Impacting Oil and Gas Sector'. She covered the recent changes in customs and GST notification for O&G operations with key changes being: - amendment in List 33 of Customs and linkage of items with HSN code, self-certification by operator instead of EC from DGH, issues in disposal of surplus items, requirement of maintaining documents to address any possible queries from tax authorities, increase in GST from 5% to 12% for import/local supplies of O&G items. She further provided information about the recent GST updates including input credit, interest and return formats and apprised about the important Supreme Court rulings on the subject.



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

Ms. Neetu Vinayek, Partner EY- Direct tax gave the presentation on 'Recent Developments in Direct Taxes Impacting Oil and Gas Sector. She provided an overview of BEPS 2.0 and mentioned its importance in the space of international taxation both for domestic companies having overseas subsidiaries/offices and international companies having establishments in India. She also covered impact on secondment issue post Supreme Court Ruling in a service tax case which may have possible consequences in the area of direct tax. Further, she explained in detail the mechanism of TDS under Section 194R.

Mr. Vivekanand, Director (Finance, Taxation & Legal) gave the closing remarks and vote of thanks. He thanked DG, FIPI for sparing his valuable time and setting the tone of webinar by his opening remarks. He thanked the EY team for giving a comprehensive view on the recent changes that have taken place in the field of taxation in oil and gas sector. He stated that FIPI is already seized with issues of change in List -33 of customs and IGST increase from 5% to 12% which were very comprehensively covered by EY in their presentation creating further awareness on possible issues.

Further, he mentioned that the topics covered during the Webinar were very informative and proved to be very helpful for all the participants that attended the webinar. He also thanked the EY and FIPI team who worked hard to make this event successful. Last but not least he thanked the attendees for their active participation by raising about 20 questions in the Q&A session.

Indian delegation at Tanzania Energy Congress 2022

Federation of Indian Petroleum Industry (FIPI) participated for the first time at the Tanzania Energy Congress 2022 in Dar Es Salaam during August 03-04, 2022. FIPI was responsible for setting up the India pavilion which was used by four National Oil & Gas companies, namely IOCL, BPCL, HPCL & GAIL. FIPI also coordinated the Indian business delegation comprising of 09 officers to the Tanzania Energy Congress 2022.

Tanzania has abundant energy resources such as hydropower, natural gas, coal, uranium, wind, geothermal, biomass, solar, tidal waves. Currently, biomass is Tanzania's largest energy source, although much of it is produced in traditional and unsustainable ways. Tanzania does not produce oil, and imports its entire consumption of refined products. Tanzania's estimated natural gas reserves stand at 57 trillion cubic feet (TCF) and Tanzania's electricity generation comes mostly from natural gas (48%), followed by hydro (31%). Tanzania Petroleum Development Corporation (TPDC) estimates that the country's gas fields are large enough to cover the domestic power and other fuel demand requirements and make Tanzania the next natural gas hub in Africa.

Shri Binaya S Pradhan Indian High Commissioner to Tanzania inaugurating India Pavilion

Shri Binaya S Pradhan, Indian High Commissioner to Tanzania, formally inaugurated the India Booth on August 03, 2022. The inaugural ceremony was witnessed by Shri Raj K Ganger, Second Secretary (Com.), The High Commission Of India and the Indian business delegation.

On the side-lines of the Tanzania Energy Congress 2022, the Indian delegation led by the Indian High Commissioner held a meeting with Hon'ble Minister January Makamba, Minister for Energy of the United Republic of Tanzania.

Minister January Makamba welcomed the Indian delegation and was keen to hear the success stories of India regarding the increased use of cleaner fuels like LPG and CNG across the country. He informed that it has been difficult for many low-income earners in Tanzania to transform from biomass energy such as firewood and charcoal to low-carbon energy, mainly LPG. He further added that the government in Tanzania wants to help women from low-income families use LPG in cooking, improve health and safety, stop deforestation, reduce carbon emissions and eliminate conventional fuel health hazards.

The Indian High Commissioner to Tanzania informed that India succeeded in expanding the use of clean cooking energy among its low-income population through successfully implemented schemes, namely Pradhan Mantri Ujjwala Yojana (PMUY) and City Gas Distribution (CGD). He further informed that the Indian delegation is in Tanzania to share more information about these schemes and to discuss how the two countries can work together to expand low-carbon cooking energy among low-income earners.

The Indian delegation shared the success stories of PMUY- LPG and CGD. In addition, the Indian High Commissioner had a detailed discussion with the Minister for Energy of the United Republic of Tanzania on opportunities for investment and collaboration between India and Tanzania. Also, the Energy Minister Tanzania agreed to send a high-level Tanzanian delegation to India to see these infrastructures and how the Indian oil & gas companies operate and to learn from them.

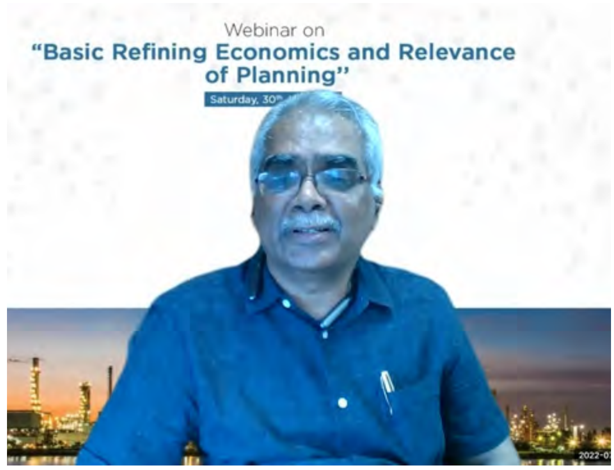
Webinar on Basic Refining Economics and Relevance of Planning

A webinar on "Basic Refining Economics and Relevance of Planning" was organized exclusively for FIPI Student Chapters on 30th July 2022.

