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Editorial Board

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

3rd Floor, PHD House,
4/2, Siri Institutional Area, August Kranti Marg, New Delhi-110016,
Tel. No.: 91-11-26535697, Fax No.: 91-11-26964840,
E-mail : dg.sectt@fipi.org.in,nkbansal@fipi.org.in,
Website : www.fipi.org.in

From the Desk of the

Director General

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

The ongoing worldwide health emergency caused by the COVID-19 pandemic has brought about a series of unforeseen challenges for the entire world. The impact of this pandemic is beyond anyone's imagination and at a level of devastation that is insurmountable, which has set back all economies of the world, by at least a few years.

In the current situation, it is not possible to assess and analyse the actual economic loss as cases of Covid-19 continue to rise. However, with global macro-economic indicators dipping, most of the forecasts for global economy have been slashed. In-fact the IMF expects the global economy to shrink by 3 per cent in 2020. According to IMF Chief Economist Gita Gopinath, the cumulative loss to global GDP over 2020 and 2021 from the pandemic crisis could be around 9 trillion dollars, greater than the economies of Japan and Germany combined.

The unprecedented disruption of this scale has affected every sector and industry across the globe and has seriously affected the oil and gas companies which have been hit by the double whammy of demand destruction of petroleum products and drop in crude oil prices. To arrest the declining crude prices, OPEC nations and other big producers arrived at a solution to cut production by 9.8 mbpd to stabilize the market. Crude Prices which fell to an unheard level of below $20 per barrel in April, have revived and are now trading at around $40 per barrel at end of June.

Lack of sale of crude oil due to decline in demand from the refineries impacted the cash flow of E&P companies. As a result, it has forced the E&P companies to cut budgets and investments planned for 2020-21. These budget cuts could delay the development of new projects globally. In a chain reaction, budget cuts from E&P companies have reduced the orders for Oil Field Service companies. Field service sector is facing operational crisis as the lockdown has impacted the mobilization of field crew and equipment domestically and internationally.

Further, service companies make significant investments in R&D activities for development of new technologies for logging tools, fracturing, cementing, mud fluids, oil field chemicals etc. to support E&P companies for exploiting oil and gas from challenging reservoirs in an innovative way, thus saving time and money. During the low oil price regime when the activities have dried up and service companies are in survival mode, the investment in R&D has become minimum, which will prevent new innovative technologies to come up to handle future challenging situation in the industry.

On the petroleum products and oil demand side, the global oil demand is expected to post a record negative growth in 2020. The biggest drop in oil demand is expected in the second quarter of 2020. Even assuming that travel restrictions are eased and industries start operations in the second half of the

year, the oil demand in 2020 is still expected to contract significantly. While experts and bankers from around the world have predicted a V shaped recovery, such scenarios seem extremely optimistic. With more than 4 billion people living under some form of COVID-19 lockdown, countries around the world witnessed a steep fall in the demand for petroleum products during the quarter.

The impact on demand of petroleum products in India was also significant. India's fuel consumption fell almost 46 per cent in April as all petroleum products, except LPG, saw massive demand erosion following the nationwide lockdown that halted economic activity and travel. However, the consumption of all petroleum products put together almost doubled in May '20 compared to April '20 levels, growth of petrol was higher at about 70% and diesel at 59%. Compared to May '19, or the early months of the current year prior to the lockdown, the growth percentage has still to catch up by 24% to 26% for all products. Refinery utilization rates plummeted to around 50% in late March and April in India with the onset of lockdown. The utilization has gone up since the start of economic activities and unlocking of activities in a phased manner.

The natural gas markets were already experiencing, pressure from oversupply and were undergoing multiple transformations at the same time will be heavily impacted by COVID-19. Aside from the very real impact that coronavirus containment measures have, the broader and potentially longer-lasting impact on GDP and industrial production will affect LNG balances later this year and into 2021. Global prices of LNG had already collapsed – first in the Atlantic basin and then more dramatically in Asia. Prices had been low due to an abundance of LNG in the market. With a sustained lower LNG price, the case for investments that promote switching from coal to gas is now stronger. LNG spot prices in Asia and Europe are close to parity with coal on a levelized cost-of-energy basis, which will minimize the cost impacts of any fuel switching in the short term.

The only silver lining that emerged from the COVID-19 situation, was that our skies were clearer with plummeting pollution levels in cities. Across the globe, this time was utilized by our ecosystem to heal and flourish. Now it is high time to realize that, thinking about climate and our environment is no more a topic of introspection, but of action. This realization should perpetuate across board rooms and seriousness should be visible in terms of increasing investments in cleaner fuel technologies and energy transition.

With no possibilities of organizing conferences, events and workshops where physical presence is required, FIPI took the digital route and organized many online webinars ranging from, impact of depressed oil price on upstream operators, challenges in oil marketing in times of COVID crisis, discussion on liquidity constraints of companies, Gas market outlook, to enhancing Workplace Wellness and Immunity.

Our industry continued to operate and serve the nation amidst most challenging business environment created by the pandemic. The industry was hit hard by low oil prices and unprecedented demand erosion leading to serious liquidity constraints and was in dire need of the much needed from Government and regulatory authorities.

To support the E&P industry, FIPI requested the Government to provide temporary tax holiday and relief from payment of OID cess to Oil & Gas producers who were hit. To support the downstream industry, which was struggling due to low prices, unmitigated inventory losses impacting working capital, liquidity and cash flow related issues in the immediate and shorter term, FIPI advocated a shift to import parity pricing, taking actual AG quotes and trade premiums for MS rather than deriving it from Singapore and incorporating Social Welfare Surcharge on countervailing duty (CVD) into pricing to provide relief to oil refining and marketing companies.

To support the Natural Gas industry, FIPI has proposed several measures across the natural gas value chain from contract negotiations, pricing freedom, bringing Natural Gas under GST immediately, reducing custom duty as well as measures to induce demand recovery.

Similarly, issues related to finance and taxation, such as deferment of due date for payment of excise duty, relaxations in terms of compliances with tax laws, relaxations on moratorium, loan system for delivery of loan credit, ECBs for meeting working capital requirements etc. have also been taken up with relevant authorities.

In this time of crisis, the Government of India has been very supportive towards the industry and has brought in a slew of reforms such as ease of doing business for upstream companies, wherein the Government has simplified procedures for oil and gas exploration and production by providing for self-certification for a host of compliance, such as a discovery notification and deemed consent for investment in fields in a stipulated time. The government has also allowed companies to monetize oil and gas discoveries without undergoing the time-consuming procedure of government approvals for field development plans and other bureaucratic process.

PNGRB has eased the LNG distribution regulation. It has been clarified that any entity can set up an LNG filling station in any Geographical Area (GA) or anywhere else, even if it is not the authorized entity for that GA. This development could potentially provide a big boost to the sector to promote green fuels like LNG and will promote the participation of more players across the value chain starting from OEMs and the fleet operators to the LNG dispensing infrastructure.

Further, the Ministry of Petroleum & Natural Gas has stated that, India plans to gradually introduce pricing and marketing freedom for natural gas as well as rationalize pipeline tariffs to help push for a greater share of natural gas in the energy basket. The new tariff structure would facilitate in creating a single gas market by attracting investment to complete the gas grid as well as ensuring equitable access to natural gas across the country.

We at FIPI, welcome such progressive initiatives of the government, and would continue to play our part as an industry body by advocating progressive ideas and reforms for the benefit of the industry. While we hope that India will win its war against the Coronavirus, we are committed to continue to support our Government in all its efforts to contain the virus.

I wish you all and your families a safe period ahead.

Dr. R. K. Malhotra

HRM

COVID-19: A Learning Landscape

Ranjan Kumar Mohapatra
Director (HR)

Indian Oil Corporation Limited

When we entered into the year 2020, no one had visualised that we shall be encountering one of the gravest, widespread and unprecedented attack across the globe. Within two months of the New Year, the world was talking of only one thing – Coronavirus or in other words, COVID-19. And by March, 2020 the World Health Organization (WHO) had declared COVID-19 as a pandemic. It was a signal to the fast-moving community of homo-sapiens to pause; and revisit, reinvent and rediscover themselves. Everyone in the world was fighting the crisis in his/her own wisdom.

India decided to go for Lockdown in March, 2020 and moved into Unlock phase from June, 2020. In a country of 1.3 billion people, it was essential that during these uncertain and unprecedented situations, the human dignity and the human life was sustained. The crisis could not have been allowed to win over and wipe out humanity. Several Lakh people worked tirelessly to ensure the health, safety, well-being and survival of a billion others. It was in this situation that our sector made its indomitable presence in ensuring that the energy lifeline of the country was maintained uninterruptedly.

As the Chief People's Officer, my biggest concern was to keep my workforce **engaged** and motivated during this trying time so that they could maintain essential social supply chain by keeping the kitchens and the engines ignited all over the country. An empowered committee was set-up under my leadership with senior Executive Directors as process owners for their respective Division/Function. The Committee has been meeting every day (though through virtual mode) without fail and the developments and decisions are being communicated regularly to leadership at all levels within the organisation for crisis management.

No individual or organization should let a crisis to go waste. Hence, I strongly believe that everyone must discover "Opportunity in Adversity" during any such trying time.

Our discovery moved as per the following **PACE**:

1. **People Focus:** Keeping an eye on the health, safety and well-being of employees, contract workers, channel partners and stakeholders
2. **Adaptability:** Abruptly transforming business processes on account of social distancing and other aspects
3. **Communication:** Maintaining communication linkages during the non-availability of physical communication channels
4. **Energy Continuity:** Ensuring nationwide supplies of essential products and assisting the Government and the Administration in various Corona containment measures

People are paramount. As an organization responsible for health and happiness of several lakh people (employees and non-employees), it was incumbent upon us to ensure their well-being. In a virtual environment that COVID-19 created, one may tend to lose sight of human sentiments. In these situations, empathy takes the forefront. In our case, when our Covid Warriors like Delivery Boys, Customer Attendants were out in the field, we displayed **empathy** in our actions – be it provision of insurance or ex-gratia or distribution of PPEs or facilitation through travel/food/shelter or support for families. The diverse aspects of our people strategy helped us. Basis our learning from these experiences, in my view, efforts towards maintaining a combination of the following beliefs can help organisations in keeping the workforce motivated during any challenge:

1. Service to society must be the paramount principle
2. Difficulties act as catalyst for behavior change
3. Exploit learning opportunities during challenging times
4. Discover innovative ways of life and new ways of doing business

The above beliefs can always be reinforced amongst people by providing an enabling environment, as we learnt as an organization during past three months. Our employee at Work from Home immersed themselves in a learning revolution by consuming 2 lakh hours of e-content in two months; and our employees/allied workforce in field found new ways to work and deliver.

Humans have the genes to adapt to change and survive. COVID-19 strengthened my belief in this thought. In such situations, even small steps can make large impact. When some drivers showed reluctance to ply vehicles due to non-availability of dhabas on the way, we arranged packed tiffin for them so that the nation must remain energised. Our Business processes were revisited as per the requirements and the circumstances of the locations and it was ensured that uninterrupted fuel supply was maintained across every part of the country. Immersed in the spirit of national service, our workforce adapted to the new normal. For the first time, we introduced a Work From Home policy and that too, as a pro-active step – days before the Lockdown. In order that our 60% population which was continuously working at supply locations do not feel drained out, we provided re-enforcement and relief in form of movement of people from other functions or other installations. Instant decision-making with an agile and adaptable mindset can be the winning stroke! Perhaps, it is also a lesson for organisations to revisit their hiring and on-boarding practices, wherein the focus must shift towards hiring talent that is agile and willing to adapt in any situation.

Such adaptability must be equally supported by an authentic communication. Handling crisis communication is the hallmark of success in any uncertain condition. We ensured an effective and focused communication channel so that there was no panic or misinformation. Regular advisories, based on Government of India Guidelines, were issued. Besides the advisories, the employee connect was expanded to inculcate resilience and behavioural change. Specific outreach measures were put in place to build a positive narrative around COVID-19 and also, connect with every employee and their families. This included sensitisation on COVID preparedness by sports and media celebrities; and our officers reaching out to all retired employees to enquire after their well-being. Various Leadership talks and reaching out initiatives were undertaken such as Leadership communications and interactions such as Town Halls/Paricharcha/Messages. I implore upon organisations and leaders to create a rallying point in difficult circumstances so that the workforce can together work towards and under a single umbrella; for instance, we created one namely, a prime national cause – Save Lives and Livelihoods!

Energy is the lifeline for a nation and essential for disbursing the health and safety services across the country. In order to maintain these supplies of automobile fuel, aviation fuel and LPG – the cooking fuel, 58% of our direct workforce moved out of the comforts of their homes, took the COVID challenge head on, to ensure that the refineries, pipelines, POL terminals, LPG plants and the entire supply chain were in place. These employees were ably supported by hundred thousand delivery boys, customer service attendants, Tank truck/lorry drivers, channel & business partners – our own Corona Warriors! The continuity of business was viewed more from a social lens than from a capitalist lens, in sync with the philosophy of the Government to ensure human based approach rather than business-based approach in this situation of uncertainty. The fiber of our organization came to our rescue!

The core values of the organisation – Care, Innovation, Passion and Trust – found an apt occasion for manifestation and the ingrained value-based culture of the organisation emerged on the surface and was visible in every action that unfolded. It took a few days for the media to realise that there were many silent warriors who were ensuring that the fuel and energy needs of the entire nation is met uninterruptedly. It is my firm belief that an organisation with a well-ordered people fabric, core values and strong fundamentals can make its people "habituated to challenges" and, maintain business continuity par excellence irrespective of any circumstances.

In my opinion, a well-knit strategy, as demonstrated above, can pace up any revolution!

REFINING

Refining Industry Outlook Post Covid-19 Crisis

Dr. Himmat Singh
Scientist:G & Prof (Retd)

Abstract

The Covid-19 pandemic is first and foremost a humanitarian challenge, as well as an unprecedented economic one. The refining industry has responded with a Herculean effort to successfully and safely operate essential assets in this challenging time. This unrivalled crisis will be a catalytic moment and may perhaps accelerate permanent shift in the industry's ecosystem, with new future opportunities. This article is an attempt to present the ways the industry and refineries are being impacted in terms of operations, product storage, demand and movement. Response from Indian and European refineries has been highlighted along with impact on Refinery margins and global outlook. Long term industry outlook has also been very briefly mentioned.

Key Words: Covid-19, Corona virus, Crisis, Refining, product demand, global impact, Refinery margins and economic issues.

1.0 Introduction

McKinsey & company in their recent Report (1) state "The oil and gas industry is experiencing price collapse combined with a supply shock and an unprecedented demand drop with a global humanitarian crisis." Additionally, the sector's financial and structural health is worse than in previous crises. Today, with prices touching 30-year lows, and accelerating societal pressure, executives sense that change is inevitable. The combination of the Covid-19 pandemic, demand disruption, and a supply glut has generated an unprecedented crisis for the industry. While the depth and duration of this crisis are uncertain, company's research suggests that without fundamental change, it will be difficult to return to the attractive industry performance that has historically prevailed.

Speaking about our own country, India is the world's third largest consumer of oil, the fourth largest oil refiner and a net exporter of refined products. The rate of growth of India's oil consumption is expected to surpass that of the People's Republic of China in the mid-2020s, making India a very attractive market for refinery investment. To maintain India's position as refining hub, the government is pursuing a very ambitious long-term roadmap to expand its refining capacity in line with the country's projected demand growth through 2040. As proven oil reserves are limited compared with domestic needs, India's import dependency (above 80% in 2018) is going to increase significantly in the coming decades (2).India's strategic petroleum reserve with a capacity of 40 million barrels can supplement the commercial storage available at refineries, for just over 10 days of current net imports.

The Hindu, a national daily (3) reported that the steep fall in domestic energy demand driven by the COVID-19 pandemic has impacted India's oil refining sector amid an oil price war and a severely stressed global petro-order. Energy demand in India has plummeted as lockdowns, enforced to contain the spread of COVID-19 infections, have derailed the

economy- they have included grounding of flights, and brought vehicular transportation to a standstill.

The stress in India's refining sector follows extreme turbulence in the global energy eco-system. Apart from the meltdown in demand, the oil glut in the market is unveiling another major problem- that of storing excess crude.

2.0 Covid-19 Impact on Refinery Operations (4)

The refining industry is entering unchartered territory as it navigates impacts from the Corona virus/ Covid-19. How will refiners handle the virus? Let us in the first instance, examine its impact on refinery operations in two steps:-

2.1. Effect on Operation Staff

The operation staff resource is normally with a limited backup. it is a definite risk issue in terms of staff availability. Accordingly the pro-active refiners are going to train backups and have them ready. The operation staff is the life line of a refinery.

The number of staff obviously depends on the size of the refinery and the number of units that are grouped together. But let's just talk about one general area of the refinery; say about the crude and vacuum unit. We might have, on each shift, eight operators at an average refinery, and then we've got three shifts in most refineries. The key point here is, operators on a particular shift. They'll work for 8 hours and then they'll be replaced. They're all important. There are different layers of supervision, and then there will be the line operators. All have key jobs. What we are really concerned about is, if there's contamination on one shift, that whole shift would probably have to go into quarantine and have to be replaced. We are also worried about the interaction between shifts. In most refineries frequently, at the shift change-out time, there's a lot of interaction between the shifts. In addition to that, they're sharing the same control panels, the same computer terminals, the same desks and chairs.

2.2 Effect on Refinery Operations

The issues that might cause a refinery to slow its output in a sort of contamination scenario like the one outlined above. Talking in commercial terms mean, demand for certain refined products has dropped globally,jet being the very obvious one. But there are others, too, and there will continue to be other fuels that see less demand as the response to this health crisis continues to roll on. That's not good for refinery. Do we see commercial reasons for refineries to slow their output at this point? Definitely there will be a drop in demand for gasoline and distillates, and especially jet fuel. Refineries, at least most of them, will have to turn down. One expects a decrease in crude runs over the next three to six months. Refiners are going to be impacted everywhere. Every major refinery center will see an impact eventually.

Presumably storage is filling up very quickly. So inventories are already high. There's not a lot of room to store gasoline and distillate or jet. So they're already in a tight spot. We have hit contango for most markets.

Gasoline demand will drop because, if for no other reason, people won't be driving to work as much. People are going to be working from home. A lot of people still drive to work every day. Staycations may become a possibility.

Middle Distillate, see a definite decrease there. Perhaps not as big, but a decrease because of discretionary spending by consumers and businesses will drop, less truck traffic across the country and less train traffic And finally, jet fuel, we've already seen a drop there, It is going to continue due to some dramatic effects on jet travel domestically, as well as internationally.

2.3 Response from Indian Refineries

Two recently published reports put the response from Indian refineries as below:-

Indian Oil Corporation (IOC), refineries (5) were operating at full capacity before the lockdown but had to curtail throughput and bring operations down to nearly 45 per cent of capacity by the first week of April in response to a steep decline in demand.

India's petroleum product demand fell for two-consecutive months in March and April forcing refiners to moderate their crude throughput across the country. Overall petroleum product demand fell 46 per cent in April, with the demand for petrol, diesel and Aviation Turbine Fuel declining 60 per cent, 56 per cent and 91 per cent, respectively.

Indian Oil Corporation, the country's largest fuel retailer, intends to operate its oil refineries at 80 per cent capacity by end of May in anticipation of increased demand during the month. With the demand for petroleum products gradually picking up, IOC has re-started several process units at its refineries that were down due to the lockdown. "With throughputs gradually picking up pace, the refineries are currently operating at about 60 per cent of their design capacities with plans to scale up to 80 per cent of the design levels by the end of the month". IOC has also resumed manufacturing of petrochemicals intermediates in anticipation of increases demand as well.

The Bharat Petroleum corporation ltd (BPCL) had forecast its refineries to operate at an average capacity of around 30 per cent in the immediate aftermath of the country's Covid-19 lockdown, which started on 25thMarch. Indian refiners had warned of refinery closures as extensions of the lockdown further cut into fuel demand.

The refineries oil product tanks were full in mid-April and refinery throughput will also increase as the products are gradually used, said BPCL director of refineries R Ramachandran. He expects demand to increase in May as the government open up more of the country after the third phase of its Covid-19 lockdown ends on 17th May 2020.

Diesel demand is increasing after the government allowed more agricultural activity, while transport operators started trucking goods. India's diesel sales dropped to 808,000 b/d last month from 1.8mn b/d a year earlier amid the Covid-19 restrictions. Gasoline demand fell to 274,000 b/d from 693,000 b/d a year earlier.

As per the recently published report (6), Indian state-controlled refiner BPCL is seeing higher crude runs at its refineries, with demand gradually increasing as the country relaxes more Covid-19 restrictions. BPCL is utilizing 80-85% of capacity of its 240,000 b/d Mumbai refinery and around 42% of its 310,000 b/d Kochi refinery on the southwest coast in Kerala state. Its 156,000 b/d joint-venture refinery with state-owned Oman Oil in Bina in central India is operating at 55-60% capacity. Bina had processed around 166,000 b/d of crude in March, Mumbai 307,000 b/d and Kochi 331,000 b/d.

3.0 Covid-19: Impact on Indian and the wider products market (7)

3.1 Impact on India's Product Market

Discussing the Covid-19 impact on transport fuel markets, it is observed that the virus has affected commodity markets across the globe, and India, the third largest oil market in the world after the U.S. and China, is no exception. The virus outbreak in India has met with a strong response from the Indian government. It is understandable that the government is moving to contain the spread rather than have to deal with the fallout.

Governments across the world are having tough time to balance healthcare issues with economic interests. It is indeed a task to come up with an adequate forecast on how India's oil demand will be affected by the measures the government is taking. What we do know is that oil demand was already slowing as the economy slowed. India's GDP growth was 7% last year, down from over 8% a few years ago, and the virus has slashed GDP projections this year to 2%.

Looking at the impact of Covid-19 from a refined products supply perspective, at this time, refiners in India should have been benefiting from low crude prices and the seasonal demand spike, but economic activity has halted as a result of the population lockdown and transport restrictions have cut sharply into jet, gas oil, and gasoline demand. As with other refining centers, margins are deteriorating and a products stockpile building. In Singapore today, gasoline margins are minus $11 a barrel, and gas oil is struggling under $7 a barrel.

Indian refiners are definitely cutting runs. And the country's largest refiner, IOC with a combined capacity of 11 million barrels per day, across 11 refineries, has cut runs by an average of 30% and possibly up to 50% at some refineries. An IOC affiliate, Chennai Petroleum has indefinitely shut two of the three CDUs at 10,000 barrels per day refinery as demand for transport fuels evaporates during this shutdown. As per industry sources the fellow state-owned refiner, BPCL with 770,000 barrels per day of refining capacity will cut runs by roughly 30%. And similarly, for 300,000 barrels per day Mangalore Refinery and Petrochemicals (MRPL), will cut runs by a third of capacity, and in terms of the two private

sector refiners, Nayara and Reliance Industries, as per information have cut around 20% to 40% as domestic demand contracts.

3.1.1 India's Unique situation

Indian refiners are indeed in a very unique situation. As per practice, at a depot or the supply point just before retail station, they typically carry up to about 20 days of inventory. And in case of any supply disruption from a refinery, this means there's very little spare capacity to carry additional fuel if the off take at the retail station is affected, as has been the case now. So, refineries have to cut quickly, if the downstream demand goes (7).

Another thing that is likely to happen with Indian refiners is that they'll postpone refining turnarounds starting April. So the second quarter is typically a very heavy turnaround period, but reduced operations means the refiners like MRPL, HPCL, and BPCL, who all have planned turnarounds in this period will postpone these. And actually, this year we have already seen less than a usual refinery turnaround season because these refiners, who had been preparing for Bharat Stage VI, Indian fuel standards, (Euro 6 equivalent), has really brought refineries down much earlier in preparation for the 1st April start, and the virus has just seen refiners reduce turnaround time even further.

Despite the refinery run cuts though, there has been a rash of gasoline and gas oil offers from Indian refiners, not a good sign about domestic demand. So, let this be viewed product by product bearing in mind that the Indian government only locked down the country starting 25th March 2020. Indian gasoline demand in March fell a hefty 18% from a year earlier to 529,000 barrels per day. Now, this fall is less pronounced than it could have been given that no one has been doing much driving to work or to go anywhere else for that matter, but state-controlled fuel stations were ordered to stay open even after the lockdown was imposed to provide fuel for migrant laborers to return to their villages. Indian gas oil has been affected even more badly. The initial numbers that we are seeing for March suggest that diesel is down 26% from a year earlier and to 1.2 million barrels per day.

It is Indian jet fuel consumption that would have been hit the hardest. Demand in March was down by 32% from a year earlier to 118,000 barrels a day. The government has banned all flights, domestic as well as international, until 26/31st May with 600 aircrafts grounded. Traffic growth has already been really slowing, and it was just under 4% last year. And this virus would devastate the aviation industry as it has in many, many countries world over. It is important to make it clear at this stage that two private refiners, Nayara and Reliance, typically supply to the domestic marketing companies through agreements. And it's still not clear, at this point, if the companies are reducing volumes they're taking in the local market, and if these volumes are also finding their way out as exports.