It was attended by 56 participants from FIPI Chapters at various institutes/Universities in India. The Session was taken by Shri Sachin Singh, Senior Principal Consultant with Aspen Technology.

The program was commenced with the Address by Shri Gurmeet Singh, Director General FIPI. He apprised the participants about the various new initiatives approved by FIPI's Governing Council which are being implemented for the benefit of the student fraternity.

Shri D L N Sastri, Director (Oil, Refining & Marketing), FIPI addressed the participants and informed about planned webinar series for FIPI Student Chapters, which will be addressed by industry experts on the relevant topics to Indian oil & Gas industry. He thanked AspenTech for agreeing to take the 1st webinar in the series.



The Speaker, Shri Sachin Singh, Senior Principal Consultant at Aspen Technology, made the presentation on the topic and touched upon various areas viz. planning & optimization: Challenges and Opportunities; Selection of Crude Oils; Distillation; Process Unit; forecasting Supply & Demand and also shared the Aspen Tech Journey to Self-Optimizing Plant, Aspen Hybrid Models, Sustainability-Carbon Capture Models in Aspen Plus & Aspen HYSYS, Biomass & Hydrogen Processing Models, Carbon Emissions Optimization Model for Planning etc.

The webinar ended with a vote of thanks to the speaker and the participants.

BP Energy Outlook 2022

Continuing the tradition, the Federation of Indian Petroleum Industry (FIPI) joined with BP India to organize BP Energy Outlook – 2022 edition on 19 July 2022 at The Imperial, Janpath, New Delhi. This Outlook was unveiled in a physical gathering and was attended by Shri Hardeep Singh Puri, Hon'ble Minister of Petroleum & Natural Gas and Housing & Urban Affairs; Shri Rameswar Teli, Hon'ble Minister of State in the Ministry of Petroleum & Natural Gas and Ministry of Labour & Employment; Shri Pankaj Jain, Secretary, MoP&NG; Mr Spencer Dale, Group Chief Economist, BP Plc; Shri S. M. Vaidya, Chairman, FIPI & Chairman, IndianOil; Shri Sashi Mukundan, President, bp India and Senior Vice President, bp Group and CEOs of major oil and gas companies in the country.

The program started with welcoming the esteemed dignitaries and presenting them with saplings as a token of appreciation.

Mr Spencer Dale, Group Chief Economist, BP Plc., made a detailed presentation on the BP Energy Outlook 2022. At the outset, he informed the participants that BP's Energy Outlook 2022 is focused on three main scenarios to explore the energy transition: Accelerated, Net Zero and New Momentum to explore the range of possible pathways for the global energy system to 2050. The scenarios included in Energy Outlook 2022 were largely prepared before the outbreak of the military action (Ukraine War) and do not include any analysis of its possible implications for economic growth and global energy markets.

Shri S. M. Vaidya, Chairman FIPI and IOCL welcomed the Hon'ble Minister Shri Hardeep Singh Puri, Minister for Petroleum and Natural Gas and Minister for Housing & Urban Affairs.

Mr Spencer Dale, Group Chief Economist, BP Plc., made a detailed presentation on the BP Energy Outlook 2022

He also added that the scenarios are based on existing and developing technologies and do not consider the possibility of emerging entirely new or unknown technologies. Government ambitions globally to tackle climate change have increased markedly and key elements of the low-carbon energy system critical for the world to transition successfully to Net Zero – installation of new wind and solar power capacity; sales of electric vehicles; announcements of blue and green hydrogen and CCUS projects – have all expanded rapidly. As a result, there are signs of a New Momentum in tackling climate change.

The presentation also brought out that although there is considerable uncertainty, some features of the energy transition are common across all the main scenarios in this year's Outlook and may guide how the energy system may change over the next few decades. The importance of the world making a decisive shift towards a net-zero future has never been clearer. The opportunities and risks associated with that transition are significant and this year's Energy Outlook will be useful to everyone trying to navigate this uncertain future and accelerate the transition to Net Zero.

Hon'ble Minister of Petroleum and Natural Gas & Housing and Urban Affairs, in his address, complimented Mr. Dale for delivering a very insightful presentation and bringing out the analysis of humanity's challenges in the context of energy.

He added that we can't look at energy without considering its sustainability and climate change dimensions. We were already addressing a very challenging international economic environment determined by the Pandemic's challenges, followed by what happened on 24 February '22 (Ukraine War). This has created a new sense of urgency for us to do things slightly faster than what would have happened if events like the Pandemic and 24 February '22 (Ukraine War) had not happened. Some of them are:

Hon'ble Minister of Petroleum and Natural Gas & Housing and Urban Affairs addressed the august gathering

Biofuel blending: India has advanced blending target of 20% ethanol in petrol by five years to 2025-26
Compressed biogas: The government is proactively working towards increasing the production of CBG under the SATAT (Sustainable Alternative Towards Affordable Transportation) initiative, which envisages a target production of 15 million Metric Ton (MMT) of CBG by 2023-24, from 5000 Plants.
Green hydrogen: India is planning to produce 5 million tonnes of green hydrogen by 2030.

One clear thing that distinguishes India from the rest of the world is that India will continue to be the critical driver of demand. Our energy consumption is about one-third of the global average, which is bound to increase further with the increasing population, industrialization and prosperity of the country's people. He concluded his speech by stating that it would be a very high price if the world goes back to individual countries taking decisions for themselves and losing the public good at the international level.

On the sidelines of Outlook 2022, the Hon'ble Minister also discussed the future of the energy sector & India's energy scenario. He also discussed the global energy scenario & the future of green & renewable energy with Chief Economist of bp Spencer Dale.

Hon'ble Minister of State in the Ministry of Petroleum & Natural Gas and Ministry of Labour & Employment, Shri Rameswar Teli in his speech stated that the Govt. has taken several initiatives to ease business and to create a conducive ecosystem for the sector's growth and also to bring foreign investment into the industry. He added that under the able leadership of the Hon'ble Prime Minister, India has made remarkable achievements and has now emerged as a global player.

Shri Rameswar Teli, Hon'ble Minister of State in the Ministry of Petroleum & Natural Gas and Ministry of Labour & Employment addressed the audience.

An expanding economy, population, urbanization and industrialization will result in India's energy needs growing more than any other country over the next decade and India is committed to providing its citizens access to a clean, affordable, sustainable energy supply. To reduce import dependency, the country is focusing on increased domestic production of oil and gas, and in this regard, an international roadshow in London has been organized to expedite & enhancing E&P activities on the domestic front.

He concluded his speech by thanking FIPI & BP for together bringing the outlook event and mentioned that the BP outlook has served as a guiding light for the entire industry in formulating strategies and this will help the oil and gas companies to navigate through the potential uncertainties surrounding energy transition in the future.

Mr Sashi Mukundan, President, BP India and Senior Vice President, BP Group, delivering his vote of thanks, highlighted the importance of this year's BP energy outlook in the backdrop of the energy transition the world is undergoing. He also added that BP is encouraged by the progressive policies announced by the government to maximize production from all forms of energy, enhance India's energy security and provide affordable and reliable energy to millions of Indians in a sustainable manner.

Mr Sashi Mukundan, President, BP India and Senior Vice President, BP Group, delivering his vote of thanks

NEW APPOINTMENTS

Dr. Ranjit Rath takes over as Chairman & Managing Director of OIL

Dr. Ranjit Rath

Dr. Ranjit Rath, an alumnus of IIT Bombay & IIT Kharagpur, took over as the new Chairman & Managing Director (CMD) of Oil India Limited (OIL), India's second largest National Exploration & Production Company, on 2nd August 2022.

Dr. Rath is a proud recipient of the prestigious National Geosciences Award from the Hon`ble President of India.

A Geoscientist with impeccable experience and expertise of more than 25 years in the field of geosciences, Dr. Rath, prior to joining at the helm of affairs of OIL, the Navratna PSU under the Ministry of Petroleum & Natural Gas, Govt. of India, was the Chairman cum Managing Director of Mineral Exploration & Consultancy Limited under the Ministry of Mines; Chief Executive Officer of Khanij Bidesh India Limited; Managing Director of Bharat Gold Mines Limited and also held additional charge of the Director General of Geological Survey of India under Govt. of India.

Dr. Rath has a rich portfolio of diverse roles spanning from strategy formulation, business development and upstream asset management to application of geosciences & exploration geology in several important projects including creation of Strategic Petroleum Reserves (SPRs), a first of its kind initiative of Govt. of India entailing underground rock caverns for strategic storage of crude oil - An intervention towards Energy Security.

Rajesh Kumar Srivastava takes additional charge as ONGC CMD

Director (Exploration) of Oil and Natural Gas Corporation Limited (ONGC) Rajesh Kumar Srivastava has taken over additional charge of the Chairman and Managing Director (CMD) of the Energy Maharatna on 1 September 2022. Mr Srivastava has been serving as Director (Exploration) since 2 August 2019 and is the senior-most Director on the Board of the energy company.

Mr Srivastava acquired his Master of Science (Geology) from Lucknow University and Master's Degree in Engineering Geology from Indian Institute of Technology (IIT), Kanpur. He also holds the prestigious Non-Executive Director Diploma from Financial Times, United Kingdom. He joined ONGC as a Geologist in 1984 at Krishna Godavari Basin in Rajahmundry.

Rajesh Kumar Srivastava

With over 38 years of experience in hardcore Exploration & Production business, Mr. Srivastava is an expert in up-stream hydrocarbon exploration from well-site operations, development geology, seismic data interpretation to monitoring and planning of exploration.

Mr Srivastava played a key role in the formulation of 'Hydrocarbon vision-2030 for North East India' driven by Ministry of Petroleum and Natural Gas. He has also evaluated several exploration and development blocks of Egypt and Sudan. As an acknowledgement for his contributions towards discovery of hydrocarbons in Indian Basins, field development and hydrocarbon exploration, Mr Srivastava was honored with the National Mineral Award in 2009. Mr Srivastava is also the Chairman of ONGC TERI Biotech Limited (OTBL) and the President of the Indian Geological Congress (IGL).

Mr. Sandeep Kumar Gupta assumes charge as Chairman & Managing Director, GAIL

Sandeep Kumar Gupta

Mr. Sandeep Kumar Gupta assumed charge as Chairman and Managing Director, GAIL (India) Limited on 3rd October 2022.