3.1.2 Impact on the Indian Consumer and Oil Sector-Beneficial

Have we seen Indian gasoline prices crash as a result of lower international prices? Actually no, not at all! So, Indian gasoline prices haven't fallen the way one might have expected despite domestic market pricing off the international market, which has fallen sharply. This has very much to do with the taxation structure in the country. Gasoline does not come under Goods and Services Tax, but instead the central government levies a duty, and the state governments put tax on gasoline sales, and the price has gone up as the respective governments try to boost revenues at this time. And if the lockdown are partially eased, then one should see an uptick in diesel demand, which is actually the case after partial opening in lockdown 4, in some parts of the country.

Et Energy world (8) reports, at least in the oil sector, the global health emergency posed by the spread of the novel coronavirus has come to the country's advantage. India's oil import bill has fallen close to 10% in FY20 as the increasing spread of coronavirus and demand squeeze globally has depressed the crude oil prices to about $ 30 a barrel now against a high of over $ 70 a barrel in September and again in January this year. According to the provisional data, from Petroleum Planning and Analysis Cell (PPAC), in FY20 India's oil import bill slipped to $ 101.4 billion from a level of $ 111.9 billion in previous fiscal FY19.

The lower import bill last year came even as quantum of imports increased marginally to 227 million tonnes (MT) from 226.5 MT reported in the previous fiscal. The fall has come mainly on account of generally lower crude oil price in FY20 with the sharp decline of over 50 per cent witnessed in March. The low oil price of around $20 a barrel in April, and expectation that crude may average between $30-40 a barrel in FY21, country's oil import bill could reach its all-time low levels in many-many years in current fiscal. The potential is it could fall to $ 64 billion in FY 21, the same as FY 16 when crude prices slipped below $26 a barrel.

3.2 Impact on Wider Refined Products Markets

Let us now have a look at wider refined products market including Asia (7). This very much depends on how the regional managements, manage the lockdown and how far they persist. But a rise in COVID-19 cases in U.S. and Indonesia, which are two of the world's largest gasoline markets, is definitely worrying for the traders and for the market as a whole. Markets have always seen the boost in gasoline prices from the US summer driving season, and also, the Islamic fasting month of Ramadan. But now, with the Covid-19 spreading across these two countries, that is weighing heavily on the gasoline market. Indonesia, usually a massive gasoline importer at 10 million barrels a month on average, has already reported a 60% drop in both gas oil and gasoline demand so far. Philippines and Vietnam, they're both typical net importers of gasoline, but they have been seen offering oil products into the market for April loading. And, of course, other major gasoline importers such as Pakistan and Sri Lanka have really been canceling April delivery cargoes. Just across the month, Vietnam and then Thailand have announced restrictions on movement. Malaysia has extended its lockdown and in Singapore, all measures have been stepped up. Japan has imposed a state of emergency in some areas. China is coming back slowly, but we still see gas oil and gasoline in steep contango with prom gas oil and gasoline trading at a significant discount through forward months reflecting the significant weakness in the markets.

It is expected that the impact of this virus is going to shackle economic activity for some time. And, of course, the ultimate difficulty is that we have no end date in sight.

Under most best-case scenarios, oil prices could recover in 2021 or 2022 to pre-crisis levels of $50/bbl to $60/bbl. Crude price differentials in this period are also likely to present both challenges and opportunities. The industry might even benefit from a modest temporary price spike, as today's massive decline in investment results in tomorrow's spot shortages. In any case, oil is in for some challenging times in the next few years (1).

4.0 Covid-19: European and Global Refiner's response & Outlook

4.1 European Refiner's Response

Despite COVID-19 hitting European countries hard, refineries have resisted the urge for closures as cheap crude, at least initially, boosted their margins. As a first step refineries opted to reduce runs, such as ExxonMobil's French site "Gravenchon and Fos". Market sources also said that adjusting operations was taking time and the next step would be to switch off (9).

Some refineries, that have been undergoing works, have chosen not to restart. Total said it was not going to restart its Grandpuits refinery near Paris after its early March maintenance due to reduced demand. The major (Total) said the plant would operate partially. Its Gonfreville refinery near Le Havre has been working at lower capacity following a fire at the CDU and as other units have also been halted, sources said. France's Feyzin refinery, which has been in maintenance since February, was also offline after halting maintenance on concerns about the spread of corona virus.

France's Lavera was also continuing its maintenance, although the works had slowed down due to the corona virus pandemic, and safety measures have been strengthened to protect staff, according to industry sources.

Many inland refineries in Germany are doing the same. Germany's Ingolstadt restarted meanwhile after maintenance; while the country's Heide refinery said it was "currently running without restrictions". Production was continuing "as usual" at Preem's two sites in Sweden - Gothenburg and Lysekil.

Italy's Milazzo refinery has not restarted its gasoline production. FCC unit has been working on and off since a maintenance that started in October. Italy's Sannazzaro delayed all non-essential works despite planning a large-scale maintenance from mid-March and has put on hold the restart of its EST residue processing unit, essential for producing low sulfur products. Another Italian refiner, API, will halt operations. It was restarted fully after works in early March, but has since been hit by slumping demand.

In the Netherlands, Gunvor also decided to postpone the start of planned works at its Rotterdam site. Maintenance is also expected to go ahead at the Netherland's Pernis, which said it would continue to operate and that planned major maintenance would take place.

Finland's Neste was one of the first to defer planned maintenance, and is now planning to carry out some of the works next year. Output was also being reduced at Spanish refineries.

Greece's Motor Oil Hellas said "a decrease in the volume of sales combined with a tightening of the sector margins will have an impact" on its financial results, but "at the present time the extent of this impact cannot be quantified as it undoubtedly will be correlated with the time duration required for normal conditions to be restored worldwide".

"The global oil surplus is increasing fast and refineries are rapidly shutting down because they either lose money for every barrel they process, or they have nowhere to put their oil products," said Bjarne Schieldrop, chief commodities analyst at the Nordic corporate bank SEB (9).

Refinery maintenance would also go ahead at Russian plants, where a host of refineries are set to start works in early April. Some, like the Moscow and Omsk refineries, said they would continue to guarantee planned production as "the high level of automation enables staff to operate processes remotely from the control rooms and observe safety measures introduced to safeguard from the corona virus outbreak."

Hydrocarbon processing (9) writes, "The profound challenges facing the refining sector have never been more evident than during the present crisis". As countries go into lock down to slow the global corona virus pandemic, demand for oil products is collapsing and with it, the market for oil. As we enter the second quarter of 2020, global oil demand could fall by almost 9 million barrels per day (b/d) from last year's second quarter.

Alan Gelder, vice president Wood Mackenzie, said: "Refinery utilization- and profitability - is falling sharply in response. Refiners have started to reduce runs, margins are coming under severe pressure and some refineries will close, albeit temporarily." In reply to a question, "Could this be a foretaste of the future," he said: "Since 1980, global refining has increased by 25%, but that growth has varied markedly by region. Investment has flowed where oil demand growth or imports of refined products have been strong; elsewhere, capacity has been either rationalized or closed." He further said: "Within the next five years, the risk of cannibalization – when each new refinery project prompts the closure of assets elsewhere – within the sector will grow."

World-scale refineries are getting bigger while the energy transition is weakening the global growth in oil demand. "Any new refineries will need to be large coastal sites that are heavily integrated with petrochemicals to ensure they are highly competitive." Gelder said: "The core competencies of operating integrated refinery petrochemical sites can be built on to create a central hub in a 'low-emissions energy complex' that brings together carbon capture and storage, chemical recycling, LNG and renewables."

Alan Gelder (10) concluded: "Refining is, after all, a conversion industry – one that must transition away from carbon-intensive feed stocks such as crude oil and into products and services that the consumer still values."

4.2 European Refining Outlook

After reviewing the refineries response let us look now at the product market picture as well. As per Chris Judge, vice-president -Argus Media (11, 12) the short-term challenges are daunting enough in themselves. The grounding of the majority of the world's planes and strict lockdowns on people's mobility bite hard into transport fuel demand. "The prospects for European gasoline look particularly grim at the moment."

A key question for European refiners over the medium to longer-term is whether the strain on public finances that the response to Covid-19 will have caused encourages European states and institutions to slow down or even abandon costly initiatives to de-carbonize their energy systems. Campbell, Head oil products research (Consultancy Energy Aspects) shares the skepticism. De-carbonization is "a long-term policy that has been adopted by the EU and refiners will have to comply".

Europe's refinery sector faces a challenge in that it has structural oversupply of gasoline and diesel-a consequence of the huge improvements in vehicle efficiency over the last few decades. Its sink markets for these products are getting increasingly competitive. Relaxing certain rules could have a modest impact on the opex of refineries. But by far the most significant impact would be a move away from the trend of electrification in the transport sector, as that is the existential problem facing the European refining sector.

Judge added: "Continued population growth and rising incomes in developing economies outweigh vehicle fuel efficiency improvements and the electrification of the transport fleet. These two factors displace over 10 million b/d of demand, but the outlook for overall growth suggests that, at present, the sector's long-term viability is assured." More capacity will be needed in the Middle East and Asia to satisfy regional demand growth. In OECD countries, weak assets will close, as local demand falls due to fuel efficiency improvements and electrification of the vehicle fleet (11, 12).

In a world aspiring to restrict the global temperature rise to less than 2^0 C, the disruption to the global refining industry could be even more severe. Wood Mackenzie's accelerated energy transition sees much greater penetration of battery technology and hydrogen into the vehicle fleet. Gelder said: "In such a scenario, localization is a key theme – refiners working closely with the local community and their government to retain a social license to adapt their business.

Longer-term, though, the electrification of Europe's road transport poses the biggest threat to gasoline, diesel and the continent's refiners. "Something has got to give," says Judge of targets such as the UK's plan to ban all new sales of gasoline, diesel and hybrid vehicles by 2035. This is five years earlier than a previous 2040 date, while EVs have a current UK market share of 2% and huge challenges on infrastructure such as charging remain unsolved. "My contention is that either the gasoline market is going to fall apart in Europe, or these de-carbonization targets are not going to be met," Judge contends (12).

4.3 Global Outlook

Continuing with refineries response outside Europe, some examples reported are: Maintenance has been delayed in the Middle East, where works at Bahrain's Sitra and Ras Tanura have been pushed to the summer, said sources. Meanwhile, maintenance at Petro Rabigh and ADNOC Ruwais continues as planned (9).

South Africa's Engen refinery said late last week it had opted for a "temporary controlled shutdown", noting that the lower demand it is already experiencing is resulting in its inventory "building up fast". Earlier in the week, Chad's Ndjamena refinery in Djarmaya decided to halt operations because of overproduction. Local media reported the refinery's storage was full (8).

According to the IEA February 2020 Oil Market Report, (13) global oil demand has been hit hard by Covid-19 and the extensive closure of China's economy. As per the report, demand is expected to fall by 435kb/d year-on-year in the first quarter of 2020, the first quarterly contraction in more than 10 years. The IEA has cut its 2020 growth forecast by 365kb/d to 825 kb/d, the lowest since 2011. The IEA has also revised down the outlook for global refinery runs. Chinese crude throughputs for the first quarter of 2020 have been cut by 1.1mb/d and are now expected to contract by 0.5mb/d year-on-year. As a result, global runs are forecast to expand by just 0.7mb/d in 2020.

The large-scale shutdown of economic activity related to the global pandemic response has caused demand for refined petroleum products to plunge dramatically, placing refiners around the world into a difficult situation. Refinery production cuts are common, while some plants have been idled.

In countries where stay-at-home orders and social distancing measures have been issued, gasoline demand is down by 50% and aviation fuel demand is down 70% or more," says Steve Sawyer, Director refining Facts Global Energy (FGE; London, U.K.;

www.fgenergy.com) (14). "Diesel demand has kept up a little better because trucking deliveries are still being made, but despite that, diesel has fallen by 30% at least." Sawyer adds, "Really, demand for all hydrocarbons coming out of a refinery are down."

Sawyer says April demand for refined products could be 23 million barrels per day (bbl/d) lower than the corresponding value from April of last year. "May could be a bit better, but if you're in a deep hole, and you take one step up, you are still in a deep hole." Weak demand will persist into June, and what happens after that depends in large part on what happens with the public health crisis, he says.

5.0 Covid 19: Impact on Refinery Margins

The Indian basket of Crude Oil represents a derived basket comprising of Sour grade (Oman & Dubai average) and Sweet grade (Brent Dated) of crude oil processed in Indian refineries in the ratio of 75.50:24.50. Out of India's total crude supply, 80% is from OPEC countries (with Brent crude as Benchmark) as compared to 9 % from North America's WTI. Brent crude has a 98 % co-relation with the Indian crude oil basket, as compared to 88 % for WTI in 2019.The significant share and high co-relation of Brent crude in the Indian crude oil basket makes Brent a preferred benchmark for hedgers in India(15).

When oil prices declined sharply in early March 2020, everyone hoped refining margins would get a boost, thanks to lower procurement costs. True, demand outlook was soft even at that time. However, lockdown in many parts of the world owing to the covid-19 outbreak have worsened the demand outlook drastically in a short span of time.

The benchmark Singapore gross refining margin (GRM) is estimated to have averaged only $1.20 a barrel up to 27 March in the quarter, compared to $1.70 per barrel in the December quarter,(16). In fact, in the second half of March 2020, the measure dropped into negative territory, largely owing to the collapse in demand for jet fuel as shown in figure 1.

This would obviously weigh on state-run oil marketing companies (OMCs), BPCL, HPCL and IOC. "Very weak Singapore GRMs, complete collapse of fuel demand due to the shutdown and even refining throughput shutdown coupled with the inventory loss owing to a $12 per barrel decline in average crude prices (and much sharper $30 per barrel dip over the 2nd-3rd week of March2020) will combine to deliver a very weak March and June quarter," wrote analysts at Centrum Broking Ltd in a report on 1st April.2020(2).The 21-day nationwide lockdown in India s expected to impact fuel demand, as all kinds of transportation activity has diminished greatly.

BPCL on June 3, posted consolidated loss of Rs 1,819.6 crore (Approx $260 millions) for the quarter ended March 2020.The oil retailer had reported profit at Rs 2,051.4 crore (Approx $293 millions) in previous quarter. Changes in inventories of finished goods, stock-in-trade and work-in-progress came in at negative Rs (-3,036.42) crore (Approx $433 millions) during the quarter against Rs 3,646.4 crore (Approx $520 Millions) in previous quarter, following steep correction in global oil prices." The outbreak of COVID-19 globally and resultant lockdown in many countries, including from March 25, 2020 in India, has had impact on the business of the Group," said BPCL(17).

A recent strengthening in refinery margins in Asia (18) is leading to a sense that the worst may be over for the embattled sector as more nations in the region start to emerge from coronavirus lockdowns. But the main risk now for both the crude oil and refined products industries is that the renewed optimism leads them to boost output to levels above the nascent recovery in demand.

The profit margins, or cracks, for producing both gasoline and gasoil, the building block of diesel and jet kerosene, have bounced off record lows in recent sessions, as traders report tentative signs of a recovery in demand and more interest in securing cargoes.

The crack for making a barrel of gasoline from Brent crude in Singapore rose to a loss of 24 U.S. cents a barrel on Monday, the highest in two months and up from the low of a loss of $13.15 on April 14.2020.

The profit on producing a barrel of gasoil with 10 parts per million sulphur lifted to $4.37 a barrel on Monday, up 147 % from the low of $1.77 on May 5,2020..However, both refined products are still well below their highs so far in 2020. Gasoline is still loss-making, compared to a high of a profit of $9.35 a barrel on Feb. 11th,2020 and the gasoil crack is some 73 % below its high of $16.15 from Jan. 3rd.2020

The improvements in cracks in recent days have lifted refinery margins close to breakeven, with a typical complex refinery in Singapore processing Dubai crude making a loss of just 6 cents a barrel, based on the prices of the underlying crude and products on Monday.

With the large discounts to benchmarks like Dubai crude being offered by major exporters such as Saudi Arabia, it's likely that many of Asia's refiners are able to make a profit from processing at current prices. This in turn may encourage them to ramp up operations, which were severely curtailed in April as the new coronavirus led to lockdown across Asia, including major economies such as India, Japan and Australia.

As much as 4 million barrels per day (bpd) of refining capacity in Asia was idled in April, according to estimates by analysts, and as much as 2.7 million bpd may be offline during the second quarter as a whole. Add in likely restarts and ramping up of output at India's export-orientated refineries and it appears likely that the risk to Asia's refining sector is one of renewed oversupply.

SP Global Platts analytics data (19) has reported avg ($/bbl) Singapore refining margins for Dubai cracking and WTI(MEH) cracking for the week ending in March 2020 as below:

Crude Oil	Dubai Cracking	WTI(MEH) Cracking
Week Ending March 20	-0,60	1.07
Week ending ,March 13	-3,38	-2.81

These margins are also shown in figure 2 along with other crudes under Singapore refining margins

In the case of Europe (20),Gasoline Eurobob barges prices, in the Amsterdam-Rotterdam-Antwerp trading hub of northwest Europe, saw crack spreads widen to negative $8.37/bbl in April 2020 , from negative $2.85/bbl on average in March 2020, before recovering to an average of negative $1.75/ bbl in May.2020

Prices for 10-ppm diesel barges were more resilient over this period, falling to an average $5.25/bbl in April and then down to an average $1.64/bbl in May, from an average $11.34/bbl in March, according to OPIS data.

Jet fuel deliveries in France fell by 87.5% in April, according to UFIP. Prices have kept relatively steady over April and May as passenger flights remain grounded, with crack spreads for FOB jet barges, basis Flushing, Amsterdam, Rotterdam, Antwerp and Ghent averaging minus $4.85/bbl in April and minus $4.06/bbl in May. This is sharply down from an average of plus $4.59/bbl in March, OPIS data show. Still, as countries begin easing travel restrictions, data for May suggests the beginning of a recovery in demand, even as gasoline and jet fuel continue to be the most severely affected transport fuels.

"Chinese energy and economic metrics continue to improve, though the rate of improvement has been slow (19). It's clear the economic damage due to the two-month lockdown has been vast, although probably not structural," Chinese margins are showing signs of recovery as well. The Arab Light coking margin to China was minus $7.90/b for the week ended March 20, however, on Monday it rose to minus $5.69/bbl.Singapore margins are still clinging to negative values, but some slight improvement is evident.

As per Platts Analytics data the Dubai cracking margin was minus 60 cents/b for the week ended March 20, up from minus $3.38/bbl the week earlier.

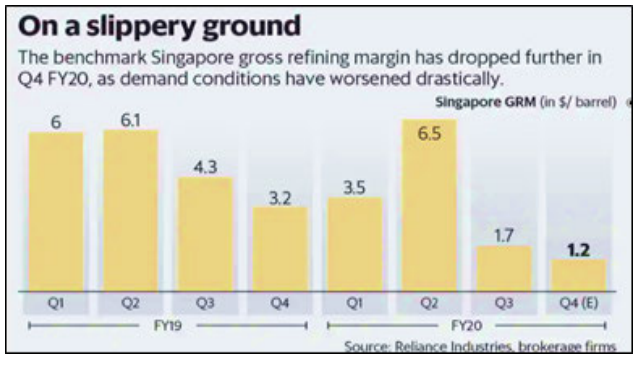

Figure 1: The benchmark Singapore gross refining margin (16)

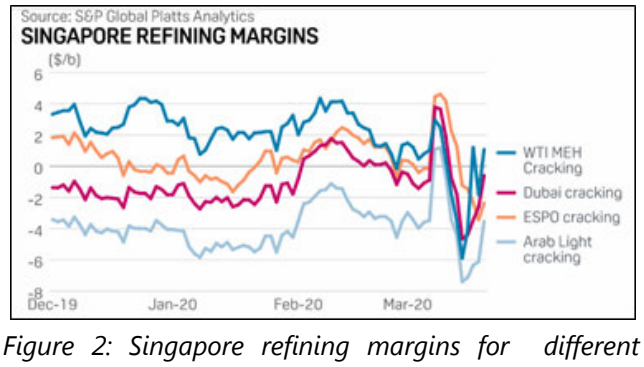

Figure 2: Singapore refining margins for different crudes(19)

6.0 Long-term Outlook

Looking out beyond today's crisis toward the late 2030's, the macro-environment is set to become even more challenging. Start with supply and demand. We expect growth in demand for hydrocarbons, particularly oil, to peak in the 2030's, and then begin a slow decline.

Excess capacity in refining will be exposed, putting downward pressure on profits—driven by marginal pricing and, in some cases outside the growing non-OECD demand markets, by the economics of some refiners that seek to avoid the high cost of closing assets.

The challenge of the energy transition will continue. Today, governments are intently focused on managing the COVID-19 pandemic and mitigating the effects on economies, which is deflecting attention away from the energy transition. That said, the climate and environment debate is unlikely to go away. The innovation that has lowered costs for wind, solar, and batteries will continue and the de-carbonization will remain an imperative for the industry. The energy transition and de-carbonization may even be accelerated by the current crisis.

No one can predict how long this outbreak lasts, how far it has to go, but maybe one can say a few things about how long the impacts, even have a quarter of substantially reduced growth like this lasts. Even if we saw demand slowly returning back to normal in the second quarter of this year, presumably one would be seeing the impacts on the refining sector for a year to come after something like this, happens.

7.0 Summing Up

All companies are rightly acting to protect employees' health and safety, and to preserve cash, in particular by cutting or deferring discretionary capital and operating expenditures and, in many cases, distributions to shareholders. These actions will not be enough for financially stretched players. The industry is likely to see an opportunity for a profound reset in many of its segments.

Closing refineries and other assets with high costs was going to be necessary anyway, when oil demand begins a secular decline. However, as has been the case in the past, the governments may intervene to prop up inefficient assets, which will place additional pressure on advantaged assets elsewhere in the global refining ecosystem. Consolidation, another wave of efficiency efforts, and the hard work needed to wring out every last cent of value from optimizing refineries and their supply chains is the likely industry response. In the medium term, the value of retail networks (and access to end customers) could increase.

The supply and demand picture for crude oil products has created a difficult period for refineries. "Most of the time, economic theory states that when prices for a resource go down, we will use more of it. But now, with demand for refined products also dropped because there's less driving and less aviation, we have the unusual situation of low oil prices coinciding with low demand for refined products with reduced refinery margins. The demand destruction due to the virus, combined with the drop in crude prices was a "double whammy" for refiners, says Sawyer (14).

Although there is no end to the pandemic in sight but we all live on hope to see return to the 'attractive refining industry's performance that has historically prevailed' once again.

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Dr. Himmat Singh Is presently an independent consultant in petroleum refining & natural gas. Earlier he served as Scientist "G" (now Chief scientist) at CSIR–Indian Institute of Petroleum, India in the field of pet Refining and petrochemicals, & R&D Advisor with BPCL, Mumbai. Experience in applied research of around 39 years. Post retirement worked as Professor& HOD with institutions of higher education/universities for over 18 years. Dr Singh holds M.Sc in Chemistry, degree in pet Refining & petrochemicals from ENSPM of IFP France and Ph.D in Refining of Lube Base stocks .Publications 190+ papers,12 patents and three books.

UPSTREAM

Digital Interventions in Upstream Industry for Operational Excellence, Incident Prevention and Cost Optimisation

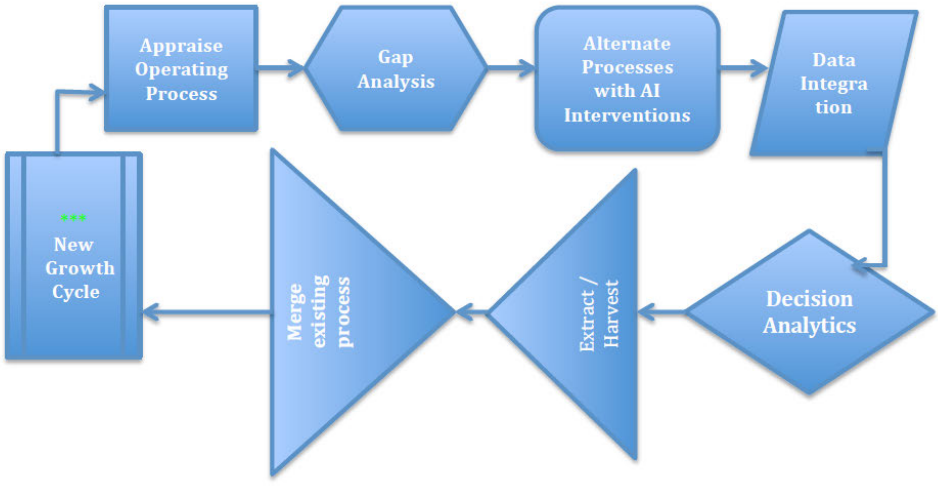
Subha Sen
CEO & Managing Director

SurasOI Inc.