Mr. Sandeep Kumar Gupta is a Commerce Graduate and a Fellow of the Institute of Chartered Accountants of India. Before joining GAIL, Mr. Gupta held the position of Director (Finance) since August 2019 on the Board of Indian Oil Corporation Limited, the leading PSU integrated Energy Company in Fortune "Global 500", and several group companies. He has wide experience of over 34 years of Oil and Gas Industry and handled F&A, Treasury, Pricing, International Trade, Optimisation, Information Systems, Corporate Affairs, Legal, Risk management, etc.

Mr. Gupta has received prestigious individual recognition such as "CA CFO- Large Corporate – Manufacturing and Infrastructure Category" in Jan.,2021 by ICAI for Financial and Risk Management during Pandemic and was adjudged among Top 30 CFOs in India by StartupLanes.com in May, 2022.

Mr. Bhaskar Jyoti Phukan assumes charge as Managing Director of NRL

Mr. Bhaskar Jyoti Phukan has assumed the charge of Managing Director, NRL w.e.f. 19th July, 2022.

Mr. Bhaskar Jyoti Phukan is a Mechanical Engineer from Assam Engineering College, Guwahati with more than 30 years of experience in the Oil Industry including Logistics, Marketing, Technical Services and Operation. Mr. Phukan started his career in Indian Oil Corporation Ltd. (Assam Oil Division) in the year 1990 and thereafter joined NRL in the year 1999. Prior to his assuming the office of Managing Director, he was holding the position of Director (Technical) NRL w.e.f. 1st February, 2017.

Bhaskar Jyoti Phukan

Nayara Energy appoints Prasad K Panicker as Chairman

Prasad K Panicker

Nayara Energy announced that Mr. Prasad K Panicker, Director and Head of Refinery would be taking over the responsibility of Chairman of the Company with effect from October 3, 2022.

Mr. Prasad K. Panicker will take on this important role from Mr. Charles Anthony (Tony) Fountain, whose 5 years of dedicated service have been landmarked by significant improvements in the level of performance and financial position of the Company. Despite a very challenging external environment, Nayara Energy has developed a clearly articulated strategy for a phased expansion into petrochemicals. The first phase of that development plan, the expansion into polypropylene, will be delivered next year.

In his new role, Mr. Panicker will deploy his outstanding technological experience and excellent knowledge of the local Indian market to lead Nayara Energy through a new set of strategic priorities with strong focus on development projects. Mr. Panicker will also continue with his critical leadership role as Head of Refinery, which will support hands on implementation of Nayara Energy's ambitious development program.

Mr. Sukhmal Jain takes over as Director (Marketing) of BPCL


Sukhmal Jain

Mr. Sukhmal Jain has taken over as Director (Marketing) of BPCL on 22nd August 2022. Prior to his elevation to the board, Mr. Jain was the Executive Director Incharge (Marketing Corporate) in the Corporate Office and before that the head of Gas Business Unit.

With graduation degree in Mechanical Engineering from Delhi College of Engineering and MBA from SP Jain Institute of Management & Research, he has held several leadership positions in Retail, LPG and Gas verticals in his 35 years with the company.

In his illustrious career of over three decades, he has been actively involved in industry defining initiatives, like Give it Up campaign and Pradhan Mantri Ujjawala Yojana, in LPG Business, and has successfully navigated the Strategy and Loyalty Programs in Retail Business.

Mr. Sukhmal Jain is also the Chairman of Goa Natural Gas Pvt. Ltd (GNGPL). Earlier he was the Chairman of Central UP Gas Ltd (CUGL) and Director on the board of Bharat Gas Resources Limited (BGRL), a wholly owned subsidiary of BPCL which has recently merged with BPCL.

Mr. Atul Gupta assumes charge as Director (Commercial) of EIL


Atul Gupta

Mr. Atul Gupta assumed charge as Director (Commercial) of Engineers India Ltd on 16th August 2022.

Mr. Gupta is a Mechanical Engineer from GBPUAT Pantnagar and joined EIL as Management Trainee in 1992. In a career spanning 30 years, has been associated in a wide array of domain and steered the successful implementation of various mega projects in India and abroad involving various modes of execution. During project implementation, led the multidisciplinary team of Technical and Commercial domain involving Process, Engineering, Contracts & Procurement, Manufacturing, Construction and Commissioning in both green field and brown field projects. He had also been posted at various Project locations in India and abroad involving Refinery, Petrochemical, Pipeline, Fertilizer etc. before moving to corporate office in 2007.

Ayush Gupta Assumes charge as Director (Human Resources) of GAIL

Mr. Ayush Gupta assumed charge as Director (Human Resources) of GAIL (India) Limited on 22nd August 2022. Prior to this, he was working as Chief General Manager (Human Resource Development) in the organisation.


Ayush Gupta

An Electrical Engineer of the 1992 batch from IIT Roorkee and MBA in Operations Management, Mr. Gupta has over 30 years of varied and rich experience in the fields of Training and Human Resource Development, Talent Acquisition, Leadership Development, Performance Management, HRD Initiatives, Project Management and Operations & Maintenance. He is currently also on the Board of Directors of GAIL Gas Limited, a wholly owned subsidiary of GAIL.