The second most discussed topic at the onset of Covid-19 emphatically is the crash of Oil price with the industry producing 30% less number of barrels, the first of course, being the pandemic itself. Incidentally, the crash of economy and the disruptive global digital transformation drive cross each others path in a rather ludicrous way that has pushed the oil industry, that until recently has been rather reluctant to redefine their conventional ways, to begin to consider downsizing COP (Cost of Production) by right sizing IT infrastructure with AI and digital interventions and embrace more dynamic ways of writing their operating manuals.

Most significantly, after almost three decades of helpless wait, we have reasons to be optimistic that information technology is finally converging with operation technology to more of a practical extent to leverage its most critical purpose of informed decision management. Multidimensional, real-time, pre-emptive data over flexible hybrid networks with extensive security are becoming the foundation of a SMART IT infrastructure with embedded QHSE that promises to be sustainable. In the Energy sector, there is an extensive revival of processes and techniques away from conventional thought processes, enabling optimization of hydrocarbon asset recovery generating significant operating cost reduction.

Fig. 1. An operational process flow diagram integrating action driven dynamic and real-time decisions



Whether vertical, horizontal or directional, across upstream drilling technologies, with the help suitable sensor driven information projections, alerts and triggers, Oil & Gas businesses are able to leverage their existing established operational procedures with enhanced pre-emptions by dynamically acting or preventing the required next step. This not only helps in a thorough QHSE oversee, it also helps in adequate operational and financial planning ensuring the most efficient processes to operate and produce at the lowest possible cost. Not only that, since the data is fetched indiscriminately across sensors, testers, devices, fibre optical sonic and seismic waves, possibilities to assess and trend operational criticality as well as possible analysis for optional alternative assets not only becomes relevant, continuous research, development alternative revenue in a sustainable manner could become a possible production strategy. Earlier offshore technology meant developing, designing and building custom-made rigs and platforms competing with businesses to secure their unique space with customer's dependency on their specific structures across drilling projects. But, today, the approach is changing vastly focusing on efficiency, reducing QHSE incidents with sincere focus on lowering cost of offshore production. Businesses are more and more looking for answers to questions such as:

- Is there a way to standardize solutions and efficiently scale unified solutions across geographies, environment, assets and technologies?
- Can we ensure tangible and sustainable impact?
- Are we on an adaptive mode to collaborate and integrate so instead of creating we innovate and instead of replicating we collaborate with the most efficient alternatives / partners available?

Interestingly, the highlight here is in point number one, a conscious avoidance to standardized tools, the nuts and bolts and a few restrictive operatives that kept the customers tied to the equipment maker for an assured longer term maintenance delivery model; a temperament that kept our industry tied to the branded pride, a possible reason that hindered the breadth-wise growth from the conventional tag. Such standardisations, however, make the seamless integration of drilling technologies possible by enabling near-real-time drilling optimization and by moving closer to realizing the benefits of the digital oilfield. Few of the most significant driving technologies across sub-surface and surface operations are the hybrid, pluggable sensors and drivers delivering actions via protocols like WITSML™ (well, drilling, completions and reporting data), RESQML™ (subsurface modelling, reservoir description and simulation data) and PRODML™ (production and field monitoring data). WITSML (Well-site Information Transfer Standard Markup Language), the most crucial among the three is best explained in something that could be considered as probably the most resonating definition, as provided by Energistics (https://www.energistics.org/). Which reads, "WITSML™ is an industry initiative to provide open, non-proprietary, standard interfaces for systems transmitting, exchanging or receiving data. The standards also provide a low-cost, low-risk, and highly innovative environment for the configuration and running of advanced optimization processes". Quite an authentic harbinger of WITSML could be the RTAS™ (Real Time Advisory System) from DrillSage™ and some of the other ubiquitous concepts like Lytt, a BP initiative, the efficient data tracking via fiber-optical sound, Digital Twins, Digital Oilfields, or Honeywell's "Connected Plant" and similar other metering data interventions with hybrid IoT and predictive analytics etc. that leaders like Gulf of Mexico, Saudi Aramco, ADNOC, PETRONAS and similar are giving serious considerations to. For example DrillSage commits that their "goal is to improve safety, reliability and performance in the oil and gas drilling industry" (refer DrillSage website).

As we stand today in 2020 safety and reliability are two words that have become synonymous to Oil & Gas business efficiency and operational cost optimization. It's most certain that despite utmost care and cautiousness, given a normal operation lifecycle of any hydrocarbon practice, its production and operation procedure and associated incidents like blowouts, leaks, oil- spills etc. could be considered part of inevitable operational hazards, most unfortunately, in most cases with disastrous consequences for the business and society alike.

Step back and flashback to somewhere between the years of 1964 and 2007.

Piper Alpha on North Sea was producing 300,000 barrels a day in 1988. A manual action involving switching on the gas pump from which the most critical safety valve had earlier been removed for maintenance in the previous shift causing the gas to activate immediate multiple explosions, eventually causing 167 human lives and complete destruction of the platform. The total financial cost of the disaster is estimated at US$ 3.4billion plus an insurance claim of US$1.4billion. Piper Alpha till date is recorded as the worst ever accidents in the history of Oil & Gas.

At this point it's relevant for the upcoming discussion to highlight the cause of the third deadliest accident of Drillship Seacrest in 1989 caused by the infamous Typhoon Gay that had left terrible devastation. However, the cause of the Drillship accident was that the Ship's superintendent had ignored all storm warnings and continued to work causing the gravest criminal irresponsible act and losing his own life.

Ten most devastating accidents recorded in Oil & Gas Industry

	Platform	Deaths	Accident Date
1	Piper Alpha Platform Accident	167	6th of July 1988
2	Alexander L. Kielland Drilling Rig Accident	123	27th of March 1980
3	Drillship Seacrest Accident	91	3rd of November 1989
4	Ocean Ranger Rig Disaster	84	15th of February 1982
5	Glomar Java Sea Drillship Disaster	81	25th of October 1983
6	Bohai 2 Oil Rig Disaster	81	25th of November 1983
7	Enchova Central Platform Disaster	42	16th of August, 1984
8	Mumbai High North Disaster	22	27th of July 2005
9	Usumacinta Jack-up Disaster	22	23rd of October 2007
10	C.P. Baker Drilling Barge Disaster	21	30th June 1964

Data Source: whatwhenwhy.net

The estimated loss in financial terms across most of the above, however, did not include the values of hidden losses of the future capacity of the platforms, the short and long term environmental impacts, the direct loss of marine lives and a massive loss of human capabilities including knowledge, experience and extremely critical technical skills of such invaluable resources. For example Macondo's total cost for the oil spill is estimated at a whooping US $65Billion. And it's said that the crack is still leaking causing the enormous risk to the environment. (Source: Reuter)

So, the fact of the matter is environmental detriments are irreversible. Hence the term is not merely Safety it is Quality Health Safety and Environment (QHSE) covering the key importance to quality in treatment across resources; human, environment and assets alike. In order to remain profitable and to gain operational efficiency aligned with QHSE its most important to adopt agile methodologies in operation and to have remote monitoring and control systems that augment proactive decisions through trending and pre-emptive advisory.

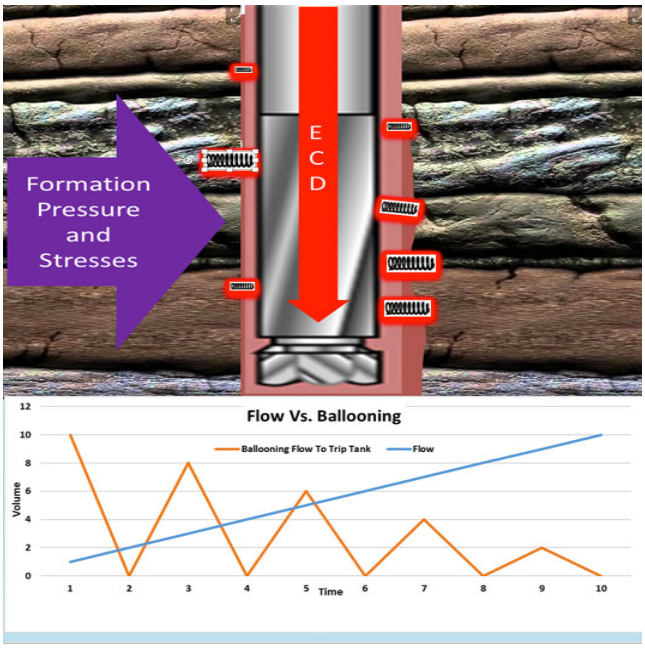
Its pertinent to note that out of the 10 worst accidents in Oil & Gas recorded, as referenced in the list, a relieving information is that the most recent happened almost 13 years back in 2007 and unlike the previous 80's examples of technical errors caused due to careless or faulty manual interventions, the cause in this case was strong winds, with enormity of 130km/h and about 8 meters high, hit the Christmas tree of the drilling well and the gas leakage from the damage caused fire killing 22 field staff on board. Including Macondo blow out, the investigation of which ultimately proved that wrongful human carelessness and stretching beyond accepted norms of quality procedure, was ultimately the reason for the disaster. At such instances, a digital intervention in cost-benefit analytics, suitably provide a pre-emptive decisiveness by not only sending out warning notes to operators, but, also to the top management who are liable to take the right decisions.

The chart explains that with every incident the industry became better with enhanced systems and risk management. However, the actions have been reactive. Automated equipment and trigger driven safety valves stop operation as reactive decision analytics measure. However, with every failed or unfinished run, there is a huge cost association and hence reactive measures are safety ordained but mostly attach considerable price to pay.

Therefore the best approach to HSE has to be prevention. If we are able to predict and trend upcoming events like weather monitoring system advise on upcoming storms or advanced maps or spatial analysis project short-comings even before an alarm rings and appropriate tweaking of action can divert the risk or else could be monitored by reducing the impacts of inevitable risks. To explain further there is a reference to a case study from DrillSage™ (courtesy www.drillsage.com).

RTAS™: Well Control Support & Loss Prevention Technology:

The System



(Source Courtesy: www.drillsage.com)

Following are the list of predictive analytics the Well Control RTAS ™ provides:

- o RTAS has the ability to issue forward watches and alarms for the risks of evolving kicks.
- o RTAS assists in clarity for operator and rig crew well control responsibilities.
- o RTAS alarms against casing seat test pressure failures.
- o Defines the limits of drilling margins (with a safety factor), hence the maximum ECD achievable at any given depth.
- o Enables improved barrier management.
- o Assist in avoiding barrier losses that can lead to kicks and potential well control incidents.

Proactive advisory regarding misinterpreting Ballooning vs. Flow:

Arguably considered the number one reason in unconventional drilling that leads to well control incidents. RTAS has the ability to offer conditional interpretations to proactively suggest if the condition is a result of ballooning, or an actual flow event.

Considerations:

Pumps ON: ECD > Rock strength and pressure. Formation elasticity creates a balloon effect, much like a series of micro springs applying forces or stress.
Pumps OFF: Formation relieves ECD applied stress causing fluid to temporarily flow back
Signs of Flow or Kick: Flow increases

Case:

If mud weight/ECD is added to a ballooning event the risk becomes loss of barrier due to formation breakdown, then:

- Loss of barrier results in a kick.
- Flow: If the mud weight/ECD is too low, the risk is kick and flow.

The case study result: Proactively knowing the difference and suitable interpretation to prevent a well control incident.

We have similar examples of predictive and pre-emptive decision analytics through real time data integration and technology interventions for example using Digital Twins. Unless such analytics and devices are proactively action oriented the use of real-time analytics become less relevant. For example, the loss of precious lives and may be some assets in the accident of Drillship Seacrest in 1989 caused by Typhoon Gay could have been averted with an interjection of a suitable RTAS™ system. Or for that matter even the worst Piper Alpha accident would not have happened with a sensor based stopper that would simply lock the gas switch the moment any valve is withdrawn. Today such triggers are definitely available against a conventional mechanical option. However, a predictive analytics could suggest an alternative action or a continuous text alert to the next relevant person in charge to consider alternative action. So, we must know the proactive responses for a. what are the action plans when it happens and b. preparedness with significant time lags between prediction and happening and not merely a reactive analytics with responses for "if it happens" and "why it happens". Similarly Digital Twin is the integral architecture of IIoT framework with advanced structural integrity management (SIM) – a must required for oil & gas asset and field maintenance management especially for offshore and sub-surface asset integrity of oil rigs, which enables real-time multi-dimensional simulated structural models or

'digital twins' with data analytics and predictive modelling. As Colin J Parris (GE) had suitably put it "A digital twin is a living model that drives business outcome" – at a point where global economy is on a downward graphical trend and environment including marine life has the maximum exposure from Oil & Gas business – investing the time and policies to incorporate digitalization for business decision pre-emption seem to be the only viable way forward in our subject.

(Photo courtesy: DNV.GL.jpg)
Digital-twin-offshore-platforms showing data and twining replications on cloud.

Therefore in upstream oil & gas its absolutely pertinent that:

1. Oil and gas companies define objectives to gain operational efficiencies through improved use of technology, such as cloud platforms, and process, such as the adoption of agile methodologies the key to profitability, and

2. Asset management, logistics, better field communication and enhanced QHSE mandate IoT-based smart RTAS™ and Digital Twins technologies resulting in assured reduction in maintenance cost, cost of production (COP) real-time monitoring, mine automation, assured security of assets and most importantly environmental compliances reducing red money.

At the outset of international environment day on 5th of June, sustainability in Oil & Gas could be considered as one of the most relevant concluding note. It is a definite that oil and gas shall remain an essential segment of energy management until we have some assured alternative source that's more economical and environmentally effective.

However, there are ways to supplement Oil & Gas resources with other alternative resources that could be supplemented by the bi-products of Oil & Gas and yet produce carbon neutral revenue generating products for example Algae-Oil, which is 80% more voluminous than most other bio-fuels and renewable resources. At the same time, Water being one of the most unsung heroes in Oil & Gas bi-produce, it is important to replenish or supplement asset valuation with appropriate remediation techniques for this asset. During the transition stage, the oil and gas industry will play an important role in managing production safety to reduce emissions, discharges, and the ecological impact while providing energy at a reasonable cost. Organisations face complex investment challenges due to a cruel operational environment of exploration and production activities where the workforce regulations aim to provide a safe and secure working environment. Proper analysis and reporting mechanisms are considered key signs of sustainable development at the oil and gas company level. Digital application and transformation surely is a consideration towards mitigation of all the above concerns and assuring sustainability in Oil & Gas business.

" If one does not want to take the time to contribute to the end product by adding auditable, accountable input, then they are not a stakeholder"

.....David Pritchard

GAS

Natural Gas Trading Hubs - Prerequisite for a Success Story

Rajeev Mathur
Executive Director
(BD-Incharge)

Raj Kumar Chakraborty
Chief Manager
(Corporate Strategy Planning & Advocacy)

GAIL (India) Limited

Energy Price and Economy:

Energy pricing and economy of any country are very closely related. The balance of energy export and import by any country affects country's GDP as the import is directly related to foreign currency disbursement. The increase of energy price usually leads to the increase of price of goods and service in the economy thereby affects inflation and reduces export opportunity. Therefore it can be inferred that raising energy price without improving the affordability, creates negative phenomenon in the national economy.

The main energy pricing rule is to properly assess the energy production, transmission, distribution and consumption costs in order to ensure the effectiveness of the overall economy (Streimikien, Konstantinavi, 2003).

To arrive at a wholesale price level of natural gas, different countries are using in general two methods namely, (i) price regulation and (ii) market based pricing. In the market based way, supply and demand forces of the market is establish the reference price index whereas in a price regulated market, Government or Regulator declares the price based on the algorithm in line with the principles of the energy economy of the country.

The International Gas Union (IGU)[1] has identified three major market-based pricing mechanisms, covering OECD and non-OECD markets (IGU, 2012). These mechanisms are:

- Oil (product) indexation, whereby gas prices are linked to other fuel prices (mostly oil or refined products, sometimes coal);
- Gas-to-Gas competition, indicating an indexation to spot prices that reflect supply and demand for natural gas in a market; and
- Netback from final product, which refers mostly to contracts where the gas price is linked to the price of ammonia;

The government regulation of prices is an important part of government economic regulation system. The government also controls competition in the market and the social security system. The state can regulate prices in two ways: economically and administratively. Economic regulation changes demand and supply ratio of the market; it is an indirect regulatory approach. Administrative regulation directly changes or stabilizes prices (Giziene, Zalgiryte, 2015).

In a market based pricing system, the major supply and demand side factors affecting natural gas price are[2] :

Supply Side	Demand Side
• Amount of natural gas production • Level of natural gas in storage • Volumes of natural gas imports and exports	• Variations in winter and summer weather • Level of economic growth • Availability and prices of other fuels

Increases in natural gas supply generally result in lower natural gas prices, and decreases in supply tend to lead to higher prices.

In the Asian-Pacific region natural gas prices to a large extent are determined by government regulations.

Trading Hubs:

Trading Hubs of several commodities are the fundamentals for the development of benchmark price index. A physical hub is a geographical point, centrally located and sufficiently inter-connected in the network where a price is set for natural gas delivered at that specific location. This mostly exists in North America with Henry Hub as a typical example. In the case of a virtual hub, trading hubs can also be used interchangeably with virtual trading points. Virtual trading points are associated with the entry-exit system from which point the same or other network users can transport the gas to exit points. For example, the NBP was established as a daily balancing tool for the entire British geographic area[3].

However the perspective of natural gas hubs is different in Europe and in the US. According to Xunpeng and Variam; 2018, transport activities are fully privatized in North America but regulated in Europe, which are believed to underlie two different approaches- hubs are used to facilitate trade in the US but are meant for daily balancing in Europe. This implies that the different market structure requires different approaches for natural gas hub. Further, based on the objective and purpose the hubs can be different for example, Balancing Hub, Financial Hub; Benchmark Hub etc. "Balancing Hubs" are used by shippers to balance their portfolios where transmission system operators (TSO) balance the gas grid in a set time period. A financial hub offers futures contracts used by the shippers to optimize portfolios and manage longer term risk i.e. for hedging or speculative purposes. British NBP, the Dutch TTF, and the US Henry Hub are the example of financial hubs. While there are many balancing hubs in Europe, and many European hubs have futures products, only the NBP and TTF have liquidity and trading volumes of futures with longer maturities, and thus, only the NBP and TTF are benchmark hubs.

Benchmark hub offers prices for other hubs, and thus, the number of benchmark hubs is very limited. Benchmark hub must have good liquidity from spot to several years forward and be fully transparent, open, and accessible to a wide range of participants. It is a risk management hub and is, therefore, a financial hub, but not all financial hubs are benchmark hubs.

Gas hubs in the matured Gas markets:

The gas hubs in North America were created by industry at appropriate places, with Henry Hub in Louisiana being the most prominent and important of these. By contrast, the National Balancing Point (NBP), a notional point at which gas is traded in the UK, was created by regulation. Both the UK and the North American markets have many players and show substantial demand elasticity based on gas demand for power generation.

There are specific features of the UK and North American gas markets which have favoured the development of gas as a commodity in these markets. Firstly, and most importantly, the development of the gas industry in these countries was based on domestic resources. North America was self-sufficient until the end of the 20th century. The UK was not only self-sufficient, but was even briefly a gas exporter at the end of the century.

It should also be noted that the geology of North America (except for fields adjacent to the Beaufort Sea) as well as on the UK Continental Shelf is characterised by a large number of small to medium sized gas fields and an absence of giant structures. In North America and in the UK, gas-to-gas competition is well developed and gas prices are no longer contractually pegged to oil prices but follow a development of their own.

In contrast to the situation in North America and the UK, gas markets in the rest of the European Union (excluding the Netherlands), and in Japan and Korea have developed based on imported gas. These markets have been shaped by the wish of exporting countries to maximise the rent from gas exports as a compensation for the depletion of their finite resources. The EU depends for 50% of its consumption on three large gas-exporting countries: Algeria, Norway and Russia.

The structure and concentration of gas supply to Continental Europe and to Japan and Korea, and their dependence on imports, makes these cases very different from North America and the UK. In turn, this suggests that differences in market structure are not only a question of sector reform.

In China, like other energy prices, natural gas prices have been under government control. To promote the use of natural gas use, the government has maintained a "cost-plus" based price regime, keeping the prices at a relatively cheap level historically compared to international markets. This kind of gas pricing is possible due to China's self-sufficiency in natural gas. However, given the projected significant increase in LNG imports (which started in 2006), the price regime is now being challenged.

Key features of a gas trading hub:

A successful gas trading hub has two basic characteristics: first and foremost it must be possible to easily move gas into and out of the market. The fundamental element of a hub is the presence of a trading point for buyers and sellers to decide a transaction. In a physical hub, the trading point is the interconnection of pipe-lines. In a virtual hub, the price is uniform in the entire balancing zone. A trading point needs adequate physical pipeline capacity to transfer the ownership of gas between sellers and end buyers, interconnection facilities to nearby gas storage.

Secondly, there must be a use for the gas, either through the existence of a significant customer base, or through the demand from other markets that can be reached from the traded hub.

An important requisite for a trading hub is the ability for market players to manage volume risk at a competitive cost. For a gas marketer, volume risk can be mitigated either by the use of storage or by having a customer base of a size and mix that matches the supply characteristics; similarly, a gas consumer will manage his volume risk by purchasing flexibility services from his supplier, or by having access to storage himself. Most hubs in North America also have access to significant quantities of storage.

Another major element of trading hubs is the legal and financial framework of the marketplace. For existing markets a number of master trading agreements have developed, most noticeably the EFET (European Federation of Energy Traders) contract for physical gas trading, and various annexes to the ISDA (International Swaps and Derivatives Association) contract. These frameworks contain the basic legal text for most standard provisions, serving as a foundation on which contracts are negotiated.

We can thus summarise the minimum requirements for a successful new trading market as:

- Access to gas sources, and to customer base.
- Sufficient liquidity in the market.
- Possibility of managing volume risk for all market participants at a competitive cost.
- Low barriers to entry for new players, known contractual setup and possible clearing services, with low transaction costs
- Managing price risk, through the market (existence of a forward/futures market)
- Fairness and transparency, leading to confidence and liquidity.

Trading Exchange and India:

With the aim to boost consumption of natural gas in the country and to bring more price transparency and competitiveness in the market and efficient pricing structure, the first natural gas trading exchange was launched on 15th June 2020 by Indian Energy Exchange (IEX) which is the parent of the India gas exchange (IGX).

India has a vision to increase the share of natural gas in the country's energy mix from current 6 % to 15 % by 2030. With expansion of gas infrastructure in the country, more numbers of customers will be connected through the pipeline grid and the scenario is expected to boost the overall gas demand in the economy. It is also anticipated that expansion of the gas market will take place. Many industries that are using natural gas will get an opportunity to purchase gas from the gas exchange to get more real time market based pricing.

Significant quantum of natural gas is currently being traded in the short term spot market. LNG spot traders can explore the opportunity to trade gas under short term contract using IGX platform. Domestic gas for which Govt. has given marketing and pricing freedom to the domestic producers from discoveries in Deepwater, Ultra Deepwater and High Pressure High Temperature areas may be considered to be traded in the IGX platform to

discover the real time price. In a similar direction, future domestic gas projected to be produced by the upstream producers may also to be considered to be traded in IGX to increase the liquidity in the gas market.

It is also expected that in future gas trading exchange can bring competitiveness in the industry through spurring investments in the gas value chain, deliver efficient utilisation of the pipeline infrastructure as well as ensuring revival of gas-based power plant. PNGRB has been working on regulations to provide full access to pipelines, reforming pipeline tariffs and other steps to facilitate a gas trading hub in the country.

For free movement of natural gas from trading point to various customers through pipeline grid, it is essential that natural gas is brought under the ambit of goods and services tax (GST). This will facilitate setting up of the gas trading hub, by improving price efficiency through harmonising the tax anomalies of present VAT structure of natural gas. Further PNGRB is working on rationalisation of tariffs to make natural gas affordable in every part of the country. It will facilitate development of gas market in eastern and north eastern part of the country. New tariff regime for authorisation of gas pipelines will make it more investor friendly. New pipeline tariff policy will replace existing practice of charging separate tariffs by different pipeline operators and customers away from gas source paying more than those nearer to source.

It is important to give a boost towards creation of a liquid market for natural gas in India by gradually moving from the current pricing regimes to the hub based price indexation, so that domestic gas and LNG imports can be used in the most efficient way and gas to gas competition can flourish.

1. *https://www.igu.org/sites/default/files/node-page-field_file/Developing%20a%20Natural%20Gas%20Trading%20Hub%20in%20Asia.pdf*
2. *https://www.eia.gov/energyexplained/natural-gas/factors-affecting-natural-gas-prices.php*
3. *Key elements for functioning gas hubs: A case study of East Asia; Xunpeng and Variam; 2018*

GAS

Gas Balancing – Transportation Network

Neeraj Pasricha
Head (Regulatory & Corporate Affairs)

Aayushi Agarwal
Business Advisor to CEO

Pipeline Infrastructure Limited

India is moving towards an advanced gas market structure. The gas sector has witnessed an increase in the number of players in the infrastructure space and the sector may soon witness more players with different roles in the gas trading zone as well. In the gas sector, pipelines play an important role in facilitating the reach of gas from source/market to the consumption point. Gas Balancing plays a critical role in the gas transportation business, particularly when more than one shipper is using the same Transportation Network.

In the gas transportation parlance, gas balancing refers to an arrangement to settle the over-use or under-use of gas between various partners. The difference in the quantity of gas delivered by the shipper at the entry point and quantity off-taken at the exit point, leads to an imbalance in the gas transportation network. Smaller imbalances are not a matter of concern but larger imbalances can affect and create problems for the network operations.

If the gas network receives more gas than what it redelivers at the exit point, it can increase the pressure in the pipeline to dangerous levels. Similarly, if the gas network receives lesser gas than what it re-delivers at the exit point, the pressure can drop to a very low level, and affect pipeline operations. Therefore, maintaining gas balancing in the pipeline network is critical for ensuring system integrity, particularly with multiple shippers in a pipeline. Gas balancing is equally important from the viewpoint of developing gas markets as the transporter must ensure that the volume reconciliation is maintained between buyer, seller, and transporter. Else, it may lead to mismatches in the quantity sold by the trader and that received by the buyer. The transporter is also obligated to deliver gas to shippers as per the agreed quality and pressure. Because of these commercial and operational reasons, gas balancing becomes a critical factor in gas transportation services.

Whenever shipper offtakes more gas than what it injects into the system it is known as **Negative Imbalance** and whenever shipper offtakes less gas than what is injected into the pipeline system it is known as a **Positive imbalance.** Both types of imbalances can result in commercial as well as operational problems.

Now, as India sets itself into moving towards structured gas markets, detailed guidelines about Gas Balancing become important. There is a need to bring in more clarity about the roles of shipper and transporter in maintaining gas balances in the network. Even globally, in developed gas markets, the subject of gas balancing is considered an important part of the gas transportation business and is governed through detailed codes/rules/ guidelines under the supervision of regulators. Comprehensive guidelines on gas balancing would not only ensure smooth pipeline operations but also contribute towards gas market integration and bringing liquidity in the gas market.

Looking at the stages of development of gas markets in major countries, gas balancing was considered as the sole responsibility of the Transporter, during the initial stages of laying of gas infrastructure. However, as these markets developed, the onus of gas balancing was on Shippers, and the Transporter was given the rights through regulations to impose penalties if Shippers created any gas imbalances in the network. However, with time there were various refinements in the gas balancing rules. In the present day scenario, the primary responsibility of maintaining gas balance in the network lies with Shipper while Transporters' responsibility is to take necessary actions to cure any such imbalances which get created. Globally, varied mechanisms are followed to provide an opportunity to the Shippers to cure their imbalances before the Transporter can impose penalties for such defaults. In some countries, even a third party is involved in providing imbalance management services.

Major Constituents of Gas Balancing

1. **Balancing Period:** Gas flows in the network on a 24X7 basis, which necessitates the need for a fixed period over which the balancing is to be ensured. Different countries follow different periods for such balancing- daily basis, hourly basis, fortnightly, or any such pre-defined no. of days. In India, balancing is done daily.

Country	Balancing Period
European countries	Varies from hourly to daily and at some places, it is a mix of both
Australia	The period is divided into part of the gas day, known as scheduling horizon
USA	Daily basis

2. **Tolerance Limits:** Tolerance is used as an important instrument to allow Shippers to manage their gas portfolios. Minor imbalances in the gas transportation system are unavoidable and do not affect the operations of the pipeline. Therefore, globally, the practice is to allow imbalances within tolerance limits. Only if the imbalances so created are beyond the predefined tolerance limits, disciplinary action is taken against the shipper for creating such imbalances in the pipeline network. European Commission has provided that the tolerances will be provided only if the Shipper does not have access to (i) short term liquid gas wholesale market or (ii) gas required to meet short term fluctuation in the demand or supply of gas or (iii) information about their inputs and offtakes of gas. The flexibility of the pipeline network, corresponding to the availability of the line pack is also a determining factor of tolerance limits.

   In India, there is a tolerance limit of 5% for Negative Imbalances and 10% for positive imbalances uniformly across all networks. In some countries, the penalty is at two levels with different imbalance charges for each level. Some countries even follow different tolerance limits for different shippers.

Country	Tolerance Limits
USA	No mandated tolerance limit, varied percentage of tolerance in vogue
European Countries	Varied tolerance limit, ranging from 3% to 10 %, except for this limit being even 25% and above in Sweden and Ireland, based on the weather conditions and exit points.

3. **Imbalance Settlement Mechanism:** Before reaching the position of penalizing the shippers for the imbalance created, globally, market regulations provide sufficient information and opportunity to the Shippers to enable them to manage their risks cost effectively. The following are some of the methods prevalent globally to manage the imbalance portfolios.

a. **Netting & Trading:** This method is used by most of the countries. Shippers are allowed with the option of netting and trading of their imbalances. The netting option is provided to the Shipper, to offset imbalance portfolios among the different contracts of the same Shipper. The trading option provides for trading the imbalance portfolios amongst the different Shippers of the balancing zone. These Shippers need to exercise these options within the balancing period.

b. **Cash Out:** One of the common methods prevalent in some countries is the cash out at the end of the Gas Balancing period. The imbalance gas is either sold or purchased from the market. Countries even follow different methods to cash out the quantity of gas imbalance i.e. separate windows of trading for imbalance gas or buying or selling in open markets in a transparent manner, indexing with the exchange, etc. At some places, there are special short-term products of intraday or day ahead to settle these imbalances. These mechanisms also help in developing short-term gas markets and creating liquidity.

c. **Imbalance Management Services:** Further, globally, different services are provided to manage the pipeline imbalances, some of such services are listed below:

i. **Line Pack flexibility services:** Transporter by using the flexibility in line pack can manage over and under drawls and thus enable the Shipper to manage their imbalances.

ii. **Parking and Lending:** In the US, similar services are provided in the name of parking and lending. Parking services enable Shippers to keep gas in the pipeline and lending services provides the flexibility to shipper to take gas on lending from the pipeline to cure the imbalances. Based on the cost-benefit analysis, Shippers use these services as per their convenience.

iii. **Deferred Delivery Services:** Under these services, Shippers can keep gas in the transmission system for a certain no. of days without paying any imbalance charges. These services are also available in the Indian gas transportation business.

iv. **Auto Balancing Services:** Under these services, the Transporter can automatically adjust the nomination of Shippers to avoid the imbalances in the pipeline.

4. **Penalties:**

a. **Imbalance penalties** are imposed as a deterrent to avoid the creation of imbalances in the transportation system, at the end of the balancing period. Different forms of penalties are practiced globally, fixed penalty charges linked to different levels of imbalances, cash out with premium or discount on gas price based on the level of imbalances, higher penalties for higher imbalances, etc.

The USA follows a principle that penalties are required if the pipeline entity assesses that penalties are necessary for fixing the system issues created out of such imbalances, to ensure system reliability.

b. **Treatment of Penalties:** As explained above, penalties are treated as a deterrent, however, the Transporter has no right to retain the amount received on account of imbalance penalty. Penalties should not be considered as an additional income to the Transporter. In India any amount received on account of imbalance penalties, after adjusting for the cost of curing these imbalances, needs to be credited to an escrow account held by the regulator. In some countries, this amount is even credited back to the Shippers through various routes. European Commission follows the concept of neutrality charges to give or receive the balance amount under penalty. However, the principle remains that the Transporter should not gain or lose from such penalties.

5. **Incentives to Transporter:** Globally there is a practice of incentivizing transporters to manage the im balances in the network in a cost-effective manner. In India also, transporters are allowed to retain the imbalance services charges over and above the regulated income from the pipeline.

Global Principles for Gas Balancing in a nutshell
1. Information in a transparent, timely and non-discriminatory manner to be provided to all Shippers
2. Opportunities to Shippers through different tools to manage their imbalances, i.e. netting and trading, parking & lending, deferred delivery services, author nomination, cash-out facilities, etc.
3. Transporters are incentivized for providing imbalance services.
4. Provision of imbalance penalties only after the balancing period provided to the Shippers to cure imbalances has lapsed.
5. The penalty amount so collected is credited back to the Shippers/Regulator after deducting the cost of curing such imbalances.

In India, though regulations on imbalances exist, there is a need for comprehensive regulations addressing different aspects of the gas balancing of networks. Guidelines are required to provide enough opportunities to the Shippers for managing their imbalances cost-effectively while at the same time empowering network operators to revise nominations and flow of gas to manage imbalances without letting it affect the safety of pipeline operations. While addressing these issues, certain areas need special attention.

Areas that need special attention in Indian Gas Markets

1. **Multi - Owner Gas Networks:** India has networks with multi-ownership which results in different gas balancing zones, which then require gas balancing in each network. There are cases, when a Shipper along the route of his consumption point, can have a positive imbalance in one network and a negative imbalance in another network. Though in total his portfolio is balanced, but due to different ownership of the pipeline network, Shipper may land up in paying imbalance penalties to both the Transporters. Therefore, there is a need to address this issue either through mutual balancing arrangements between the Transporters or allowing the Shippers to manage their gas balancing portfolio across different networks.

2. **Making gas balancing zones:** In India, pipelines can be mainly divided into two parts, regional networks, and trunk pipelines. Another point of contention is, whether to consider the trunk pipeline and connected regional networks as one balancing zone or consider them separately. Each option has its pros and cons which need to be addressed keeping in view the technical feasibility of balancing by Transporters and the convenience of the Shippers.

3. **Taxation Mechanism:** In India, there is a different tax system for commodity and gas transportation. Providing any imbalance management services with a dual tax regime has its own set of issues. For example, Parking and Lending would result in taking gas from shipper in the system or providing gas to the shipper from the system which under Indian tax laws will be considered as sale or purchase of gas and attract applicable taxes. The application of taxes on such transactions makes the whole exercise costlier, less attractive, and defeats the whole objective of such transactions. The transactions for managing the imbalances in the gas networks should not be considered as sale or purchase transaction. **Therefore, there is a need to take up with the appropriate authorities to view these transactions differently.**

4. **Commodity Transaction to manage imbalances:** Provisions are required in the regulations to allow Transporters to sell or buy gas in a transparent manner to manage imbalances in the network and the same should not be treated as a gas marketing activity. This will help the Transporter in maintaining the characteristics of an unbundled entity.

Detailed guidelines on gas balancing would not only help in clearing the uncertainties regarding the imbalance quantities but also help in creating liquidity in the gas markets. In fact, European countries have - enabling liquidity in gas markets and facilitating Shippers cure their imbalances, as one of the objectives, while framing balancing codes. Such detailed guidelines would be a big step towards the development of the Gas Markets and also fast track the GOI's mission of increasing share of natural gas to 15% in the energy mix by 2030.

Pipeline Infrastructure Limited (PIL) is owned by India Infrastructure Trust, an infrastructure investment trust sponsored by Brookfield Asset Management, a global leader in alternative asset management. PIL was the first company to offer imbalance management services to its customers.

PIL owns and operates a pipeline of 1375 km in length, 48 inch diameter, from Kakinada to Bharuch, traversing 5 states across the peninsular region. Additionally, there are spur lines of nearly 105 km in length. The PIL pipeline incorporates 10 compressor stations, with a total installed power of 900+ MW, and has a gas transportation capacity of 80 MMSCMD at design conditions. The pipeline is a vital link connecting eastern gas sources with western and northern gas demand centers and forms the country's backbone for a vast pan-India national gas grid.

GAS

Gas Exchange: India's Maiden Online Gas Trading Platform – Challenges and Way Forward

Sanjay Kaul, FEI
Founder Univ of Petroleum Energy UPES, Univ of Tech & Mgmt, ISPe, IESD,
Sanmarg, BGCL, PwC O&G, Deloitte Energy Resources

The gas pricing mechanism adopted in 2014 linking domestic prices to a combination of international benchmarks was perhaps the least imperfect of solutions for an evolving yet unconsolidated market quite far from maturity.

Establishment of Gas exchange in India was a long overdue beginner's step. The other big ticket reforms now must also be pushed which include providing level playing field, direct incentives for market development and demand side conversion, ease of regulations and permissions at State and Center level, free pricing, uniform taxation, open sourcing and demand side correction of value chain economics.

The trading platform which the Exchange will provide would also push and encourage liberalization of the India's gas market by transparent matching of demand and supply resulting in free market pricing of natural gas.

It takes time for a hub to build volume and credibility; and often, it takes concerted government push and follow through to facilitate buyers and sellers to use the hub; and it all hinges on broader and wide-ranging market reforms.

"The gas trading platform will play a vital role to discover our own price benchmark for gas, address demand supply gaps, accelerate investments in the value chain. The transparency, reliability, flexibility, and competitiveness of our gas markets will contribute in reviving India's industrial and economic growth," Pradhan said.

For perspective, it took more than 10 years for TTF in the Netherlands to establish itself as a benchmark. Even in markets where hubs could formalize existing relationships, e.g. Japan-Korea Marker (JKM), it took years to build liquidity—10+ years after its launch, the marker is still barely included in long-term contracts.

Perhaps, over time, Indian Gas exchange could be a basis for pricing LNG—the way Henry Hub in the USA, NBP in the UK and TTF in the Netherlands have become. But that is a long, long way out; even China has not reached that stage yet.

Several regulatory and structural changes, such as, pipeline tariff mechanism, standardized network access code, gas utilization policy, developing standard contracts, unbundling of marketing & transportation companies, simplification of tax regime, GST reforms, etc. are required for the hub to flourish.

Inadequate gas pipeline infrastructure and connectivity of LNG Regasification terminals to the demand centers remains a challenge; ramping up terminal usage and pipeline connectivity, as well as, rationalization of pipeline tariffs is critical to boost gas demand.

One of the much-needed reform is the unbundling of gas trading and transmission business and setting up of independent system operator (TSO) as well as online booking of capacity to ensure transparent allocation of capacity.

Availability of unbundled entity which solely relies on transmission trade & tariff would attract an entire gamut of institutional investors, infrastructure funds and multibillion-dollar pipeline Cos., e.g Penspen and Enbridge, to form Special Purpose Vehicles (SPVs) and Joint Ventures (JVs) to create complementary and supplementary transmission network. This may include both greenfield and brownfield infrastructure development of the natural gas infrastructure connecting R-LNG terminals to the demand centers.

India's current daily consumption of gas is about 165 mmscmd, of which 47% is met through imported liquefied natural gas (LNG). Gas accounts for around 6.2% of India's primary energy mix against the global average of 24%. The government plans to increase this to 15% by 2030. The country's LNG capacity is also expected to increase from 37.5 million mtpa to 62.5 mtpa by 2021-22. India's gas demand is expected to be driven by fertilizer, power, city gas distribution and steel sectors.

The next challenge for the government will be revival of gas-based power plants – 14305 MW of generation capacity remains stranded for want of fuel. The challenge is inadequate domestic gas production and costlier imports. The exchange will help in the revival of stranded Gas fueled power projects and reducing fertilizer prices and subsidy. The exchange may also facilitate power and fertilizer sector to be direct importers of LNG.

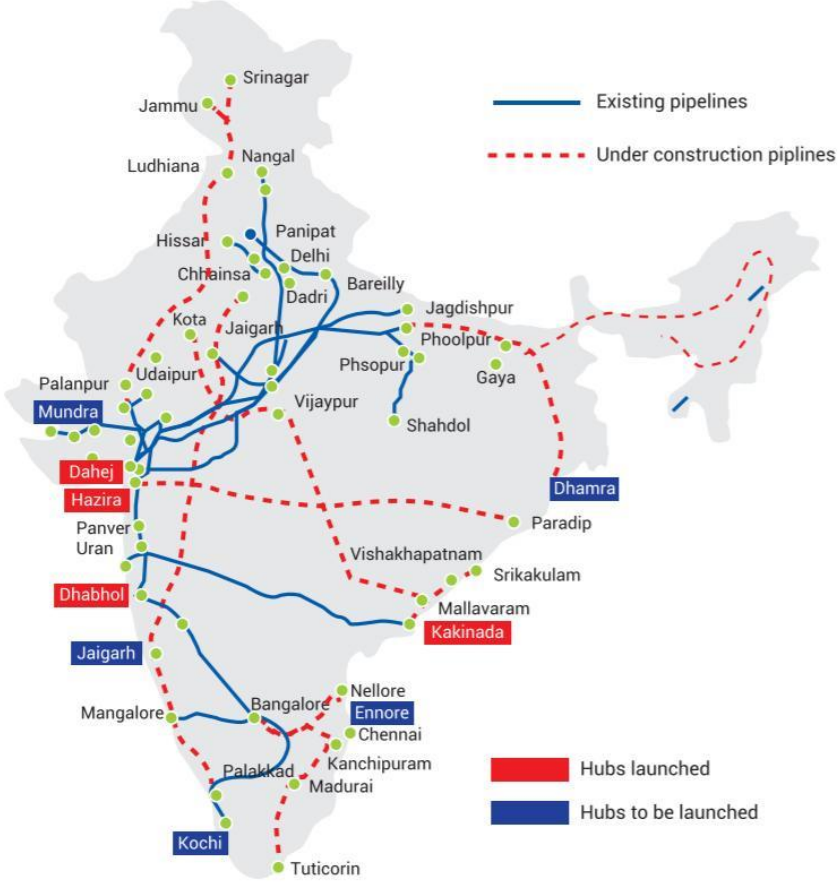
Like the rest of Asia, the bulk of India's LNG term import deals are oil-linked, resulting in an average import price of over $8/MMBtu in 2019 - about 50% higher as it could have been if linked to spot (such as JKM). Falling spot LNG prices amid bulging global supply have resulted in a pushback from Indian buyers, who are seeking to either re-negotiate those deals or diversify procurement to spot markets.

Gas exchange will play a key role in discovering gas prices in a transparent and competitive manner for a price sensitive market like India. The current global gas oversupply is likely to support hub as well as gas price index developments in Asian markets.

The exchange is initially expected to facilitate trading in LNG, while the price of domestic gas is notified by the government. Domestically produced gas should also be traded on hubs; it will be a huge boost for the E&P companies. It will also definitely help the small producers (e.g. Coal Bed Methane, Marginal Fields, etc.) and marginal buyers.

It is important to note that, at a time when the price of domestically produced natural gas is at $2.39 per mmBtu, which most E&P companies have cited as unviable, the newly established exchange has got a market-discovered price of $4.07 per mmBtu within the first two days of operation.

Initially, the exchange will offer spot and forward contracts at three physical hubs - Dahej, Hazira, and Kakinada. Spot contract for the day-ahead market means gas will be delivered the following day. Additionally, there will be forward contracts for daily, weekly, monthly, and fortnightly markets.



A Gas hub eventually is as important and influential in developing a transparent market as the volume of gas which gets traded on it. Hence all efforts should be now to bring wide ranging reforms both on demand and supply side and attract major investment and facilitate, fast track, ease development of gas processing, storage transmission infrastructure. Only then any serious volumes will appear on the trading screens.

On the **demand-side** complete and successful development of 200 + CGD projects, reforms and revitalization of Power and fertilizer sector are going to be the **key drivers.** On the **supply-side** major investment in gas transmission network, unbundling and allowing large scale monetization, increasing regasification infrastructure and capacity are some of the volume drivers.

A major supply side volume driver could be successful commissioning of a transnational pipeline if all stakeholders could manage the geopolitics and accompanying security threats.

In conclusion, establishment of a Gas exchange is a first step in the right direction. Let us not burden the exchange with high expectations. Creating a competitive well traded gas hub takes time and its success will depend concerted effort of all stakeholders. There is still a long way to go for it to become a benchmark. Celebrate it for what it is - a small yet significant and hard-won step in the right direction.

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GAS

COVID-19: Is LNG Industry Bracing for a Tougher Time?

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

The global LNG industry grew much larger and more flexible during 2019, but also faced challenges due to oversupply and low prices, driven by increasing gas production, commissioning of new export terminals and lower than expected demand from Asian markets. It entered 2020 with demand challenges, exacerbated by the impact of **"Double Whammy"** COVID-19 & Oil Crash, reducing gas demand and prices further. The bearish tone continued further as markets around the world started to announce lockdowns starting February 2020 to control the spread of the COVID-19 virus. These factors are accelerating the reshaping of the industry.

Throughout most of its history, LNG trade has been driven more by supply than demand. Producers output as much as they can and the market somehow balances, as any 'surplus' cargoes find a home in a market of last resort. However, this year is becoming the year when this assumption ceases to apply. The emergence of the pandemic and the oil price crash in early March 2020 has served to rapidly accelerate the trends that were witnessed throughout 2019 and to further propel the LNG industry into an over-supply and low-price environment.

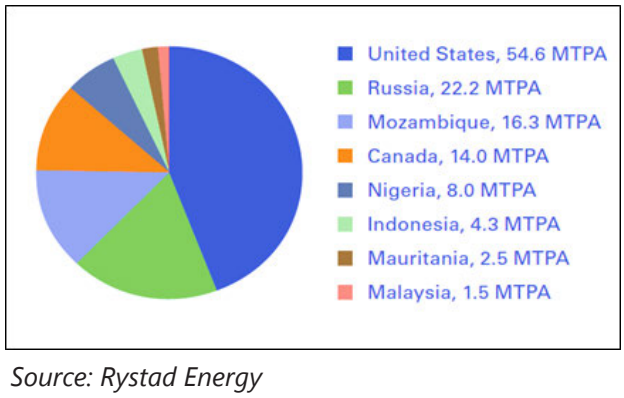
LNG Flashback 2019

The LNG industry in 2019 has made robust and impressive progress, although the developments were those before the Coronavirus outbreak and the collapse of oil prices. According to GIIGNL (International Group of LNG Importers); the Global LNG trade in 2019 reached 355 million tonnes, an increase of 40.93 million tonnes since the end of 2018. This constitutes an increase of 13%, its fourth consecutive year of double-digit growth.

The LNG shipping industry kept pace, adding 42 new vessels to a total of 541 active vessels by the end of 2019. The active fleet includes 34 FSRUs and 4 FSUs, demonstrating the continued interest in flexible solutions to enable markets to access modern energy and energy security worldwide.

The industry in 2019 saw record numbers of final investment decisions (FID) for gas liquefaction projects, mostly in the US, Russia, and Mozambique. By December 2019, 123.3 million tonnes/year (MTPA) of liquefaction capacity was under construction or sanctioned for development (Figure 1), with about 44% in the US, where the excessive supply of shale gas is doing to the LNG industry what shale oil has done to the oil industry – uncontrolled supply with optimistic forecasts of demand. However, given the ongoing pandemic and the changes this is bringing, this expectation is getting revised.

Figure 1: Global sanctioned liquefication capacity by country, 2019

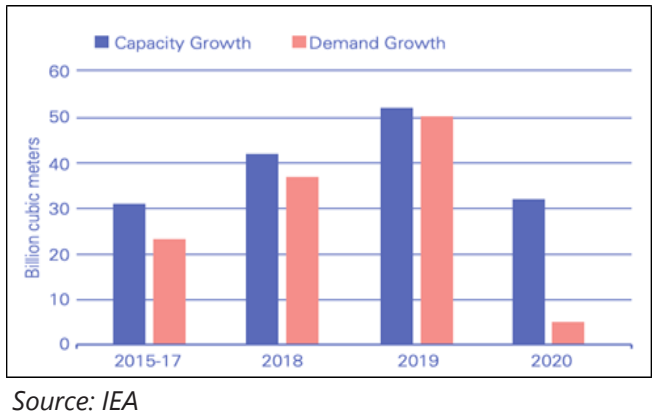


Source: Rystad Energy

According to IGU (International Gas Union); 24.3 MTPA out of the 123.3 MTPA capacity is expected to come online in 2020. These will increase the global liquefaction capacity to 455 MTPA by the end of 2020. This is well over demand, expected to remain around 2019 levels, about 355 MTPA. There are more than a dozen liquefaction plants scheduled for FID in 2020 and if buyers remain hesitant to sign long-term agreements, most of these may be deferred and some will be cancelled. With most majors announcing significant spending cuts this year and next, investment decisions will be delayed.

Currently, 907.4 MTPA of liquefaction capacity is in the pre-FID stage, with the majority of the proposed capacity coming from the US and Canada. Africa with 93.3 MTPA pre-FID, could emerge as a key LNG production region if those projects materialize. With the current weak global LNG demand and persistently weak global prices, many of these are not expected to progress. Hence, new LNG export projects, and developers, need to brace themselves for a continued glut as further production is added, outpacing global demand, contributing to the prolongation of depressed prices. Should all these projects, and some of those at the pre-FID stage, eventually materialize – even if construction is delayed by a year or two – it would extend the expected period of oversupply far into this decade and the problem of longer-term overcapacity and oversupply now looms very largely (Figure 2).