Mr. Gupta is recipient of the prestigious Chevening Rolls Royce Science, Innovation, Policy and Leadership fellowship from Oxford University in 2013, Winner of the National Corrosion Awareness Award 2004 and Emerging HRD Thinkers Award in 2011. He is the co-editor of the book 'Natural Gas Markets in India' published by Springer International and has to his credit several best papers awards for papers published and presented at national and international forums.

Mr. Ashok Das takes over as Director (Human Resources) of OIL

Ashok Das

Mr. Ashok Das took charge as Director (Human Resources) on the Board of Oil India Limited on 02.09.2022. Mr. Das is a Graduate in Political Science and Masters in Business Administration (MBA). Mr. Das began his career as an Executive Trainee with OIL in 1989 and over the span of more than three decades, he played a pivotal role in shaping OIL's Human Resource functions like Talent Acquisition, Performance Management, Compensation Management, Employee Relations, Wage Negotiations, Training & Development, HRIS, Employee Engagement etc. Shri Das was Executive Director (HR) at OIL prior to taking over as Director (HR) of the Company.

Known for his performance-focused people-centric leadership style, Mr Das has successfully managed HR functions in OIL and has taken several progressive HR initiatives like introduction of IT-enabled HR practices, streamlining of HR systems & policies to enhance transparency, objectivity & fairness. He led the HR team in designing and implementing Online Performance Management System. Mr. Das has also led several Corporate Social Responsibility initiatives at OIL and is instrumental in setting up of the Skill Development Institute in Guwahati, a first of its kind institute in Northeast India.

An alumnus of Cotton College and Gauhati University, Mr. Das is a former national level football player and a theatre artiste with several awards & accolades.

Mr. Rajiv Agarwal takes charge as Director (Technical) of EIL

Mr. Rajiv Agarwal took charge as Director (Technical) of Engineers India Ltd. on 26th September 2022. Prior to this, he was serving as the Executive Director in EIL.

Rajiv Agarwal

Mr. Rajiv Agarwal graduated in Chemical Engineering from IIT Roorkee. He joined EIL as Management Trainee in year 1988, with extensive technical and consulting experience across hydrocarbon value chain.

He has served EIL in various capacities and led successful implementation of many prestigious projects in Oil & Gas and Fertilizer sectors. During his illustrious career spanning over 33 years, he has led design of mega refineries & petrochemical projects, Gas Processing complex & Fertilizer Projects.

He has led teams of Process Design, R&D, Environment, Water & Safety and other divisions of the company and is also leading company's initiative in the sunshine areas like Green Hydrogen, Biofuels, Net Zero interventions, Renewables, etc.

Mr. S. Bharathan takes over as Director (Refineries) of HPCL

S. Bharathan

Mr. S. Bharathan took over as Director (Refineries) of Hindustan Petroleum Corporation Ltd on 1st October 2022. Prior to this, he was an Executive Director – Refineries Coordination of the Company with Additional Charge of R&D.

Mr. Bharathan has wide exposure to the Refinery operations of the Company and has worked in Operations and Technical Departments of Mumbai and Visakh Refinery for over 25 years. He has also worked in the Corporate Office on Margin Management & Refinery Project Process for over 4 years. Further, he is also leading HPCL's Green R&D Centre in Bengaluru for the last 3 years. Under him, HPCL Green Research & Development Centre (HPGRDC) has reached filing of about 380 patents.

STATISTICS

INDIA: OIL & GAS

DOMESTIC OIL PRODUCTION (MILLION MT)

		2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April - June 22 (P)	% of Total
Onshore	ONGC	5.9	6.0	6.1	6.1	5.9	5.8	1.5	39.7
	OIL	3.3	3.4	3.3	3.1	2.9	3.0	0.8	20.5
	Pvt./ JV (PSC)	8.4	8.2	8.0	7.0	6.2	6.3	1.5	39.8
	Sub Total	**17.6**	**17.5**	**17.3**	**16.2**	**15.1**	**15.1**	**3.8**	**100**
Offshore	ONGC	16.3	16.2	15.0	14.5	14.2	13.6	3.5	94.2
	OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pvt./ JV (PSC)	2.1	1.9	1.9	1.5	1.1	1.0	0.2	5.8
	Sub Total	**18.4**	**18.1**	**16.9**	**16.0**	**15.4**	**14.6**	**3.7**	**100.0**
Total Domestic Production		36.0	35.7	34.2	32.2	30.5	29.7	7.5	100.0
	ONGC	22.2	22.2	21.0	20.6	20.2	19.5	5.0	66.6
	OIL	3.3	3.4	3.3	3.1	2.9	3.0	0.8	10.4
	Pvt./ JV (PSC)	10.5	10.1	9.9	8.4	7.4	7.3	1.7	23.0
Total Domestic Production		**36.0**	**35.7**	**34.2**	**32.2**	**30.5**	**29.7**	**7.5**	**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	9.50
Visakhapattnam	8.30
Total	**17.80**
Other PSU Refineries	
NRL, Numaligarh	**3.00**
MRPL	**15.00**
ONGC, Tatipaka	**0.07**
Total PSU Refineries Capacity	**143.92**

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	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-June 22 (P)
IOCL	65.19	69.00	71.81	69.42	62.35	67.66	18.94
BPCL	25.30	28.20	30.90	31.53	26.22	29.84	7.55
HPCL	17.80	18.20	18.44	17.18	16.42	13.97	4.81
CPCL	10.30	10.80	10.69	10.16	8.24	9.04	2.88
MRPL	15.97	16.13	16.23	13.95	11.47	14.87	4.33
ONGC (Tatipaka)	0.09	0.08	0.07	0.09	0.08	0.08	0.02
NRL	2.68	2.81	2.90	2.38	2.71	2.62	0.79
SUB TOTAL	137.33	145.22	151.04	144.71	127.50	138.08	39.31