Figure 2: Annual capacity and demand growth for LNG, 2015 to 2020



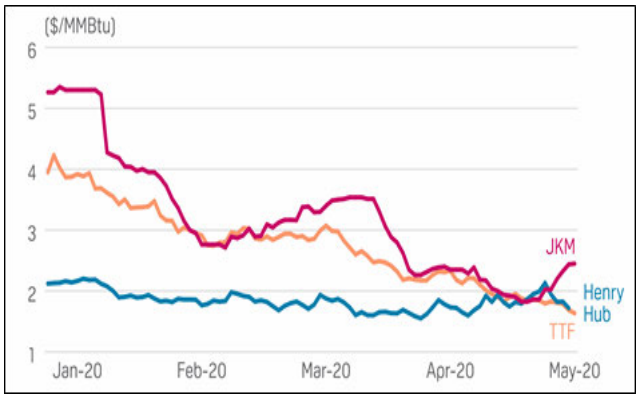
Source: IEA

On the demand side, switching from coal to natural gas was the largest single contributor to consumption growth in 2019, accounting for over 55 bcm of additional demand. Low spot prices drove fuel switching for power generation, while clean air policies remained the principal driver of fuel conversion in China.

LNG Prices

Global gas prices were at record lows in 2019 only to be beaten by even lower prices in 2020 (Figure 3). Natural gas prices were already low before the crisis due to increasing oversupply combined with a mild winter. With gas demand affected by lockdowns and gas storage almost full, oversupply was exacerbated and gas prices collapsed to levels not seen ever before. Prices in Europe and Asia have converged close to the Henry Hub price, below $2/mn Btu. The current market environment lowers the expectation of seeing a significant recovery in prices back to 2019 levels any time soon.

Figure 3: Global gas prices in 2020



Source: S & P Global Platts

Whilst the trend towards an over-supply and low-price environment is clearly favourable for LNG buyers, it creates significant hurdles for the wider LNG industry. Low prices threaten the economics of not just new projects, but also existing gas production, with some liquefaction plants having to shut-in production –especially in the US. With oil prices staying low, oil-indexed LNG prices will also stay low, and with new, and already sanctioned, liquefaction projects continuing to come into the market until 2027, the pressure on prices is expected to continue.

The Oxford Institute of Energy Studies projects that the LNG glut will last a decade, at prices that can compete with coal for power generation and oil in key petrochemical uses. The energy research firm Rystad energy lowered its natural gas price forecast for 2021 and 2022, based on the weaker demand seen globally throughout the year as a result of lower economic growth and ample LNG supplies. In medium to long-term China will import more via transnational gas pipelines which will create weak Asian demand and increasingly saturated European gas markets – and storages – mean that the LNG oversupply problem and low prices will persist for the time to come.

Challenges Ahead

Challenges that will influence or affect the LNG industry in the years ahead include:

- Russian pipeline gas versus LNG in Europe;
- The role of gas/LNG in a future "renewable electricity world";
- LNG demand in China –LNG demand growth on rising local gas production, Power of Siberia-2, the cross-border Russia- China gas pipeline, faltering economy, LNG price levels, regional demand dynamics
- Broader use of LNG portfolio approaches, relying more on short-term and spot markets to allow for arbitrage and hedging as energy prices change;
- Further commoditization
- LNG projects that are under development are facing significant delays due to COVID-19 induced issues

These all pose potential challenges, but also opportunities, to the future of gas and LNG markets, requiring solutions.

New Opportunities Emerging for LNG

Despite the current headwinds being faced by the LNG industry, there are good reasons to be optimistic about a considerably brighter medium and long term future. Perhaps the most important factor is that global population growth will continue to drive increased demand for energy. A global population of nearly 10 billion people is predicted by 2050, an increase of around 30% from today. Much of that growth is occurring in developing regions where demand for energy is also being driven by increased economic prosperity. That very large emerging middle class will continue to boost energy demand over the coming decades. Production of natural gas, and LNG, will almost certainly need to rise to meet some of that additional demand.

It is not just increased demand driven by population and prosperity growth that signals a likely resurgence and escalation of the LNG business. However, the acknowledgment of climate change and the need for "cleaner" sources of energy finally reached mainstream public consciousness in 2019, to such an extent that it has begun affecting the policies and behaviours of energy companies, shareholders, financiers, governments and other stakeholders. That trend is unlikely to change and could result in a boon for the LNG business. The LNG oversupply and low prices open up opportunities, especially if gas can beat coal in Asia, a switch that would be good for consumers and the climate. Although, there could have an impact on the further development of gas projects in the gas-rich areas, new opportunities for gas may now emerge in importing countries, given the current low price environment.

I. LNG as Fuel for Power

In the US, Natural gas continues to dominate the power generation mix, while coal-fired generation falls to new lows. This trend has been supported by low gas prices due to the shale gas boom and, more recently, a growing focus on cleaner energy. This combination of ample supply and low prices has made gas an increasingly popular option for power plants. The output of gas-fired power generation reached new highs, rising to a record share of about 38% of total generation. It increased by 8% or 123 TWh in 2019, against a sharp decline for coal (down 181 TWh).

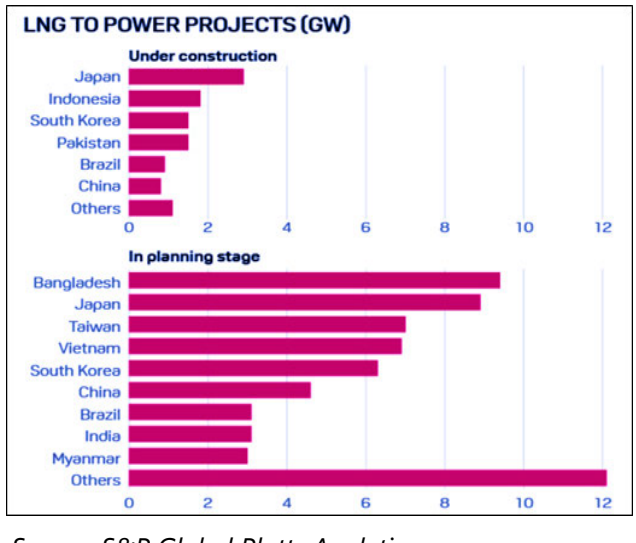
In Europe, Gas-fired power plants saw their output increase by about 11% or almost 70 TWh, against a sharp decline for coal (down 24%). Spain was the single largest contributor to higher gas burn with an annual increase of almost 50%, which accounted for about 40% of the growth in gas demand in the European Union. Assuming enough coal-to-gas switching capacity is still available to create demand for yet more LNG imports, European gas prices will need to be low enough for the rest of 2020 and into 2021 to outcompete coal.

The oil price environment and collapsing gas prices could be a game-changer for coal-to-gas switching in Asian markets. A sustained low oil price will make contracted LNG volumes sold on an oil-indexed basis considerably cheaper, dragging down the weighted average cost of gas (WACOG) in Japan and South Korea. In both Japan and South Korea, gas-fired power generation is generally underutilized. In China, the coal-to-gas conversion program (launched in 2017 to battle air pollution) helped to further increase the share of natural gas in the industrial and residential sectors in 2019.

In India, LNG at the prevailing rate is competitive or even cheaper at most of the polluted industrial clusters that use imported coal. This can drive coal replacement demand among industries. As the gas prices are competitive with coal prices, meaning that not only is there potential for additional coal-to-gas switching but also support for a large number of intermittent renewables being added.

A number of LNG-to-power projects are underway in Asia (Figure 4) with 9 GW in construction and about 52 GW in planning, on top of the 127 GW of LNG-fired power capacity currently operational in the region. We see a shift away from the three traditional large LNG importers – Japan, South Korea, and Taiwan – as newer LNG importing countries, including Bangladesh, China, and other South East Asian countries are building LNG to power capacities.

Figure 4: LNG to Power Projects (GW)



Source: S&P Global Platts Analytics

II. LNG as Fuel for Long- Haul Transportation

LNG is an attractive alternative to diesel for Heavy-Duty Vehicles (HDV). LNG as a transport fuel is costs competitive with diesel and also leads to lower emissions and a significant reduction of engine noise. As a result, LNG as a fuel for trucks, also known as Auto LNG, has been gaining traction in major markets.

China is the market leader and the USA along with Europe are following suit given the advantages of LNG over diesel. China's market has been growing at a high rate due to supportive government policy. Although LNG is a fossil fuel, it is the cleanest burning fossil fuel available today and could be a bridge to a future dominated by renewable energy sources. The technology is mature, fuel sourcing is not an issue and environmental advantages imply that LNG will be the fuel for future generations.

III. LNG as Fuel for Propulsion

The IMO's new regulations have come into effect from January 1, 2020, wherein the ocean-going vessels have to cut the sulfur content in fuels to 0.5% from the previous limit of 3.5% established in 2012. As shipping companies prepare to bring their fleets into compliance with IMO 2020, LNG is poised to capture a growing portion of the international bunker fuel market across the globe. According to Sea-LNG, an international industry coalition promoting the use of LNG as a marine fuel; the adoption of LNG as a bunkering fuel is expanding across the globe, with new bunkering infrastructure being built in Europe, Asia, and North America.

As per Oxford energy institute, the broad consensus is of LNG demand level between 20 and 30 mtpa (28 and 40 bcm) per annum by 2030 which will primarily be driven by new builds and LNG-fuelled vessels under construction while retrofitting for LNG is an unlikely option in the majority of cases.

Conclusion

Although the LNG market in the short to medium-term will continue to pose profitability challenges owing to COVID-19 pandemic and low LNG prices, the future is bright for LNG and it remains an attractive, reliable and viable clean energy market, provided it remains cheap, and the industry takes the opportunity to restructure and reshape itself. Further, to realise this potential, the LNG business may need to adapt and evolve to face the challenges of current and future circumstances, such as the impact of COVID-19. Significant, but not seismic, operational and contractual adaptations will have to be made within the LNG market to ensure its enduring growth.

As the world has entered an unprecedented era of low LNG prices, which might be the new normal going forward and could be the opportune moment for the environment, as there is a stronger economic case for switching from more polluting fuels to natural gas. If we could switch all coal to gas tomorrow, we would be half way to achieving enough cuts in emissions to keep temperatures within 2°C. Hence, going forward, Gas/LNG will continue to play a vital role towards an economically and environmentally sustainable energy future.

GAS

LNG - Transition to Transport Fuel

Sanjay Kaul, FEI
Founder Univ of Petroleum Energy UPES, Univ of Tech & Mgmt, ISPe, IESD,
Sanmarg, BGCL, PwC O&G, Deloitte Energy Resources

Any entity now being allowed to open an LNG Station in any GA is a recent policy call to recognize, encourage, dialogue/ debate and initiate commercial activity to establish LNG as a Transportation fuel.

For promotion of LNG as transport fuel, all stakeholders (transport fleet operators, regulators, suppliers, vehicle manufacturers, OEMs, CGD operators and financial institutions) need to be activated.

Just as a perspective, China despite exercising centralized State control push have taken a decade to have an impressive half a million vehicles on the road.

Few private players are now planning to develop "LNG Corridors" for the supply of LNG as fuel to diesel fired long-distance heavy vehicles/ freight carriages and passenger buses.

If this situation has to leapfrog to let's say a target to consume 5-7 MT of LNG, then we are talking of at least ensuring that all 2,50,000 new trucks getting added every year are LNG fuelled. If we add the 80,000-85,000 new buses that are added every year, we will need another 2 MT. So, 9 MT of new LNG business can be taken as the first phase target which roughly translates to the capacity of an average LNG Terminal.

Who is this opportunity for and whether they would see this as an opportunity?

- Companies with existing retail outlet on main trunk routes/ highways can experiment with setting up LNG infrastructure and then help create the demand and ecosystem for LNG.
- Existing CGD players setting up CNG stations can convert the ones on the highways to LNG as well and can use the LNG storage facility as a 'virtual pipeline' for their network.
- LNG Importers can see this as a forward integration of entering Petro-retail by having their own dealers and distributor network.
- OEMs to Vehicle manufacturers will face import vs domestic R&D, design challenges and much stiffer safety norms compliance. They would require seeing a future demand volumes which makes setting up dedicated production lines viable.

However on the demand side i.e. fleet operators of trucks and buses, the long term savings on fuel cost and increase in range is currently not commensurate with the upfront capital investment required (new vehicles or conversions) and restriction of their vehicles to few set routes as per availability of fuel. This segment would need hardcore incentives for them to make a viable case to raise funds for making a significant shift.

The notification of LNG as automotive fuel via an amendment to the Central Motor Vehicles Rules (1989) in 2017, was the first giant step forward to revolutionise the use of LNG in the transport sector in India.

On a per-kilometre basis, taking into account engine efficiency and other factors, there is a minimum savings of 20% for LNG-fuelled transportation vehicles. The benefit can go up to 30%.

The advantage is, way lesser retail outlets for LNG are required, as the mileage is far better. One fill of LNG can take a loaded LNG truck to around 900 km, while a diesel truck needs a station every 400-500 km.

Today, we have around 70,000 petroleum retail outlets and been already planning to double that. Even if we have 1,000 LNG filling stations, they can cater to around 1.5 lakh trucks across the country.

EVs for local and LNG & CNG for long distance and heavy vehicles is the best environmental scenario for India which requires a heavy and consistent push of policy measures, continuous technology innovation and tangible incentives.

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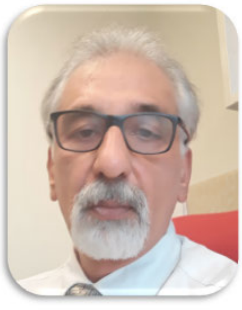
FINANCE

Tax and Regulatory Relief Measures to Boost Economy Amidst the Outbreak of Covid-19



Sanjay Grover
Partner

Hiten Sutar
Director

Palak Agrawal
Senior Consultant

Ernst & Young LLP

The COVID-19 pandemic has caused deep impact on the Indian economy and almost all businesses are facing uncertainty about their future. Revenue streams of the Government of India ('GOI') have also been impacted with dip in direct and indirect tax collections with simultaneous increase in expenditure to support the economy.

To sustain in such unprecedented times and to build self-reliant (Aatmanirbhar) India, the GOI has announced economic and fiscal package of INR 20,000 Bn i.e., 10% of India's GDP, with focus on land, labour, liquidity and law. These involves various reforms to boost economy with the major focus on the Micro Small and Medium Enterprises (MSME) sector. MSMEs provide largest share of employment after agriculture and hence, it was of utmost importance to protect MSMEs against economic impact of COVID-19.

To increase the coverage of companies under the fiscal stimulus measures, the definition of MSMEs has been widened to include higher investment limit and additional criteria of turnover. The GOI has removed the distinction between Manufacturing and Service MSMEs[1]. The revised criteria of MSMEs based on investment and turnover are summarised as under:

Criteria	Micro	Small	Medium
Investment	< Rs. 10 million	< Rs. 100 million	< Rs. 500 million
Annual Turnover*	< Rs. 50 million	< Rs. 500 million	< Rs. 2.5 billion

** Exports will not form part of annual turnover*

Key benefits available to MSMEs from Governments are:

Central Government –

i. Priority sector status for borrowings from Scheduled Banks

ii. Interest relief @ 2% for incremental borrowings

iii. Statutory timeline of 45 days for payments by buyers

iv. Mandate of minimum procurement by Central Government and Public Sector Undertakings (PSUs) for Micro and Small Enterprises ('MSE')

v. Benefits in tenders for MSEs with respect to no fees for procurement of tender and price adjustments to the extent of 15% to match the lowest bidder

State Governments –

i. Subsidy on capital investment
ii. Subsidy on interest payment
iii. Support of seed capital
iv. Reimbursement of GST/ stamp duties/ electricity cost/cost incurred on employers contribution of ESI and PF for generating employment, etc.

Among others, one of the other major announcements was to prohibit global tenders for government contracts up to INR 2000 Mn to help push local MSMEs[2]. While on one hand this amendment shall boost local MSMEs, on the other hand will entail foreign entities not being eligible to bid for government contracts of value upto INR 2,000 Mn. This shall impact many oil and gas foreign service providers affecting their ability to bid for projects from outside India.

The outbreak of COVID-19 has also resulted into myriad challenges for the taxpayers in the country. With a view to avoid undue hardship faced by the taxpayers, the current environment has led the government to announce relief measures by way of, expeditious release of refunds, deferment of dates for certain compliances, reduction in withholding tax rates for residents, etc.

Immediate grant of tax refunds

With the deepening of COVID-19 pandemic, businesses are going through liquidity and financial shock. In order to tackle financial stress, especially for small taxpayers and facilitate trade, GOI has taken measures to expeditiously process and dispose all the pending income-tax refunds to non-corporate tax-payers and GST and customs refund claims.

The GOI has released income-tax refund of INR 262,420 Mn dues to about 1.68 Mn taxpayers after the government decided to expeditiously issue tax refunds to cash-strapped individuals and businessmen because of the nation-wide lockdown due to COVID-19 pandemic[3].

Reduced withholding tax rates

There has also been reduction of 25% in usual withholding tax rates and Tax Collection at Source for the specified payments to residents from 14 May to 31 March 2021[2]. This will result in reduced cash blockages of tax for businesses who do not estimate sufficient profits in current financial year.

Donation and CSR for PM Cares Fund

Donation to the 'Prime Minister's Citizen Assistance and Relief in Emergency Situations Fund' (PM CARES Fund)' shall be allowed as deduction for income tax purpose and shall also be considered as eligible expenditure for Corporate Social Responsibility ('CSR') obligation by corporates[4]. Where donation to PM CARES Fund is made by employees through their employers, claim for deduction of such donations for income-tax will be available on the basis of withholding tax certificate issued by employer.

Further, GOI has decided to reward employers for payment of ex-gratia to employees to fight the Covid-19 crisis by considering the same as CSR expenditure[5].

Social security contribution

To provide further liquidity, provident fund contribution for both employer and employee is reduced to 10% from existing 12% upto July 2020[2]. This covers all class of establishments (non-government) covered under the Provident Fund ('PF') Act.

Under the Pradhan Mantri Garib Kalyan Yojana (PMGKY), the Central Government would pay 24% of the monthly wages into PF accounts for 3 months (now extended upto August 2020)[2]. This facility will cover employees with wages below INR 15,000 per month, employed in establishments having up to 100 employees, with 90% or more of such employees earning monthly wages less than INR 15,000.

In addition, employees are also allowed to withdraw provident fund investments upto 3 months wages (basic and dearness allowance) or 75% of provident fund, whichever is lower[6]. This withdrawal will not be taxable in the hands of the members. The PF authorities are working towards speedy disposal of such claims by members.

It has also been clarified that the ESI beneficiaries may avail emergency / non-emergency medical treatment through other hospitals with which ESI Corporation has a tie-up.

Partial withdrawal will be permitted from National Pension Scheme to meet treatment expenditure of COVID-19 illness of member, his/ her spouse, children including adopted child or dependent parents.

Liberalisation of interest/ penal consequences

Penal provisions on delayed payment of taxes on both direct tax and indirect tax front have been liberalized.

On direct tax front, reduced rate of interest of 9% shall be charged for non-payment of Income-tax (e.g. advance tax, TDS, TCS), Equalization Levy, Securities Transaction Tax, Commodities Transaction Tax which are due for payment from 20 March 2020 to 29 June 2020 and paid by 30 June 2020. Further, no penalty/ prosecution shall be initiated for these non-payments[7].

On indirect tax front, taxpayers with a turnover of up to INR 50 Million are eligible for a waiver of late fees, interest and penalty on delayed payment of tax and filing of returns upto 30 June 2020. Interest rate on late payments, beyond the extended due dates has been reduced to @ 9% per annum (as against 18%) for taxpayers with a turnover of above INR 50 Mn upto 30 June 2020[8]. For taxpayers with turnover of up to INR 50 Million, the aforesaid relaxations are further extended up to 30 September 2020[9].

Measures for promoting international trade

Measures for exporters

- Currently, export proceeds of goods and services exported are required to be realized and repatriated to the country within 9 months from the date of exports. As one of the measures for dealing with disruptions caused by COVID-19 pandemic, the RBI has extended the time period for realization and repatriation of export proceeds from 9 months to 15 months (from date of export) for exports made up to or on 31 July 2020[10]. This shall enable the exporters to realise their receipts, especially from COVID-19 affected countries, within the extended period and also provide greater flexibility to negotiate future export contracts with buyers abroad.
- Validity of export duty credit scrips has been extended till 30 September 2020. The extension is likely to benefit exporters who could not file the application or utilize the scrips due to COVID-19 pandemic.
- The Government is allowing 24X7 clearance at all customs stations till 30 June 2020 to address any congestion, delay or surge on account of the prevailing conditions under COVID 19.

Measures for International workers

- Due to lockdown and suspension of international flights, many individuals who had come to India on a visit and had scheduled plans of returning overseas before the end of the tax year 2019-20, are stranded in India. This forced stay in India would impact the residential status of these individuals and thereby taxability in India. In order to avoid genuine hardship, the Government has announced relaxation wherein presence in India during the said period, will be disregarded for evaluating tax residential status for tax year 2019-20. A similar clarity is expected for tax year 2020-21[11].
- On similar lines, there is an increasing clamour from the industry for a clarification in connection with relaxation for foreign companies constituting unintended permanent establishment in India due to forced extended stay of employees.

Extension of statutory deadlines for various compliances

To ease the procedural framework, statutory deadlines for various compliances has been extended; delayed filing of income-tax returns for FY 2019-20 to 30 November 2020 and new GST returns system and e-invoicing to 30 September 2020[2]. The extension of due dates shall provide respite to industries/ tax consultants who have been facing challenges while working from home and struggling to meet the compliance deadlines.

Further, period to opt for Vivad se Vishwas Scheme (i.e. Amnesty Scheme for pending litigation under Income-tax Act) by making payment of disputed tax without levy of interest/ penalty is extended to 31 December 2020[2]. Similarly, Sabka Vishwas (Legacy Dispute Resolution) Scheme was introduced to clear the backlog of huge pending litigations from pre-GST regime. The due date for making payment under this scheme is extended to 30 June 2020. This was pertinent to accomplish success of the scheme as many taxpayers would have found it difficult to pay settlement amounts under the tax amnesty in such trying times.

The time limit for issue of notice, notification, filing of appeals, declarations, time limit for completion of tax scrutiny by the authority and for investments for roll over benefit of capital gain has also been extended[4]. The field offic ers are also directed not to initiate any adverse action / communication against the taxpayer till further directions.

Temporary suspension of provision restricting the claim of input tax credit for unreported transactions

Currently, the taxpayer is allowed to avail Input Tax Credit (ITC) based on invoices reported by the vendors in their returns wherein the ITC on unmatched invoices is restricted to 10% of matched invoices. Unmatched invoices are those invoices which have not been disclosed/uploaded by the supplier in their respective GST return. This restriction has been relaxed for the tax period February 2020 to August 2020. However, taxpayer would be required to make a cumulative adjustment for the aforementioned months in the GST return for the month of September 2020.

Other measures

Postponing effective dates for tax withholding on ecommerce operators and widening of tax collection at source on sale of goods and services provisions to 1 October 2020 is a welcome move and shall provide sufficient time to industry to incorporate appropriate changes in their systems to comply with this new provision. The government has brought a big relief for businesses by clarifying that widened scope of tax collection on sale of goods shall not be applicable to exports and imports of goods from/ to India. However, industry is still expecting further relaxations for excluding certain essential goods (like lubricants used for agriculture) from the scope of tax collection at source.

The Ministry of Corporate Affairs has also introduced an amnesty scheme for the non-compliant companies. This will be good opportunity for companies to get the pending compliances up to speed without the burden of additional fees or penalties.

With a view to curb opportunistic takeovers / acquisitions of Indian companies by foreign investors in light of the COVID-19 pandemic, the Department for Promotion of Industry and Internal Trade has announced that the following investments will require prior approval of the Government

- investment by entities based in countries which share land border with India or
- where the beneficial owner of the investment in India is situated in or is a citizen of such country[12].

Also, FDI limit in defence manufacturing under automatic route would be raised from 49% to 74%.

Industry expectations

Considering India's current focus is to foster growth of indigenous goods and services, industry is expecting that additional incentives are granted to promote indigenous manufacturing capabilities. To attain normalcy in business activity post lockdown era, lowering import duties on certain products such as components that are essential for exports from India may help in improving the competitiveness of exports from India. Similarly, the Government may also consider announcing some tax deductions/ allowances for taxpayers who are setting-up and operating or contributing funds for such quarantine centres.

The above reliefs may provide the much-needed liquidity to taxpayers in current difficult times and also facilitate tax compliances. However, given the severity of the financial hit, more measures may be required to shore up the confidence of the industry.

1 https://pib.gov.in/PressReleseDetailm.aspx?PRID=1628925
2 https://pib.gov.in/PressReleseDetailm.aspx?PRID=1623601
3 https://www.incometaxindia.gov.in/Lists/Press%20Releases/Attachments/835/PressRelease_Refunds_amounting_26242cr_issued_22_5_20.pdf
4 http://www.mca.gov.in/Ministry/pdf/Circular_29032020.pdf
5 http://www.mca.gov.in/Ministry/pdf/Notification_10042020.pdf
6 https://pib.gov.in/PressReleseDetail.aspx?PRID=1608961
7 https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1609734
8 Notification Nos. 30-36/2020-CT and Circular No. 136/06/2020-GST all dated 3 April 2020
9 Recommendations of the 40th GST Council meeting held on 12 June 2020
10 https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=49619
11 https://pib.gov.in/PressReleasePage.aspx?PRID=1622386
12 https://dipp.gov.in/sites/default/files/pn3_2020.pdf

COMMERCE

Impact of COVID-19 on Crude Prices and Product Demand

Siddharth Banerji
Senior Assistant Director (Policy & Planning)

Federation of Indian Petroleum Industry (FIPI)

Over the long history of oil, the market has endured multiple shocks, but none comes closer in ferocity and severity to what it faced in April this year. The market has been hit by a double whammy of falling prices and shrinking demand. Early in the month of March, crude oil prices nose-dived due to a fallout between Russia and OPEC over production cuts. In any otherwise situation, falling oil prices would have spurred a rise in demand and the market would have stabilised. However, March 2020 was different. The increasing number of COVID-19 cases and the mounting death toll led to sweeping lockdowns and travel bans across all major demand centres, resulting in a shrinkage of demand. As a result, on 21 April, due to the widespread containment measures taken by 187 countries and territories, for the first time in the almost 150 years long history of the oil industry, US WTI prices entered the negative territory.

So....What really went wrong on 20th April?

It is not common for any commodity, let alone oil, to trade in the negative prices. Here it will not be wrong to point out that the oil prices, too, fall prey to the pandemic. The global lockdown prompted by the pandemic shuttered factories and stopped movement of people and goods, leading to an overall contraction of economy. Consequently 29 Million barrels per day (Mbpd) of oil demand was wiped off from nearly 100 Mbpd a year ago. Taking account of the grim outlook for oil consumption, OPEC, Russia and other oil producing nations, on 12 April, agreed to cut output by ten per cent, amounting to 9.7 Mbpd. However, in face of the unprecedented demand contraction, the production cut proved too little too late. This resulted in an over-supply situation for the oil market.

On 21 April, as the WTI May-dated future contracts were due to expire, buyers of WTI future contracts were essentially left with two choices. They either had to take delivery of the contracted volume from Cushing, Oklahoma or close the contracts by selling it at whatever price possible in order to avoid taking physical delivery of the crude. In this case, due to the massive over-supply in the market, sellers offered money to buyers to purchase crude oil. A large number of sellers and fewer buyers in the market on the day, drove prices down to negative USD 37/bbl.

During this period, the Brent crude oil prices, the international benchmark, also dropped briefly to a 21 years low of USD 15.98/bbl.

The Recovery

By mid-June, the global crude oil prices had recovered and surpassed USD 40/bbl. The recovery was fuelled chiefly by an easing global supply glut, and nations beginning to relax lockdown restrictions that have crippled oil-intensive sectors like transport and manufacturing. The crude oil prices were further stabilized as the oil ministers of OPEC and other major oil producing countries led by Russia met on 6 June and decided to continue the 9.7 Mbpd production cut through July.

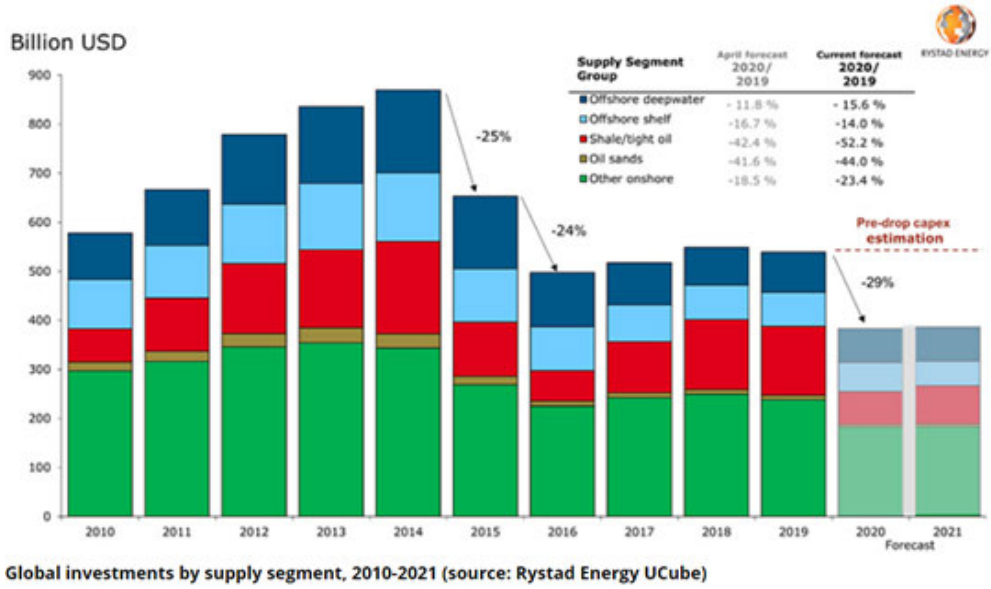
One risk is that reviving the world economy after the worst of the pandemic passes will prove more difficult than investors are now anticipating.

While production cuts and voluntary shut downs have helped bringing the supply and demand closer, there is still enough oil in tank farms and on ships that could flood the market. Additionally, speculations are ripe among the traders that the demand will remain low in the coming few months as economist around the world have predicted for a COVID inflicted economic downturn.

Impact of Low Oil Prices and COVID on Future Investment

According to Rystad Energy, Global oil and gas investments are set to fall to USD 383 Billion in 2020, registering a fall of 29 per cent compared to USD 539 Billion in 2019. The report expects investments to only marginally recover to USD 386 billion in 2021. Investment in shale and tight oil are expected to see the biggest hit due to the COVID induced recession and are expected to witness over 52 per cent shrinkage in investment. Rystad Energy forecasts that the offshore investments will prove to be the most resilient during these testing times and will only lose 14 per cent in investment.

Segment wise Upstream Investment 2010-21

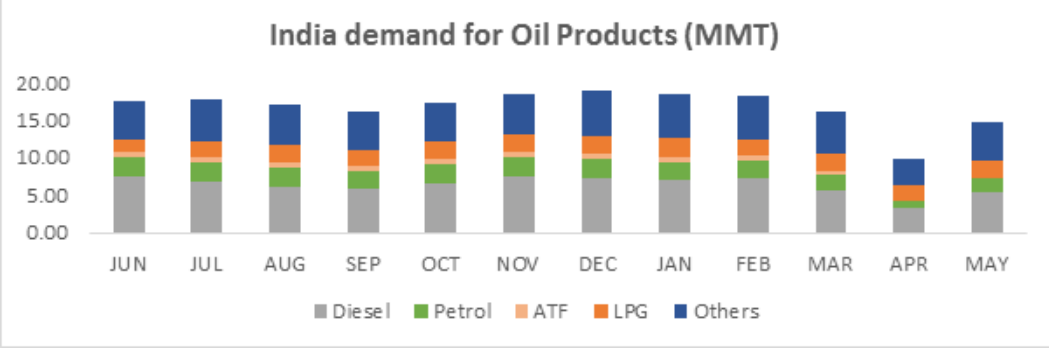


Global investments by supply segment, 2010-2021 (source: Rystad Energy UCube)

The report further mentions that as of mid-June, over 125 E&P companies had already spending cuts worth USD 100 Billion in 2020. National Oil Companies (NOCs), which are not expected to cut investments drastically, have also been forced to cut spending by USD 32 Billion to deal with these uncertain times.

But....Aren't Low Oil Prices a Boon for India

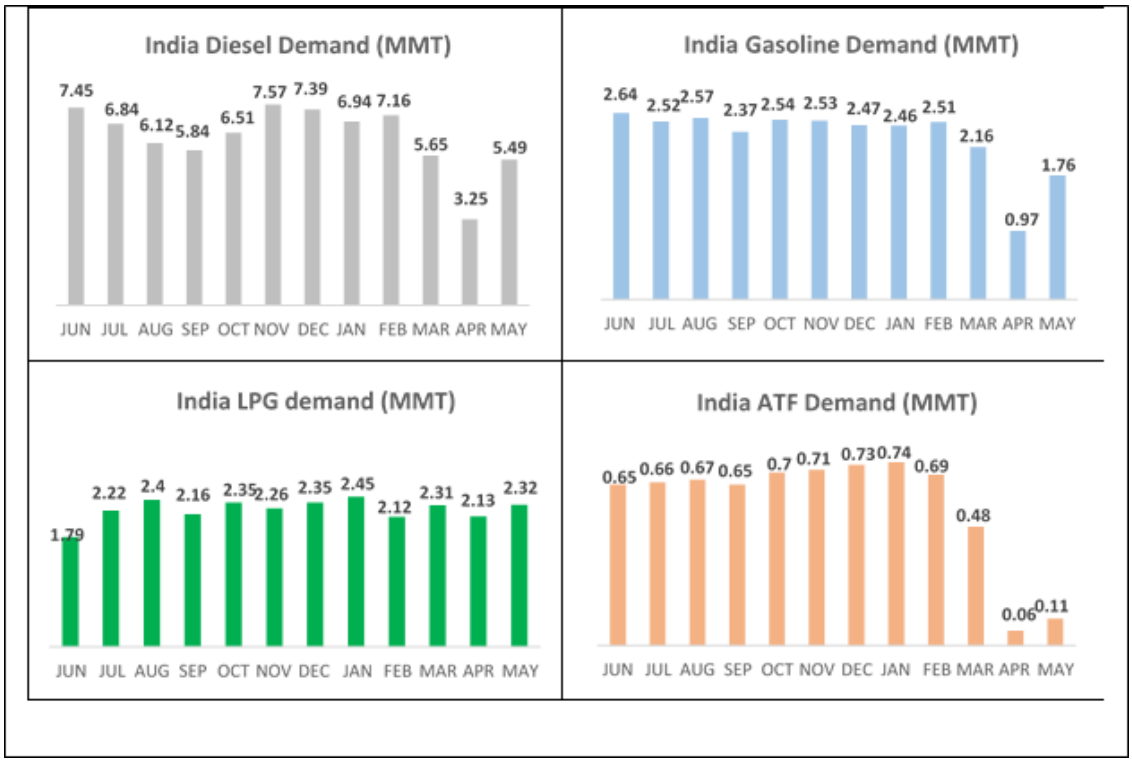
Under usual circumstances, low oil prices are a blessing for oil importing countries like India. In an otherwise situation, low oil prices would have led to huge savings in foreign exchange and the country would have filled its storage facilities with the cheap oil. However, as the oil prices rock bottomed in April 2020, most countries, including India, was under strict lockdown. During the initial phase of lockdown, industrial activities in the country was restricted to essentials, road transport dropped by as much as 90 per cent while all commercial aviation fleet were grounded as a precautionary measure. As a result, oil products demand in the country was reduced to 9.9 MMT, recording a fall of around 46 per cent.



Source: PPAC

Unprecedented Drop in Fuel Demand

The ongoing measures to control the spread of COVID'19 in India have severely dented the country's fuel consumption. Due to concerns over coronavirus spread, social distancing and the announcement of lockdown that came into effect from 24 March, the consumption of petroleum products witnessed a sharp fall of 18 per cent in the month of March. The demand further dropped by 46 per cent in April. The demand situation only improved in May but still remained far from Pre-COVID levels



Source: PPAC

Diesel: Diesel finds extensive usage in transport and industrial sectors, constituting 40 per cent of India's total oil demand. Due to the lockdown, diesel consumption in India dropped to 3.25 MMT in April compared to 7.23 MMT a year ago, recording a record fall of 55.6 per cent. Riding on the lockdown relaxations provided in May, Demand for diesel increased to 5.49 MMT, still staying almost 30 per cent lower than the previous year

Gasoline: Gasoline consumption in India, after witnessing 30 straight months of growth, fall by 16.27 per cent in March due to the nationwide lockdown. It further dropped to 0.97 MMT in April, recording a contraction of 65 per cent. In May, however, the demand situation has improved to 1.76 MMT, which is over 35 per cent lower than the consumption in last year.

ATF: All commercial airlines fleet were grounded since 22 March and the services only resumed on 25 May. The Centre for Asia Pacific Aviation (CAPA) estimates that the Indian aviation industry may have to bear losses of up to USD 3.6 billion in the April-September period. Demand for ATF plummeted by as much as 90 per cent (0.58 MMT) in the month of April. During the period of lockdown, ATF was consumed only for the defense needs. The Government resumed commercial airline services from 25 May. As a result, ATF consumption increased to 0.11 MMT in May, still staying almost 84 per cent lower on a YoY basis

LPG: LPG has emerged as the only fuel that has witnessed an increase in consumption since the lockdown. Even before the declaration of lockdown, there was an increase in consumption due to panic booking. The Government announcement to provide three free LPG cylinders under the PMUY scheme further increased consumption. As a result, against an annual growth of 6.6 per cent in FY'20, LPG consumption grew by over 12 per cent in the month of April, 2020 alone. The consumption of domestic LPG, in April, increased by over 25 per cent. In May, LPG consumption increased to 2.32 MMT, recording a YoY growth of over 13 per cent.

Drying Liquidity for Indian OMCs

Due to the unanticipated fall in demand, the Oil Marketing Companies (OMCs) in India are faced with a difficult liquidity situation. Since the declaration of lockdown on 23 March, the demand for petroleum products has dropped by as much as 60 per cent. While the retail demand had virtually disappeared, OMCs continued to pay for imported crude shipments and other variable costs. This has resulted in a severe cash flow situation for the retailers. Government support will be imperative for Indian OMCs to tide over the present crisis. Meanwhile, the OMCs are adopting serious cost cutting measures and working closely with their retail franchisees to alleviate the situation.

BUSINESS

The Journey to Sustained Profitability: How to Benchmark the Efficiency of Your Investment
Invest Strategically | Grow Profitably

Keith Couch,
Senior Director,
Technology Sales and
Integrated Projects

Matthew Griffiths
Manager of
Strategic Projects

Joseph Ritchie
Senior Chemical
Engineering Manager

Pankaj Srivastava
Lead Solution
Development Manager

Honeywell UOP

A New Methodology: Honeywell UOP's E6 Framework

The refining industry is critical to the world economy, providing energy and materials required for global development. The Covid-19 pandemic has reduced demand for fuels and other products, disrupted pricing, lowered capacity utilization, and delays in some early-stage projects. At the same time, refiners are under pressure from shareholders, boards, institutional investors and their own management to chart a path for sustained growth and prosperity.

Refinery and petrochemical investments are capital intensive and require careful long-term planning. They must deliver a strong return on investment and advance socially and environmentally responsible investment goals.

To develop the most efficient and bankable projects, UOP has identified six critical performance factors to evaluate an investment in a standalone refinery, or one integrated with petrochemicals. The UOP Six Efficiencies (E6) framework considers carbon, hydrogen, utilities, emissions, water as a scarce resource, and capital.

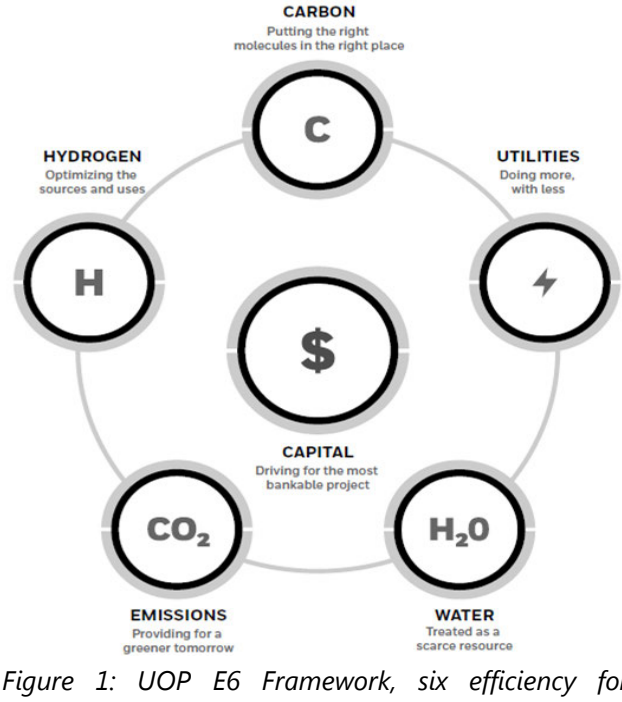


Figure 1: UOP E6 Framework, six efficiency for investment measurement

The E6 framework measures how an investment compares to best-in-class benchmarks. It differs from other industry metrics by measuring an investment against the latest technologies currently available. These benchmarks change annually due to technology innovation, continuously classifying competitiveness against emerging technologies and identifying new opportunities. The UOP E6 model is a planning tool that provides insight into an investment's profitability, social and environmental impact, and timing.

Quantifying the Six Critical Efficiencies

The UOP E6 model may include a grassroots or brownfield, downstream complex, producing fuels or petrochemicals, and is valid for a range of available crudes. This paper introduces a methodology for a whole complex, or just individual process technologies, but not the full life cycle analysis (LCA) of the net products.

The benchmark for each of the six categories is based on fully optimized configurations for the latest technologies available today.[1] Each category is measured by comparison to a benchmark configuration with similar objectives, crude quality and product slate.

The E6 methodology identifies strategies to improve the design and the performance of new and existing complexes – "futureproofing" with best-in-class configuration and infrastructure.

Carbon Efficiency

The objective for any complex is to maximize the transformation of carbon into high-value products, directing the right molecules to the right processes, and minimize the work to convert to high-value products.

The effectiveness of the conversion of carbon is determined by the carbon metric for the configuration.[2, 11, 12 & 14] The reference line in Figure 2 represents benchmark carbon metric performance across the continuum from fuels to maximum petrochemicals, for an Arabian Light crude. Note that the benchmark line never fully achieves 100% petrochemicals. Crude barrels to the complex – not net products – is the basis for the measurement,[14] accounting for losses such as petroleum coke, fuel gas, sulfur and other lesser contributors

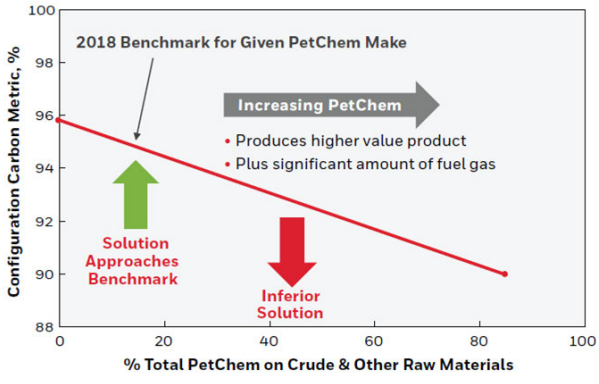


Figure 2: 2018 Carbon Metric Benchmark (Hydrocracking technologies without carbon rejection via FCC or Coker) vs. % Total Petrochemicals on Feed-Arabian Light Crude[14 & 18]

Comparing the carbon metric for the configuration against the benchmark configuration produces a measurement of carbon efficiency, defined by Equation 1.[6]

Equation 1: Carbon Efficiency, % = 100 * Configuration Carbon Metric / Benchmark Configuration Carbon Metric

A carbon metric below the line signals sub-optimized performance with an efficiency less than 100%. This may show the need to re-optimize the configuration, or review business objectives as they relate to carbon.

Factors influencing the carbon metric include quantity of petrochemicals produced, crude slate and complexity of the configuration. An optimized configuration restricts carbon rejection technologies and applies more selective technologies, improving molecule management, and carbon, hydrogen and capital efficiency.

Hydrogen Efficiency

Hydrogen efficiency is highest when hydrogen is used as sparingly as possible to transform molecules into a desired product. Hydrogen is produced from crude as a by-product of catalytic reforming, steam cracking and propane dehydrogenation. The major consumers of hydrogen are hydrotreating and hydrocracking units. Hydrogen efficiency is improved by reducing the need for external hydrogen, while poor hydrogen management results in waste.

Hydrogen efficiency is calculated directly, rather than by comparison to a benchmark,[11, 13 & 14] using Equation 2.[7]

Equation 2: Hydrogen Efficiency, % = 100 * Hydrogen in Saleable Products / (Hydrogen in the Feed + Hydrogen from Hydrogen Plant)

The line in Figure 3 is an example of hydrogen consumption across the continuum from fuels to maximum petrochemicals for an Arabian Light crude.

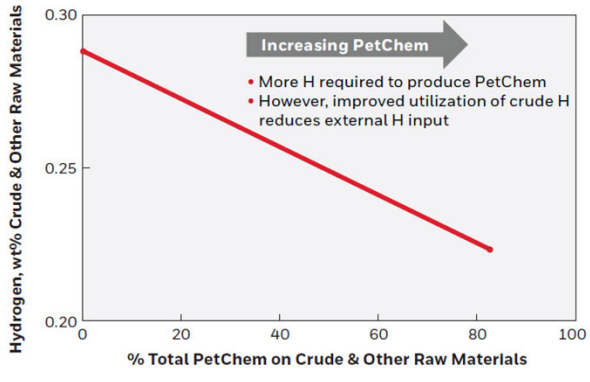


Figure 3: Hydrogen Consumption vs. % Total Petrochemicals on Feed -Arabian Light Crude[14 & 18]

A lot of hydrogen is required to produce petrochemicals. Efficient recovery of hydrogen from dehydrogenation reactions reduces hydrogen plant size. For example, sending propane to a dehydrogenation unit produces more olefins and less fuel gas than a steam cracker. If co-production of aromatics is desired, hydrogen must be removed. Therefore, an optimal solution will balance hydrogen addition and removal to produce the ideal combination of olefins and aromatics while minimizing hydrogenation and dehydrogenation cycles. Ultimately, hydrogen efficiency is a factor of crude quality, the heavy oil upgrading strategy, and level of petrochemical production. Hydrogen addition lowers this efficiency, while carbon rejection improves it.

Utilities Efficiency

The goal is to use as little energy as possible for feedstock conversion. Utilities efficiency determines the energy demand impact of fuel selection, utility system design, crude quality, complexity of the facility and level of petrochemical production. Total energy use is the sum of all utilities.

Process energy consumption typically represents 30 to 40% of the operating cost of a best-in-class complex design. In the E6 framework, utilities are measured in terms their equivalent consumption of methane, so the objective is to reduce this consumption to lower resource use and operating cost.

The amount of energy consumed represented by the utilities metric.[3, 11, 14 & 15]. The reference line in Figure 4 shows benchmark performance across the spectrum from fuels to maximum petrochemicals for an Arabian Light crude using a higher efficiency combined cycle gas turbine power plant. All the power requirements are provided by a natural gas-fueled turbine generator.

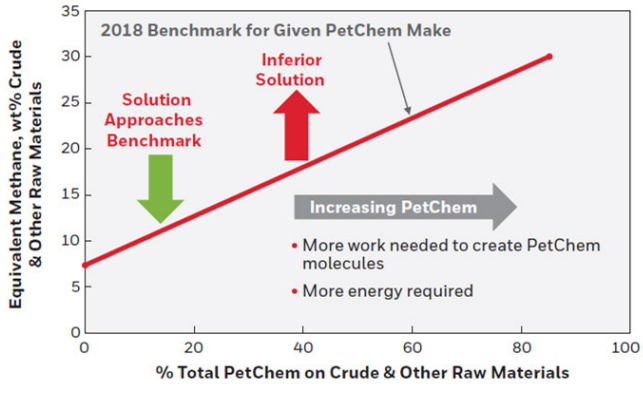


Figure 4: 2018 Utilities Metric Benchmark (natural gas fired combined cycle gas turbine power plant) vs. % Total Petrochemicals on Feed for Arabian Light Crude[14 & 18]

Utilities efficiency measures how effectively the configuration uses energy by comparing against benchmark performance, calculated using Equation 3. [8 & 17].

Equation 3: Utilities Efficiency, % = 100 * Benchmark Configuration Utilities Metric / Configuration Utilities Metric

To minimize consumption of utilities, you must view the process unit utility requirements and the utility system design as a single integrated network.

Emissions Efficiency

Emissions efficiency measures greenhouse gas emissions with the goal of lowering the CO_2 footprint. The E6 model accounts for CO_2 from combustion emissions and as a reaction by-product.