JV Refineries	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-June 22 (P)
HMEL	10.52	8.83	12.47	12.24	10.07	13.03	3.23
BORL	6.36	6.71	5.71	7.91	6.19	7.41	2.10
SUB TOTAL	16.88	15.54	18.18	20.15	16.26	20.44	5.33

Pvt. Refineries	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-June 22 (P)
NEL	20.92	20.69	18.89	20.62	17.07	20.16	5.07
RIL	70.20	70.50	69.14	68.89	60.94	63.02	16.18
SUB TOTAL	91.12	91.19	88.03	89.51	78.01	83.19	21.25

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-June 22 (P)
All India Crude Processing	245.40	251.90	257.25	254.38	221.77	241.70	65.88

Source : PIB Release/PPAC

CRUDE CAPACITY VS. PROCESSING

	Capacity On 01/01/2022 Million MT	% Share	Crude Processing April-June 22 (P)	% Share
PSU Ref	143.9	57.3	39.3	59.7
JV. Ref	19.1	7.6	5.3	8.1
Pvt. Ref	88.2	35.1	21.2	32.3
Total	**251.2**	**100**	**65.9**	**100**

Source: PIB/PPAC

POL PRODUCTION (Million MT)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-June 22 (P)
From Refineries	239.2	249.8	257.4	258.2	229.3	250.2	67.2
From Fractionators	3.5	4.6	4.9	4.8	4.2	4.1	0.9
Total	**242.7**	**254.4**	**262.4**	**262.9**	**233.5**	**254.3**	**68.1**

DISTILLATE PRODUCTION (Million MT)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-June 22 (P)
Light Distillates, MMT	71.0	74.7	75.4	76.8	71.4	76.5	19.9
Middle Distillates , MMT	122.5	127.5	130.8	130.2	110.7	120.2	33.3
Total Distillates, MMT	196.9	206.8	211.1	211.7	186.3	200.7	54.1
% Distillates Production on Crude Processing	**79.1**	**80.6**	**80.5**	**81.7**	**82.4**	**81.7**	**80.9**

PETROLEUM PRICING

OIL IMPORT - VOLUME AND VALUE

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-June 22 (P)
Quantity, Million Mt	213.9	220.4	226.5	227.0	196.5	212.0	60.2
Value, INR '000 Cr.	470.2	566.5	783.2	717.0	469.8	899.3	369.1
Value, USD Billion	70.2	87.8	111.9	101.4	62.2	120.4	47.7
Average conversion Rate, INR per USD (Calculated)	67.0	64.5	70.0	70.7	75.5	74.7	77.4

OIL IMPORT - PRICE USD / BARREL

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-June 22 (P)
Brent (Low Sulphur - LS-marker) (a)	48.7	57.5	70.0	61.0	44.3	80.7	113.7
Dubai (b)	47.0	55.8	69.3	60.3	44.6	78.1	107.9
Low sulphur-High sulphur differential (a-b)	1.7	1.6	0.7	0.6	-0.3	2.7	5.8
Indian Crude Basket (ICB)	47.56	56.43	69.88	60.47	44.82	79.18	109.49
ICB High Sulphur share %	71.03	72.38	74.77	75.50	75.62	75.62	75.62
ICB Low Sulphur share %	28.97	27.62	25.23	24.50	24.38	24.38	24.38

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

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-June 22 (P)
Gasoline	58.1	67.8	75.3	67.0	47.5	89.7	137.8
Naphtha	47.1	56.3	65.4	55.1	43.9	79.9	93.1
Kero / Jet	58.4	69.2	83.9	70.4	45.8	87.3	147.2
Gas Oil (0.05% S)	58.9	69.8	84.1	74.1	50.0	90.2	159.3
Dubai crude	47.0	55.8	69.3	60.3	44.6	78.1	107.9
Indian crude basket	47.6	56.4	69.9	60.5	44.8	79.2	109.5

CRACKS SPREADS ($/ BBL.)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-June 22 (P)
Gasoline crack							
Dubai crude based	11.1	12.0	5.9	6.7	2.9	11.7	29.9
Indian crude basket	10.6	11.4	5.4	6.5	2.6	10.5	28.3
Diesel crack							
Dubai crude based	12.0	13.9	14.8	13.8	5.5	12.2	51.4
Indian crude basket	11.4	13.4	14.2	13.6	5.2	11.0	49.8

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
October 22 - March 23	8.57	12.46

Source: PIB/PPAC/OPEC

GAS PRODUCTION

		2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-June 22 (P)
	ONGC	22088	23429	24677	23746	21872	20629	5087
	Oil India	2937	2881	2722	2668	2480	2853	743
	Private/ Joint Ventures	6872	6338	5477	4770	4321	10502	2724
	Total	**31897**	**32648**	**32875**	**31184**	**28672**	**33984**	**8553**
		2016-17	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22 (P)**	**April-June 22 (P)**
Onshore	Natural Gas	9294	9904	10046	9893	9601	10471	2547
	CBM	565	735	710	655	477	518	169
	Sub Total	**9858**	**10639**	**10756**	**10549**	**10078**	**10989**	**2716**
Offshore		22038	22011	22117	20635	18428	22869	5837
	Sub Total	22038	22011	22117	20635	18428	22869	5837
	Total	**31897**	**32649**	**32873**	**31184**	**28506**	**33858**	**8553**
	(-) Flare loss	1049	918	815	927	721	727	212
	Net Production	30848	31731	32058	30257	27785	33131	8341
		2016-17	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22 (P)**	**April-June 22 (P)**
	Net Production	30848	31731	32058	30257	27785	33131	8341
	Own Consumption	5857	5806	6019	6053	5736	5760	1437
	Availabilty	24991	25925	26039	24204	22049	27371	6904