The emissions metric quantifies the CO_2 emitted by a complex.[4, 11, 14 & 16]. The reference line in Figure 5 is based on Arabian Light crude and represents benchmark performance across the range of fuels to maximum petrochemicals.

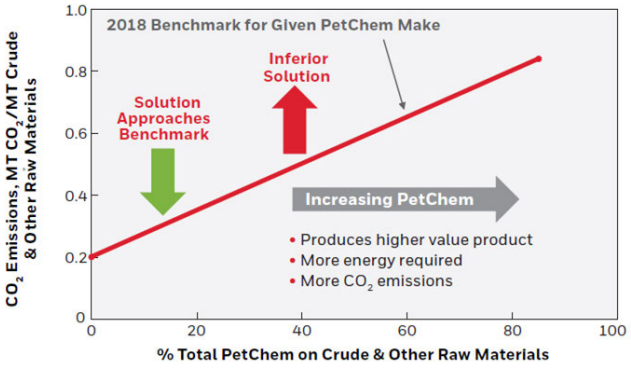


Figure 5: 2018 Emissions Metric Benchmark vs. % Total Petrochemicals on Feed for Arabian Light Crude [14] & [18]

Emissions efficiency measures the reduction of CO^2, and is determined in the same way as utilities efficiency.[9] & [17] It accounts for fuel selection, crude quality, complexity of the complex and level of petrochemical production. The selection of fuel for the utility system is critical. For example, lower heating-value coal will decrease emissions efficiency due to higher emissions relative to the benchmark which uses natural gas. Greater utilities efficiency will improve emissions efficiency.

Water Efficiency

Many new projects treat water as a scarce resource, so the E6 methodology aims for zero discharge.

Production of fuels and petrochemicals requires a lot of water for heat addition by steam, heat removal by cooling water, and hydrogen generation. The objective is to use water sustainably and minimize fresh water makeup.

The water metric measures water consumption.[5, 11] & [14] The reference line in Figure 6 represents typical performance across the range, from fuels to maximum petrochemicals, for an Arabian Light crude.

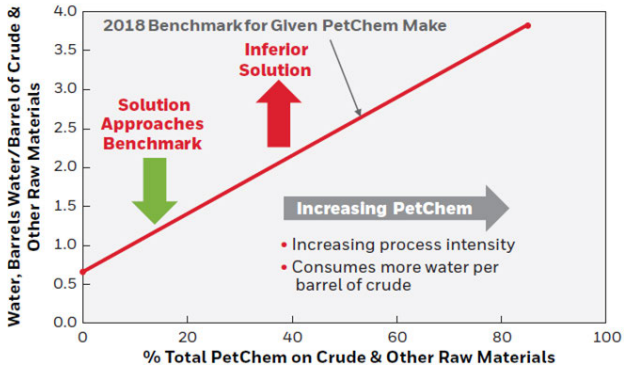


Figure 6: 2018 Water Metric Benchmark vs. % Total Petrochemicals on Feed for Arabian Light Crude [14] & [18]

Water efficiency is determined the same way as utilities and emissions,[10 & 17] comparing the use of the primary water source to typical performance. The benchmark line is based on a standard evaporative circulating cooling water system. The use of air-cooled exchangers rather than cooling water exchangers or a closed circulating cooling water system using sea water are possible solutions to reduce water loss.

The E6 methodology adjusts to establish the water metric benchmark specific to crude quality, configuration complexity and the level of petrochemicals being produced.

Capital Efficiency

Carbon, hydrogen, utilities, emissions, and water are balanced against capital efficiency -- the first five determining the sixth. All six criteria may assist or contend with each other, but can be used to balance the facility's operational goals with market demand, regulatory restrictions and other factors to develop a bankable project.

Each of the first five efficiencies are essential factors for driving the internal rate of return (IRR), which is the measure of capital efficiency. An increase in one of the five efficiencies may improve or reduce the IRR, so understanding the trade-offs helps a refiner balance the impact of many individual objectives to enable better project decisions.

Within the E6 model, the IRR is based on standard economic inputs – price, capital, and regional impact. The E6 model benchmarks technology-based performance, independent of project-specific execution models and regional variable cost components. As a project moves towards a final investment decision, capital efficiency is used to help a refiner better understand and manage its competitive position in the market.

How to Use the E6 Model to Drive Efficiency Improvements and Optimized Economics

This section includes a commercial project example where the E6 framework identified a solution that improved the economics of a customer's plant configuration. This analysis considered the application of technologies, stream routing and inter/intra technology molecule management.

A linear program (LP) model matched the base case configuration material balance to analyze improvements and establish performance within the E6 framework.

Commercial Example

As summarized in Table 1 below, the customer asked if it was possible to increase the profitably of the base configuration and simultaneously increase production of petrochemicals from a deeply integrated configuration.

Crude basis	Arab Light: Kuwait (50:50)
Px production limit)	3,000 KMTA Max
IRR	24%
NPV	32,300 $MM
Business drivers	Minimum fuels & maximum petrochemicals to meet domestic demand
Petrochemicals production	60 wt.%*
Fuel production	21 wt.%*
Location	South East Asia

*on crude & other raw materials

Table 1: Customer Configuration Basis

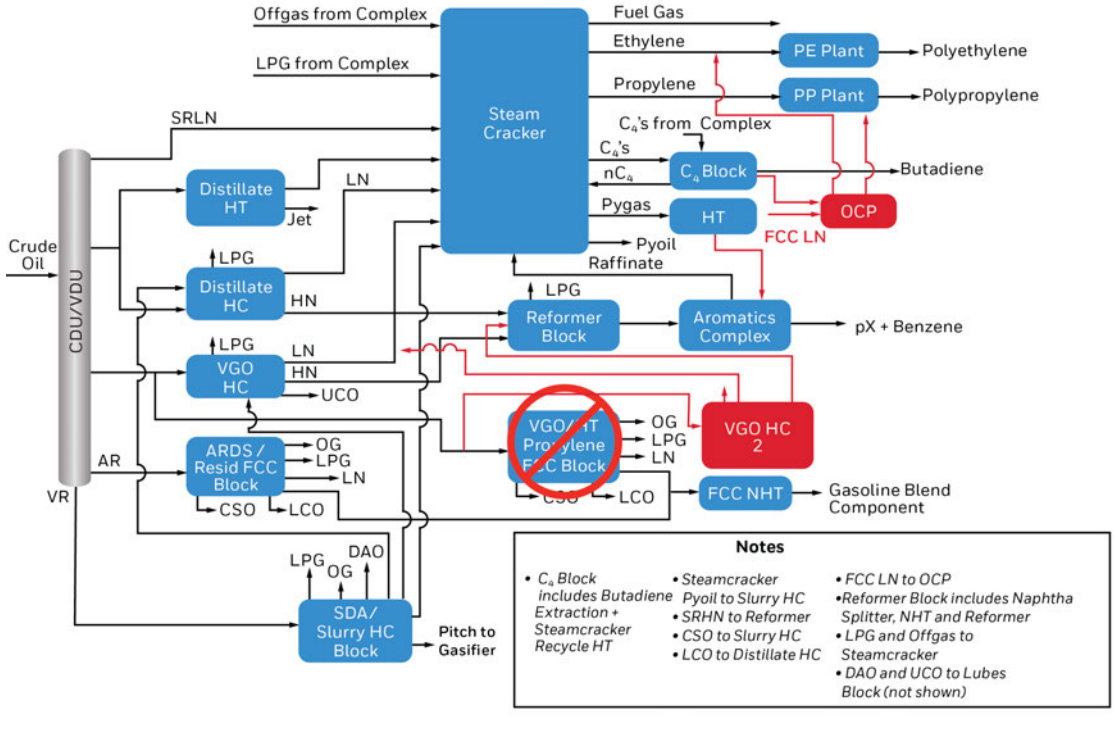


Figure 7: Optimized Configuration (with improvements shown in red)

These modifications demonstrate examples of the molecular management practices needed to develop an optimized configuration:

- **Routed steam cracker pyrolysis gasoline to the aromatics complex.** Gasoline production was reduced, pX production was maintained and surplus naphtha was redirected to the steam cracker to increases olefin production.

- **Added a VGO hydrocracker and eliminated the VGO hydrotreater and high propylene fluidized catalytic cracking unit (FCC).** FCC coke production decreased by 31%, making additional material available for olefins production. Capital cost and complexity also were reduced.

- **Routed C4/C5 olefins from the steam cracker and FCC gasoline to the Olefins Cracking Process (OCP) for light olefins production.** Avoid C4/C5 stream hydrotreatment and recycle to steam cracker, minimize hydrogen addition/removal cycles and backfill freed steam cracker capacity with naphtha. More efficient approach with additional net olefin production from OCP versus the steam cracker. Deeper integration into petrochemicals inherently results in the production of more fuel gas. In this case, improved steam cracker feed and more selective conversion in the OCP minimized the increase in fuel gas production.

The proposed configuration increased petrochemicals production from 60 to 68 wt.% while fuels production fell from 21 to 13 wt.% on crude and other raw materials. Table 2 summarizes carbon, hydrogen, utilities, emissions, water, and capital in terms of the E6 framework:

	Carbon Efficiency, %	Hydrogen Efficiency, %	Utilities Efficiency, %	Emissions Efficiency, %	Water Efficiency, %	Capital Efficiency (as IRR, %)
Customer Configuration	85.8	94.7	56.7	40.0	68.5	24.0
Optimized Configuration	86.5	96.0	57.4	40.4	69.8	25.8
Efficiency Delta	+0.7	+1.3	+0.7	+0.4	+1.3	+1.8

Table 2: E6 Results – Customer Configuration vs. Optimized Configuration

Strategies adopted for improving efficiencies are summarized in Table 3.

Efficiency	Strategy for Improvements
Carbon	Reduction in FCC capacity and optimal routing of olefins streams to OCP; better management of molecules between steam cracker and aromatics complex.
Hydrogen	Removal of VGO hydrotreater; reduction of steam cracker recycle hydrotreater capacity; elimination of high severity FCC, reducing hydrogen loss in FCC coke.
Utilities	Increasing petrochemicals requires more energy consumption, but optimized configuration improved utilities efficiency despite higher petrochemicals production.
Emissions	Coal as a fuel source lowers emissions efficiency. More efficient use of energy increases emissions efficiency.
Water	Reduction of FCC capacity: reduces reactor steam requirements; reduces steam for driving wet gas compressor and main air blower turbines; and reduces cooling water. Reduced boiler feed water by 3,520 KMTA and cooling water load by 1,340 million m3/year. 27 million m3/year water losses avoided.

Table 3: E6 Results – Efficiency Improvement Strategies

Capital efficiency aggregates the preceding five efficiencies. The impact of these gains is visible in capital efficiency improvement. Increasing production of petrochemicals at better efficiencies strengthened the profitability of the project. With only a 1% capital cost increase, the modifications grew net cash margin by $6/BBL or $890 million/year. The IRR increases from 24.0 to 25.8% and NPV grew by $5.2 billion. See Figure 9 and Table 4.

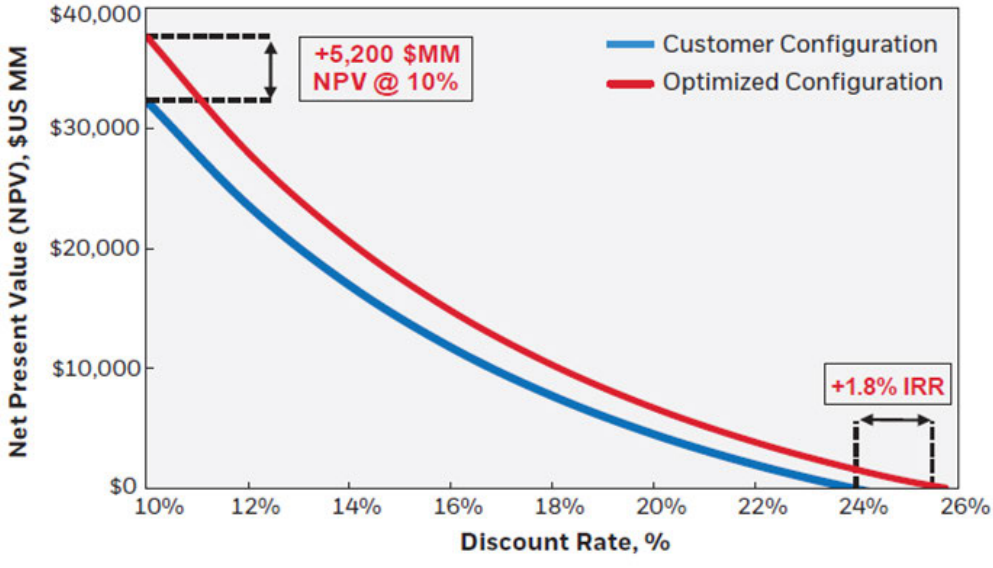


Figure 9: Summary of Results -- NPV Sensitivity to Discount Rate
Note: IRR is the discount rate at which NPV equal zero.

	Customer Configuration	Optimized Configuration
Products, kMTA		
Benzene	736	1,547
pX	3,000	3,000
Total Olefins & Derivatives	8,187	9,040
Naphtha & Gasoline	2,839	1,609
Jet	1,035	1,035
Lubes	917	917
Economic Performance		
Net Cash Margin (NCM), $MM/year	9,060	9,950
Net Cash Margin (NCM), $MM/BBL	63.1	69.3
Net Present Value (NPV), $MM (10% discount rate; 20-year term)	32,300	37,500
Internal rate of Return (IRR), %	24.0	25.8

Table 4: Summary of Results -- Production Profile & Economic Performance

Conclusion

The UOP E6 framework is a future-forward decision-making methodology that provides a data-driven approach to more profitable performance and growth. The methodology shows how a new or existing facility compares to the latest technology benchmark for each of the constrained resources. The E6 methodology aligns a firm's needs, wants and budget to identify a strategy to improve the performance of new or existing assets.

Acknowledgments
David Avers
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John Simley

Notes
1. Optimization of configurations was performed utilizing Aspen PIMS Linear Programing (LP) planning software.
2. Configuration Carbon Metric, % = 100 * Carbon in High-Value Products / Carbon in the Feed.
3. Configuration Utilities Metric = 100* Metric Tons of Equivalent Methane Consumed / Metric Ton of Feed.
4. Configuration Emissions Metric = Metric Tons of CO2 Emissions / Metric Ton of Feed.
5. Configuration Water Metric = Barrels of Water Consumed / Barrel of Feed.
6. Carbon Efficiency, % = 100 * Configuration Carbon Metric / Benchmark Configuration Carbon Metric.
7. Hydrogen Efficiency, % = 100 * Hydrogen in Saleable Products / (Hydrogen in the Feed + Hydrogen from Hydrogen Plant).
8. Utilities Efficiency, % = 100 * Benchmark Configuration Utilities Metric / Configuration Utilities Metric.
9. Emissions Efficiency, % = 100 * Benchmark Configuration Emissions Metric / Configuration Emissions Metric.
10. Water Efficiency, % = 100 * Benchmark Configuration Water Metric / Configuration Water Metric.
11. The inputs to the configuration formulae in notes 2 through 5 and note 7 are obtained from the output of the LP model.
12. High-Value products do not include materials that are combusted within the complex for energy (e.g. FCC coke or fuel gas) and they do not include low-value by-products such as coke from the delayed coking unit.
13. Saleable products do not include materials that are combusted within the complex for energy (e.g. FCC coke or fuel gas).
14. The feed to the complex includes crude oil plus any other raw materials converted to products (e.g. methanol, VGO, etc.), but excludes any raw materials combusted as a fuel (e.g. purchased natural gas, crude oil used as fuel, etc.).
15. The utility requirements for each individual unit are combined into a total requirement for each utility (net usage of electrical power, steam, fuel gas, etc.). Each total utility consumption is converted to an equivalent methane requirement. This conversion step is included in the LP model scope and the amount of equivalent methane consumption is provided as an output.
16. CO2 emissions include process releases (e.g. hydrogen plant by-product) and combustion emissions. Combustion emissions are determined from the total utility needs converted to an equivalent methane consumption requirement (see note 15).
17. Since this category is one where minimization of the configuration metric is desirable, dividing the benchmark value by the configuration value, yields a result that increases with improved efficiency.
18. %Total petrochemicals include all the olefins and aromatics produced by the complex.

REFINING

Comprehensive Approach for Energy Saving Opportunities in Refineries

M Rajasekar
Manager, R&D

G Srivardhan
Manager, R&D

Vijay Yalaga
Sr. Manager, R&D

S C Gupta
Chief General Manager, R&D

Engineers India Limited

Abstract

Climate change due to global warming has made it obligatory for all Nations to reduce their carbon emissions for saving the Earth and Environment. Energy consumption by industries, in which refineries are a major part, contributes substantially to carbon emissions. In this regard, Bureau of Energy Efficiency (BEE) has developed and introduced PAT cycle. Through this, the Refining sector was mandated to achieve the target of approximately 6% energy consumption reduction by 2021-22. Towards this, Centre for High Technology (CHT) has developed a mechanism to reduce the MBN (Million British Thermal Unit per Thousand barrels per Energy Factor) of refineries and a "Comprehensive Study on Energy and Performance Improvement" was entrusted to EIL to meet the target set for refining sector of ~ 18,00,000 MTOE/Yr.

Keywords: Energy Audit, EnCon Schemes, Process and Utility Optimization, Quick Win Schemes, Bureau of Energy Efficiency

As part of this Energy Study, various activities including collection of design & operating data / documents, technical interactions & refinery site visits, identification and development of EnCon schemes and its broad based feasibility for short listing of opportunities were carried out. The major potential energy saving areas identified were in inter/intra unit heat integration, low level heat recovery, Intervention of new Technologies, Rationalization & Up-gradation of Facilities, Steam and Power Network Optimization, Fired Heaters' Efficiency Improvement and Optimizing the Operating Parameters etc. The opportunities were categorized into Quick-wins, short term schemes and Medium term schemes w.r.t. ease of implementation & capital investment. Based on the preliminary feasibility, the short term / medium term schemes are being pursued for implementation after detailed study.

EIL identified potential energy savings equivalent to 15 % more than the target set by BEE for refineries. The paper mainly highlights the approach adopted, potential energy saving areas and a few case studies on helping the refineries plan and reduce their energy consumption levels.

I. Introduction

A petroleum refinery, while being a vital source of fuel and energy to various end users, consumes a part of the crude for its captive use as fuel and power. In addition, processing losses often accounted as "loss" add to the normal operating cost. Refinery configuration and complexity, process technology employed as well as its product slate & specifications are the major contributing factors towards energy consumption. However, inter-unit heat integration, use of energy efficient equipment and addition of energy saving devices / schemes etc. can reduce fuel consumption and loss leading to the improved performance of a refinery.

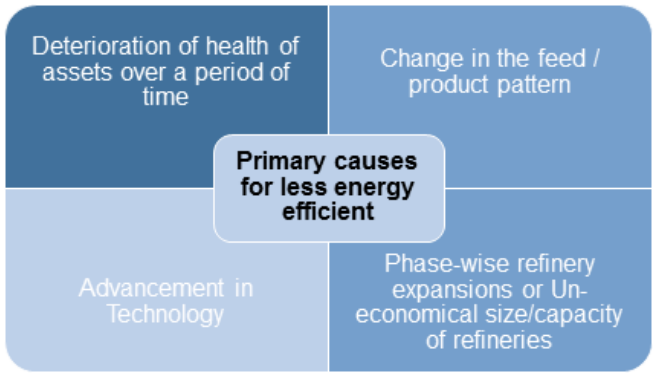
Depending upon the various factors outlined above, typical fuel and oil losses vary from 7 to 10% of the crude processed (expressed as fuel oil equivalent) based on the refinery's complexity. The fuel & loss figures tend to increase as more and more secondary processing units are added either for meeting stringent fuel specifications or for upgrading bottom of the barrel for converting heavier fractions to more & more light & middle distillates for improving margins. In terms of economic evaluation of the refinery, energy consumption constitutes a major operating cost and hence reduction in fuel consumption and losses offers great potential and incentive to improve unit as well as overall refinery profitability.

Though, Indian refiners have long understood the importance of energy optimization & effective management as the cornerstone for sustenance, the energy study's outcome often suggests that there are still considerable numbers of potential areas that can be taken-up by the refinery for further reduction in energy consumption.

II. Objective of Comprehensive study on Energy and Performance Improvement

Based on the greenhouse gases emission considerations as per climate change, Bureau of Energy Efficiency (BEE) has set the target for reduction in refinery specific MBN (Million British Thermal Unit per Thousand barrels per Energy Factor). Accordingly, Metric Ton of Oil Equivalent (MTOE) saving targets for the short term and medium term have been worked out, based on the refinery's performance corresponding to FY 2015-16.

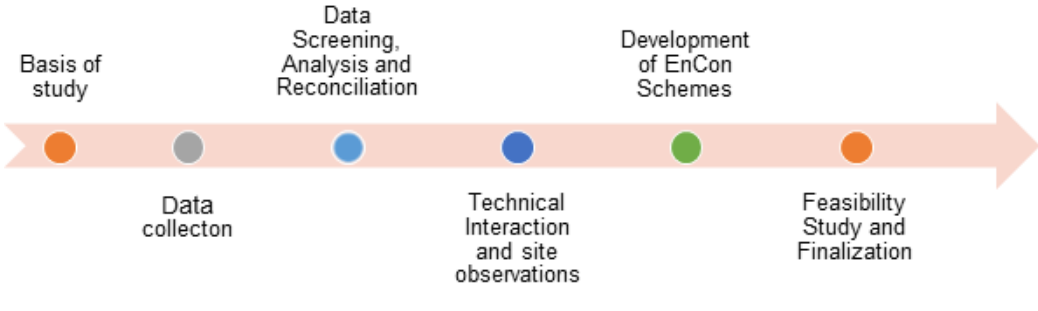
Subsequent to setting-up of most of the Indian refineries with primary units, a number of secondary process unit / utility systems have been added in stages as a part of capacity augmentation, product quality improvement and meeting the statutory norms. Presently, some of the process units / utilities are less energy efficient primarily owing to the following reasons:



The above factors also result in lower profitability and adverse impact on the environment. Therefore, it requires a comprehensive study to identify the gap areas with respect to energy performance covering process units, utility systems and major energy consuming equipment viz, furnaces, compressors, turbines, boilers etc.

III. Brief Methodology

All the process units, utility systems are required to be studied in a holistic manner to identify the gaps. The methodology involves various activities described as follows:



• **Basis of Study**

It is a first and essential step to establish the base line energy consumption pertaining to steady and sustainable operation of the refinery covering all process units and utility systems, operating data and design documents to be used for identifying the potential energy saving areas.

• **Data collection**

Data collection is the most important and crucial phase of the study. It is not only the most time consuming activity but also demands significant information about the unit's/equipment's present status as well as its trend. The success of any Energy Efficiency Improvement Study greatly depends on the accuracy of the data. Therefore, it is important to have right and authentic data to achieve the desired results

• **Data Screening, Analysis and Reconciliation**

All the data and information collected have been analysed thoroughly to check their consistency, completeness and correctness. The next phase of the study is data screening, analysing and reconciliation of operating data required based on design data, past trend, in-house technical data bank and design tools.

• **Technical Interaction and Site Observations**

For complete understanding of the operating data and documents submitted and to understand unit / system constraints, site feasibility of the identified schemes, technical interaction with domain experts and preliminary site assessment is required.

• **Development of EnCon Schemes**

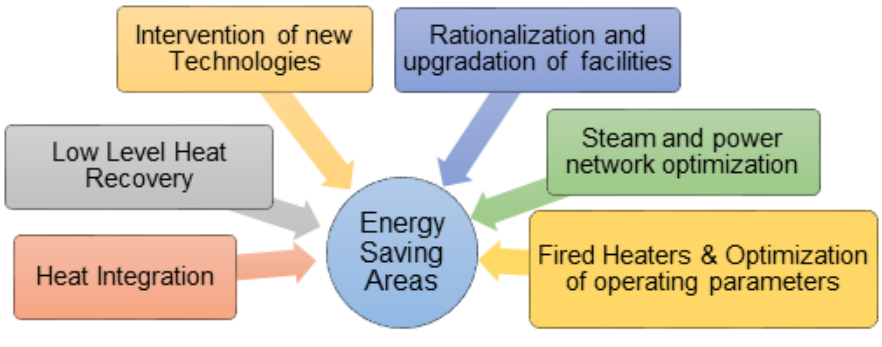
The key to the study is to identify various energy conservation schemes along with their energy saving potential, brief site feasibility and costing based on the operating / design data.

• **Finalisation of EnCon Schemes**

Subsequent to the development of EnCon schemes, the schemes are required to be discussed mutually to finalise w.r.t saving potential, site feasibility and constraints, if any.