AVAILABILITY FOR SALE

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-June 22 (P)
ONGC	17059	18553	19597	18532	16972	15874	3893
Oil India	2412	2365	2207	2123	1930	2190	554
Private/ Joint Ventures	5520	5007	4235	3549	3147	9307	2457
Total	**24991**	**25925**	**26039**	**24204**	**22049**	**27371**	**6904**

CONSUMPTION (EXCLUDING OWN CONSUMPTION

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	April-June 22 (P)
Total Consumption	49677	53364	54779	58091	54910	59277	14304
Availabilty for sale	24991	25925	26039	24204	22049	27371	6904
LNG Import	24686	27439	28740	33887	32861	31906	7400

GAS IMPORT DEPENDENCY

	2016-17	2017-18	2018-19	2019-20	2020-21 (P)	2021-22 (P)	April-June 22 (P)
Net Gas Production	30848	31731	32058	30257	27785	33131	8341
LNG Imports	24686	27439	28740	33887	32861	31906	7400
Import Dependency (%)	44.5	46.4	47.3	52.8	54.2	49.1	47.0
Total Gas Consumption*	**55534**	**59170**	**60798**	**64144**	**60646**	**65037**	**15741**

* Includes Own Consumption

Source: PIB/PPAC

SECTOR WISE DEMAND AND CONSUMPTION OF NATURAL GAS

Qty. in MMSCM

		2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)	2022-23			
								April	May	June	Total
Fertilizer	R-LNG	7592	7781	8711	9556	11227	12363	1125	1247	1107	**3479**
	Domestic Gas	7802	6862	6258	6559	6554	5716	402	475	466	**1343**
Power	R-LNG	2410	2645	2869	3554	3564	2670	168	141	177	**486**
	Domestic Gas	9131	9375	9194	7526	7272	6260	388	485	434	**1307**
City Gas	R-LNG	3030	3881	3981	5146	4456	5238	455	428	405	**1288**
	Domestic Gas	4276	4659	5240	5737	4774	6890	574	617	656	**1847**
Refinery Petrochemical Others	R-LNG	12440	11109	12650	13130	12386	9725	563	696	533	**1792**
	Domestic Gas	3978	5225	5225	5285	5823	10656	818	892	866	**2576**

2022 WORLDWIDE ACTIVE RIG COUNT

REGION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
US	601	636	661	690	718	739	756	764
Canada	190	220	185	107	93	143	186	201
Latin America	158	153	160	163	155	160	163	172
Europe	111	102	78	81	79	87	87	104
Middle East	289	287	303	300	314	303	309	308
Africa	86	81	87	78	76	78	78	77
Asia Pacific(1)	120	112	111	108	115	119	119	122
India	77	78	76	76	78	77	77	77
TOTAL	**1632**	**1669**	**1661**	**1603**	**1628**	**1706**	**1775**	**1825**

Source: Baker Hughes

(1) Excluding India's Rig Count

CGD INFRASTRUCTURE

		As on 31st March 2019	As on 31st March 2020	As on 31st March 2021	As on 31st March 2022	As on 31st July 2022
PNG	**Domestic**	50,43,188	60,68,415	78,20,387	93,02,667	97,40,405
	Commercial	28,046	30,622	32,339	34,854	35,626
	Industrial	8,823	10,258	11,803	13,215	13,833
CNG	**CNG Stations**	1,730	2,207	3,101	4,433	4,664
	CNG Vehicles	33.47 lakhs	37.10 lakhs	39.55 lakhs	44.09 lakhs	46.21 lakhs

Source: PPAC/Vahan

MAJOR NATURAL GAS PIPELINE NETWORK As on 30.06.2022

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 Sept. 22	Capacity Utilisation (%) April-July 2022
Dahej	Petronet LNG Ltd	17.5	87.6
Hazira	Shell Energy India Pvt Ltd	5.2	47.0
Dabhol*	Konkan LNG Ltd	5	23.6
Kochi	Petronet LNG Ltd	5	16.8
Ennore	Indian Oil LNG Pvt Ltd	5	13.0
Mundra	GSPC LNG Ltd	5	18.2
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 Petroleum Corporation Ltd.	Mr. Arun Kumar Singh	Chairman & Managing Director
5	BP Group	Mr. Sashi Mukundan	President, bp India & Senior Vice President, bp group
6	Cairn Oil & Gas, Vedanta Limited	Mr. Sunil Duggal	Group CEO, Vedanta Ltd.
7	Chandigarh University	Mr. Satnam Singh Sandhu	Chancellor
8	Chennai Petroleum Corporation Ltd.	Mr. Arvind Kumar	Managing Director
9	Chi Energie Pvt. Ltd	Mr. Ajay Khandelwal	Director
10	CSIR-Indian Institute of Petroleum	Dr. Anjan Ray	Director
11	Decom North Sea	Mr. Will Rowley	Interim Managing Director
12	Dynamic Drilling & Services Pvt. Ltd.	Mr. S. M. Malhotra	President
13	Engineers India Ltd.	Ms. Vartika Shukla	Chairman & Managing Director
14	Ernst & Young LLP	Mr. Rajiv Memani	Country Manager & Partner
15	ExxonMobil Gas (India) Pvt. Ltd.	Mr. Monte Dobson	Chief Executive Officer
16	FMC Technologies India Pvt. Ltd.	Mr. Housila Tiwari	Managing Director
17	GAIL (India) Ltd.	Mr. Sandeep Kumar Gupta	Chairman & Managing Director
18	GSPC LNG Ltd.	Mr. Anil K. Joshi	Chief Executive Officer
19	h2e Power Systems Pvt. Ltd.	Mr. Siddharth R Mayur	Managing Director & CEO
20	Haldor Topsoe India Pvt. Ltd.	Mr. Alok Verma	Managing Director
21	Hindustan Petroleum Corp. Ltd.	Dr. Pushp Kumar Joshi	Chairman & Managing Director
22	HPCL Mittal Energy Ltd.	Mr. Prabh Das	Managing Director & CEO
23	HPOIL Gas Private Ltd.	Mr. Arun Kumar Mishra	Chief Executive Officer
24	IHS Markit	Mr. James Burkhard	Managing Director
25	International Gas Union	Mr. Luis Bertran	Secretary General
26	IIT (ISM) Dhanbad	Prof. Rajiv Shekhar	Director
27	IMC Ltd.	Mr. A. Mallesh Rao	Managing Director
28	Indian Gas Exchange Ltd.	Mr. Rajesh Kumar Mediratta	Managing Director & CEO
29	Indian Oil Corporation Ltd.	Mr. S.M. Vaidya	Chairman
30	Indian Strategic Petroleum Reserves Ltd	Mr. Ajay Dashore	CEO & MD (Addl. Charge)
31	Indraprastha Gas Ltd.	Mr. Sanjay Kumar	Managing Director
32	Indian Oiltanking Ltd.	Mr. Rajesh Ganesh	Managing Director
33	IPIECA	Mr. Brian Sullivan	Executive Director

S No	Organization	Name	Designation
34	Invenire Petrodyne Ltd.	Mr. Mannish Maheshwari	Chairman & Managing Director
35	IRM Energy Pvt. Ltd.	Mr. Karan Kaushal	Chief Executive Officer
36	Jindal Drilling & Industries Pvt. Ltd.	Mr. Raghav Jindal	Managing Director
37	LanzaTech	Dr. Jennifer Holmgren	Chief Executive Officer
38	Larsen & Toubro Ltd	Mr. S.N. Subrahmanyan	CEO & Managing Director
39	Maharashtra Institute of Technology (MIT) Pune	Mr. Rahul V. Karad	Executive President
40	Mangalore Refinery & Petrochemicals Ltd.	Mr. M. Venkatesh	Managing Director
41	Megha Engineering & Infrastructures Ltd.	Mr. P. Doraiah	Director
42	Nayara Energy Ltd.	Mr. Prasad K. Panicker	Chairman & Head of Refiniery
43	Numaligarh Refinery Ltd.	Mr. Bhaskar Jyoti Phukan	Managing Director
44	Oil and Natural Gas Corporation Ltd	Mr. Rajesh Kumar Srivastava	CMD (Addl. Charge) & Director (Expl.)
45	Oil India Ltd.	Dr. Ranjit Rath	Chairman & Managing Director
46	Petronet LNG Ltd.	Mr. Akshay Kumar Singh	Managing Director & CEO
47	Pipeline Infrastructure Ltd.	Mr. Akhil Mehrotra	Chief Executive Officer
48	Rajiv Gandhi Institute of Petroleum Technology	Prof. A.S.K Sinha	Director
49	Reliance BP Mobility Ltd.	Mr. Harish C. Mehta	Chief Executive Officer
50	Reliance Industries Ltd.,	Mr. Mukesh Ambani	Chairman & Managing Director
51	SAS Institute (India) Pvt Ltd.	Mr. Noshin Kagalwalla	CEO & Managing Director-India
52	Schlumberger Asia Services Ltd	Mr. Vinay Malhotra	Managing Director
53	Scottish Development International	Mr. Kevin Liu	Head of Energy Trade, Asia Pacific
54	Secure Meters Ltd.	Mr. Sunil Singhvi	CEO - Energy
55	Shell Companies in India	Mr. Nitin Prasad	Country Chair
56	Siemens Limited	Mr. Gerd Deusser	CEO (Siemens Energy - India)
57	SNF Flopam India Pvt. Ltd	Mr. Shital Khot	Managing Director
58	South Asia Gas Enterprise Pvt. Ltd.	Mr. Subodh Kumar Jain	Director
59	THINK Gas Distribution Pvt. Ltd.	Mr. Hardip Singh Rai	Chief Executive Officer
60	TotalEnergies Marketing India Private Ltd.	Ms. Ahlem FRIGA-NOY	Country Chair
61	University of Petroleum & Energy Studies	Dr. S.J. Chopra	Chancellor
62	UOP India Pvt. Ltd.	Mr. Mike Banach	Managing Director
63	VCS Quality Services Private Ltd.	Mr. Shaker Vayuvegula	Director
64	World LPG Association	Mr. James Rockall	CEO and Managing Director