IV. Potential Energy Saving Areas

The potential energy saving areas identified under energy study can be summarized under various energy study areas as described below:



a. Heat Integration

This is an energy study area in which the potential of inter unit and intra unit heat integration is explored. Under inter unit / intra unit heat integration, it is observed that most of the heat potential in the streams is lost through the air-coolers/ trim coolers during their routing to storage or due to the existing configuration / operating philosophy. So, wherever possible, emphasis is given to increase the preheat temperature of feed to the unit / equipment. Under this category, various schemes like feed preheat improvement in CDU, NHT ISOM, NHT CCR, DHDT etc. are studied and recommended.

b. Low Level Heat Recovery

This mainly focuses on the effective utilization of low level heat available within different streams in the refinery viz. unit rundowns, flue gases from boilers / heaters and boiler blow-downs. It is observed that these streams have significant heat potential which is currently disposed-off to atmosphere directly (in case of flue gases) or lost through air coolers / trim coolers. The schemes recommended under this category are heat recovery from DHDT/VGOHDT rundowns, heat recovery from HRSG's blow down etc.

c. Intervention of New Technologies

This is an important area of energy saving explored during the study. Under this, thrust is given to implement the new technologies like replacing the extraction based hexane treating with fixed bed reactor process, installation of Divided Wall Column (DWC) combining ISOM and hexane manufacturing unit (HMU) in place of conventional separation systems and replacement of last stage ejector with LRVP in VDU.

As a part of this, new energy saving schemes like use of electrical tracing / heating in place of steam tracing / heating, and fan less cooling towers in place of conventional induced draft cooling towers are also recommended. Further, installation of Plate & Frame exchangers in ARU and SWS can help reduce the steam requirement in re-boilers.

d. Rationalization & Up-gradation of facilities

In the category of Rationalization & up gradation of facilities, importance is given to reduce specific energy consumption to produce unit quantity of product. It is observed that in the refinery, old systems / configurations are being used with inherently lower efficiencies and use of drives is often linked to operating philosophies.

The schemes that are recommended, as part of this area of energy study are Replacement / Up-gradation of existing CDU/VDU, with new, integrated, state of the art, efficient processes, rationalization of GT's and recovery of hydrogen from refinery off gases, reduction of column top pressure, rationalization of air compressors, and installation of PRT.

e. Steam and Power Network Optimization

Any energy saving scheme, if implemented in the refinery often affect the steam network and / or power network. Therefore, these facilities need to be optimized. In the current scenario, a complete steam and power network balance is carried out. The energy saving measures identified in this area is

- Recovery of steam / condensate loss in refinery complex
- Replacing PRDS with turbo generator for generation of power

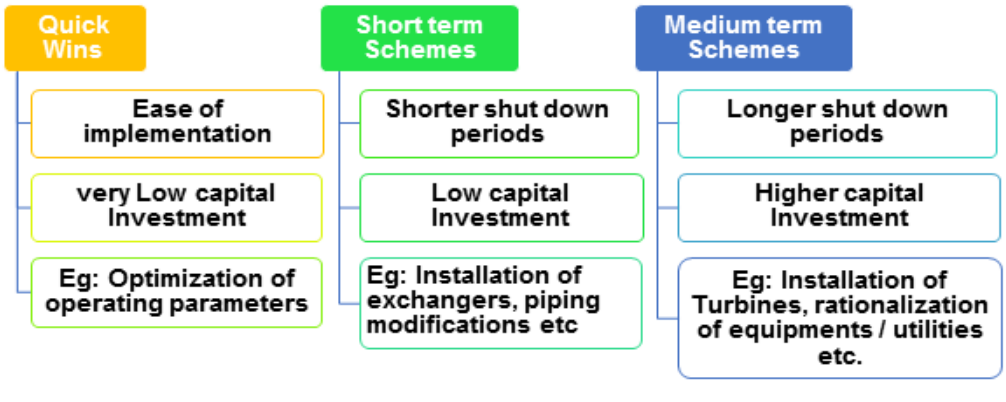
f. Fired Heaters' Efficiency Improvement

Fired heaters contribute considerable part of the energy consumption in a refinery. A comprehensive study and optimization of fired heaters will greatly reduce the specific energy consumption of a refinery. The areas which are evaluated under this category are excess air optimization by incorporating reliable O_2 analysers, thermal efficiency improvement by augmenting APH system based on predominant gas firing, changing worn-out burner components for improved combustion performance and replacement of critical dampers.

g. Optimization of Operating Parameters

Optimizing the operating parameters is expected to contribute greatly to the reduction in energy consumption without significant impact on product pattern and with no investment. Some of the recommended schemes are stoppage of stripping steam to LGO & HGO strippers, optimization of stripping steam to crude column and minimizing the product recycle in units etc.

The opportunities emerging from the Energy study were categorized as Quick wins, Short term schemes and Medium term schemes:



Based on the preliminary feasibility, the short term / medium term schemes are being pursued by way of a detailed study for implementation.

V. Case Studies

Most of the energy saving schemes is specific to refinery operations. This section describes few case studies which help the refineries to plan and reduce their energy consumption levels.

i) Replacement of PRDS with TG

Presently in refineries, high pressure steam is let-down to low pressure through PRDS to meet the steam demand. There is potential to generate power by installing a Turbo Generator instead of killing the pressure through control valves. A Turbo generator has been proposed to generate power of ~ 3.5 MW from 55 TPH of high pressure steam (60 kg/cm^{2}g & 440 degC) let down to medium pressure steam (13.5 kg/cm^{2}g & 280 degC). This requires a parallel arrangement of Turbo generator to the existing PRDS to meet the plant low level steam demand as shown in figure 1.

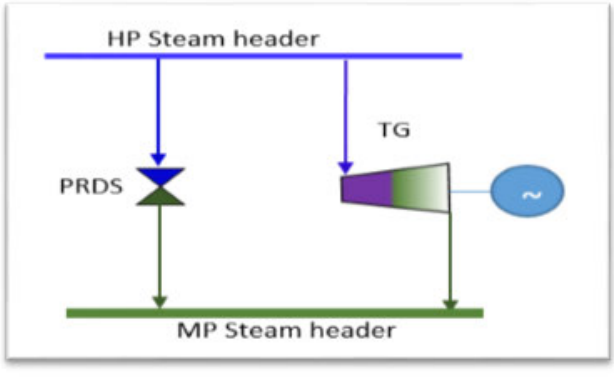


Figure 1. Installation of TG for Power Generation

ii) Stoppage of lean amine preheater by routing hot amine to downstream units

It is observed that lean Amine from amine regenerator is being cooled to ambient temperature using air cooler & trim coolers in amine regeneration unit and routed to various units viz, DHT, HCU etc. This stream is again being reheated using steam in respective units which leads to loss of energy. It has been recommended to supply the hot amine directly to units instead of cooling in ARU and preheating in respective units, which leads to saving of LP steam supplied to lean amine heaters. In one of the refineries, this could save energy equivalent to 1030 MTOE /Yr.

iii) Installation of step-less control in make-up gas compressors

In a typical hydroprocessing unit, fresh (make up) hydrogen from the refinery hydrogen header at ambient temperature is routed to Make-up Gas Compressor (MUG).This MUGs (reciprocating type) are motor driven with fixed RPM and consume substantial amount of power. These compressors are provided with spill-back control valves to return the excess flow to suction leading to loss of energy. Therefore, step-less control system can be installed in these compressors to operate at desired flows without spill-back operation which will reduce the power consumption. Most of the times, this measure has the potential to reduce the power consumption by 400-800 kW depending on the process hydrogen demand.

VI. Summary

The major potential energy saving areas identified are in inter/intra unit heat integration, low level heat recovery, Intervention of new Technologies, Rationalization & Up-gradation of Facilities, Steam and Power Network Optimization, Fired Heaters' Efficiency Improvement and Optimizing the Operating Parameters etc. The area wise energy saving identified in the study in 15 PSU refineries is as shown in Figure 2.

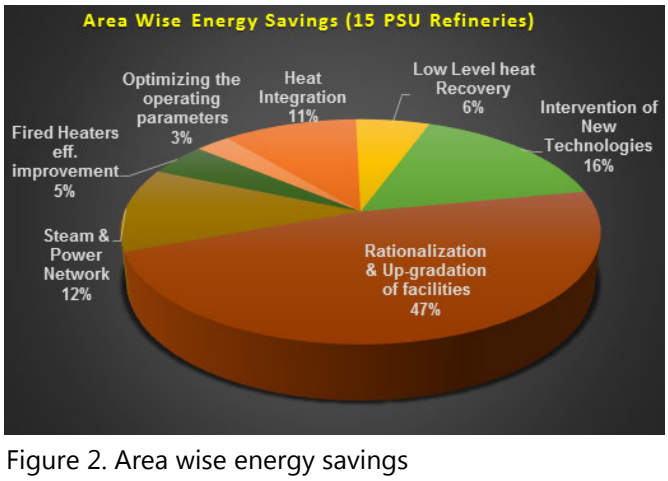


Figure 2. Area wise energy savings

It can be observed that rationalization & up gradation of facilities, steam power network optimization, intervention of new technologies and heat integration among process units have good potential for reducing the specific energy consumption thereby improving the MBN of refineries.

PETROCHEMICALS

On-Purpose Butadiene (OPBD) Production: Current Scenario and Emerging Trends

Dr. Chanchal Samanta
BPCL R&D

Dr. Rajaram Bal
IIP Dehradun

Dr. Bharat Newalkar
BPCL R&D

Mr. Sanjay Bhargava
BPCL R&D

1. Introduction:

Butadiene (BD), also known as 1,3-Butadiene (boiling point : minus 4.5 deg C), is a colorless, non-corrosive gas and has a mild aromatic odor. With its two carbon-carbon double bonds (CH_2 = CH-CH = CH_2), combined with its low molecular weight and high chemical reactivity, butadiene is a very useful building block in the production of polymers and copolymers (Fig 1). It is also used as an intermediate in the production of several useful chemicals. The derivatives of butadiene is used to manufacture synthetic rubber for tyres, hoses, gaskets, paints and adhesives [1,2]. The tyre and automotive industries accounts for 70-75% butadiene derivative demand. Applications of various butadiene derivatives are listed in Table 1.

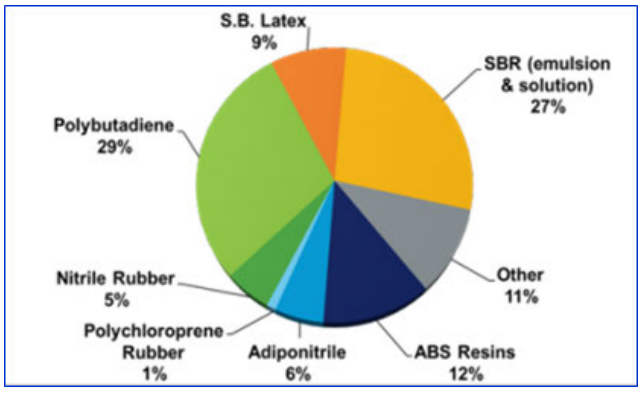


Fig 1: World's demand of butadiene by derivatives (Source: IHS Chemical)

Butadiene is a globally traded commodity and its global demand is growing at about 3% per annum. Global butadiene production exceeded 10 million tons in 2013 and it is expected that by 2025 the demand will reach to 15.0 million tons per year. Some of the leading butadiene producers are BASF,Borealis, Equistar Chemical, ExxonMobil, INEOS, Polimeri Europa, Repsol YPF, SABIC, Shanghai Petrochemical, Shell, Sinopec, RIL, JSR, CNOOC-Shell.

Table 1 : Various butadiene derivatives and their end uses

Sr. No	Butadiene Derivatives	End uses
1	SBR (Styrene Butadiene Rubber) and PBR (PolyButadine Rubber)	Tires and plastic materials include applications in conveyor belts, gaskets, hoses, floor tiles, footwear and adhesives
2.	Neoprene	Gloves, wetsuits, waders and foams
3.	Nitrile rubber	Hoses, gloves, gaskets and seals
4.	Styrene Butadiene Latex	Adhesives and binder to produce carpet, paper coatings and interior paints
5.	Adiponitrile	Precursor for nylon-6,6
6.	Acrylonitrile-butadiene-styrene (ABS)	Automotive and electronic sectors, appliances, pipes, fittings and construction products

2. Indian refining scenario and current challenges

India's refining sector has seen tremendous growth in the last two decades. The refining capacity has leapfrogged from a modest 62 MMTPA (Million Metric Tonnes per Annum) in 1998 to nearly 250 MMTPA at present comprising of 22 refineries. As a result, Indian refining sector has establish itself as a major player globally and currently India holds the

second position in the Asia-Pacific region. A number of refining expansion projects have been envisaged to increase the refining capacity to 300 MMTPA in the near future.

The country has become one of the largest exporter of petroleum products in Asia since August 2009 as the production has grown significantly than the domestic consumption. India's domestic fuel consumption has also increased continuously in the last 5 years (Fig. 2) due to rapid growth in the automotive sector driven by rapid urbanization and rising income of the middle class population.

Gasoline consumption has increased from 19.1 MMT in FY 2014-15 to 28.2 MMT in FY 2018-19 whereas diesel demand has increased from 69.4 MMT in FY 2014-15 to 83.5 MMT in FY 2018-19. However, these growth trends in the fuel consumption are going to change in the medium to longer term because of the arrival of various disruptive factors in the existing transportation sector such as penetration of electric vehicles (EVs), hybrid and CNG vehicles, shared mobility, rapid electrification of railway network and overall improvement in the vehicle engine performance. In fact, during FY 2019-20, there was a negative growth in diesel consumption for the first time since 1998 even before arrival of the COVID-19 factors.

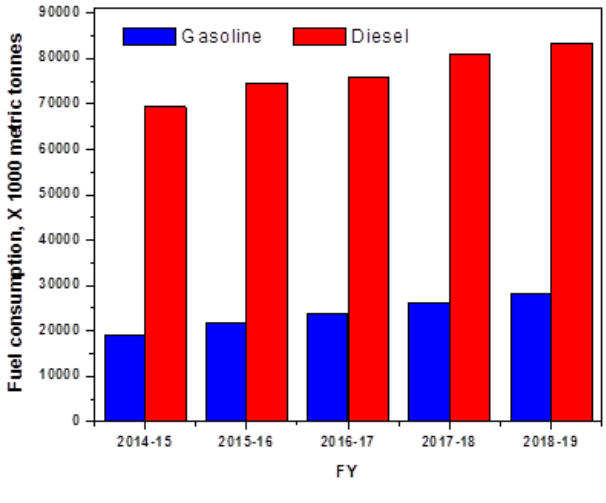


Fig 2: India's domestic consumption of gasoline and diesel fuel from 2015-19 (data source: PPAC)

The most important disruptive factor threatening the refinery business is the advent of EVs. Governments worldwide are promoting EVs to reduce environmental pollution from the transportation sector. Indian government's push for the early adoption of electric mobility and business/customer friendly policies are promoting greater penetration of the electric vehicles in the country. Moreover, changing customer perception about the environmental pollution from the fossil fuel based automobiles is further driving demand of EV's worldwide. As a result, a number of car manufacturers have already started production of EV's in the country. In EV sector, battery technology is progressing very rapidly and many global automobile companies especially Tesla, General Motors are marching towards development of "million mile "battery. This will bring a major step forward and wider adoption of EVs and the traditional fossil based automobiles would face steep competitions from EVs.

Besides, India is rapidly increasing renewable electricity capacity as per India's commitment for the Paris Agreement. According to a recent report of International Energy Agency (IEA) on Energy Policy Review-India 2020, India's investment in solar PV was greater than the collective investment of electricity generation from all fossil fuel sources. By December 2019, India had deployed a total of 84 GW of grid-connected renewable electricity capacity. By comparison, India's total generating capacity reached 366 GW in 2019. India is also making rapid progress towards its target of 175 GW electricity production from renewables by 2022. In September 2019, Shri Narendra Modi, the Prime Minister of India, announced that India's electricity mix would eventually include 450 GW of renewable energy. The capacity addition through renewable electricity is driving rapid electrification of unelectrified railway network which used to rely on diesel fuel earlier.

In the current market scenario, Indian refining sector is exposed to various new challenges such as surplus refining capacity, competitive refinery margins, lower demand, stringent product specifications and meeting environmental regulations. Thus, to remain relevant and sustainable in the business, integration of petrochemical with refineries is one of the most logical step Indian refiners are looking forward. This is because unlike transportation fuels, India is a net importer of petrochemicals products. In the polymer sector, India's domestic demand is expected to outpace the domestic production in the coming years. As per Indian Petrochemical Industry Report 2018, India's polymer import dependency was at 34% in 2016-17. The polymer sector is expected to see robust growth in the coming decade. As per ICIS

data, India's domestic per capita plastic consumption was 6.4 Kg in 2009 which is projected to grow to 14.2 Kg by 2020. India's per capita plastic consumption in 2014 was 9.7 kg as against USA's 109 Kg, EU's 65 Kg and China's 45 Kg. Thus, there is tremendous growth prospects in the petrochemicals sector and government's push for "Make in India" to become self-reliant offers opportunities to integrate refineries with petrochemicals. Therefore, valorization of excess refinery feedstocks such as Naphtha, VGO and n-butane/butylenes mixture to useful olefin intermediates such as ethylene, propylene, butylene and butadiene would be a good proposition. In this context, production of butadiene and its various derivatives (Table 1) which have good demand in India and Asia-Pacific region, may be looked into under "Make in India" initiative and to generate additional revenue from these useful products.

3. Butadiene: Indian Scenario

Among the light olefins, the estimated growth for butadiene in the coming years to be around 7-10%, while growth for ethylene and propylene are expected to be 12.4 and 5.4%, respectively (Source : CPMA). The major driver for the growth of butadiene is due to growth in the automobile sector and demand for high quality consumer products. As per IHS estimate, India to become world's third-largest passenger vehicle market by 2025. As a result, demand for synthetic rubbers used for making automobile tires and plastics would increase, resulting in higher demand for butadiene. This gives ample opportunity to the domestic butadiene producers to build new stream crackers and also explore building on-purpose butadiene production units to meet the rising demand for butadiene derivatives and generate revenue through export of butadiene derivatives.

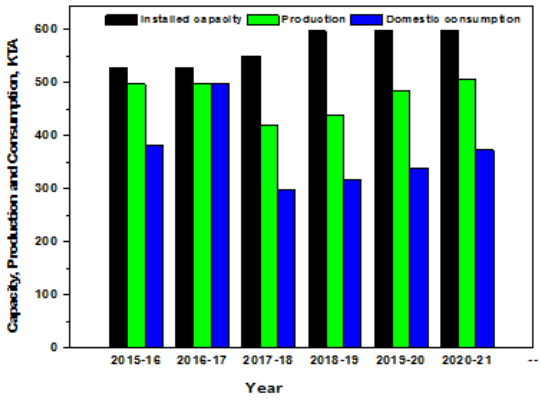


Fig 3: India's butadiene installed capacity, production and consumption patterns (data source: CPMA)

As per data and projection of Chemicals & Petrochemicals Manufacturer's Association (CPMA), demand for butadiene is steadily growing since FY 2017-18 and demand is projected to grow at a CGAR of 6-7 % (Fig 3). The current installed capacity of butadiene in India stands around 590 KTA, these include (RIL: 200 KTA, Haldia Petrochemicals: 95 KTA, IOCL: 138 KTA and ONGC Petro Additions Limited (OPAL): 115 KTA). Currently, the country is self-sufficient to meet the domestic demand for butadiene and around 100-120 KTA is being exported. However, there is opportunity to valorize butadiene to various butadiene derivatives for the domestic consumption as well as exports to the Asian market.

4. Dynamics of Butadiene Market: Challenges and Opportunities

Currently, 1,3-Butadiene is produced almost exclusively as a by-product of naphtha cracker (Fig 4.) Some butadiene is recovered from olefinic refinery gases, mainly from the fluid catalytic cracker. Butadiene is recovered from the crude C_4 fraction produced in steam cracker. The production of butadiene is dependent upon the feedstock cracked, operating conditions and severity of cracking. In high severity naphtha cracking, the C_4 fraction is about 9 wt% of the cracked products and contains 45–50 wt% butadiene. The small amount produced by cracking light feedstock (Fig. 5) is not economically recoverable and these units usually do not have butadiene extraction equipment.

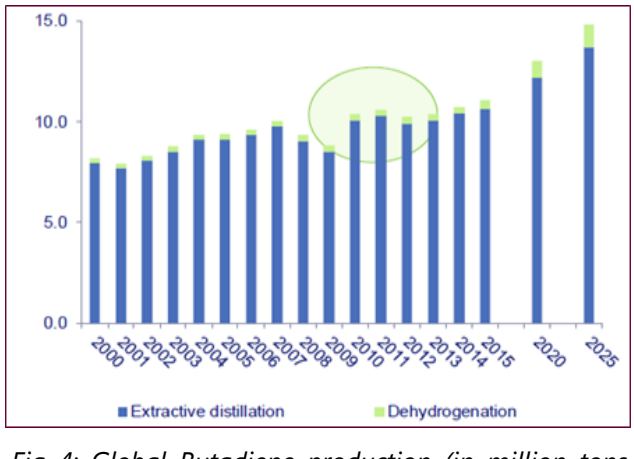


Fig 4: Global Butadiene production (in million tons per year) by extractive distillation and dehydrogenation process (Source: Nexant)

The "Shale gas" discovery in the North America and its vast reserves has promoted building of new gas crackers and the relative cost competitiveness of gas crackers is further weakening the prospect of naphtha/gasoil crackers. In fact, USA has lost almost 600,000 t/yr of BD output from 2007 to 2014. Similarly, Western European countries are expected to lose about 200,000 t/yr of BD output during 2011 to 2020. Therefore, it is anticipated that construction of new heavy naphtha/gasoil cracker will be diminished and also the operation load of the existing steam crackers will be going down on a mid and long-term basis.

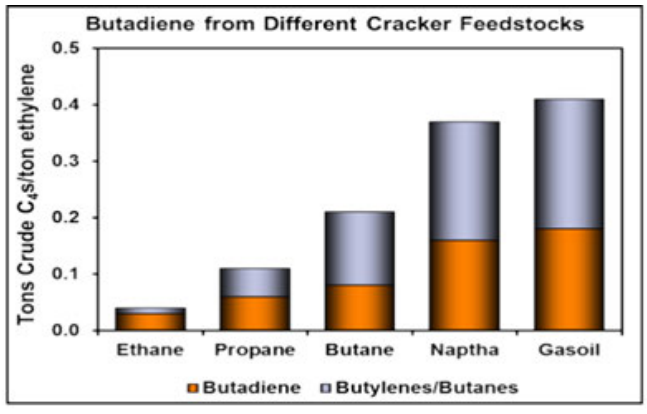


Fig 5: Butadiene yield vs function of carbon numbers in feedstock (Source: IHS Chemical)

Because of the low yield of butadiene from the newly built gas crackers, serious imbalance of the butadiene supply and demand is anticipated. Similar situation happened during 2011-12, when the butadiene price reached at a record high of ~ 3000 USD/ton because of the strong demand but insufficient supply of butadiene. It may be noted that naphtha will remain as a major feedstock for the ethylene production in the Asian market in the near future (Fig 6). However, there will be significant shift in the production of ethylene through on-purpose routes using coal and natural as feedstocks (CTO:Coal-To-Olefins)/MTO: Methanol-To-Olefin) and other gaseous feedstocks such as ethane, propane and butane. China is especially driving coal based CTO/MTO processes for the light olefins production.

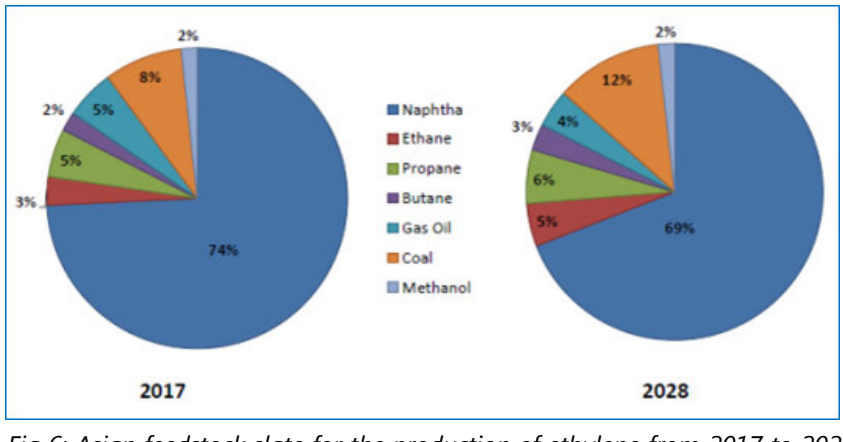


Fig 6: Asian feedstock slate for the production of ethylene from 2017 to 2028 (Source: S&P Global Plats analytics)

The lighter hydrocarbon feedstock such as butane in the steam cracker produces much lower yield of butadiene (2%) than naphtha (5%) does (Fig 7). This gives ample opportunity for the on-purpose production of butadiene and can act to control this unfavorable balance.

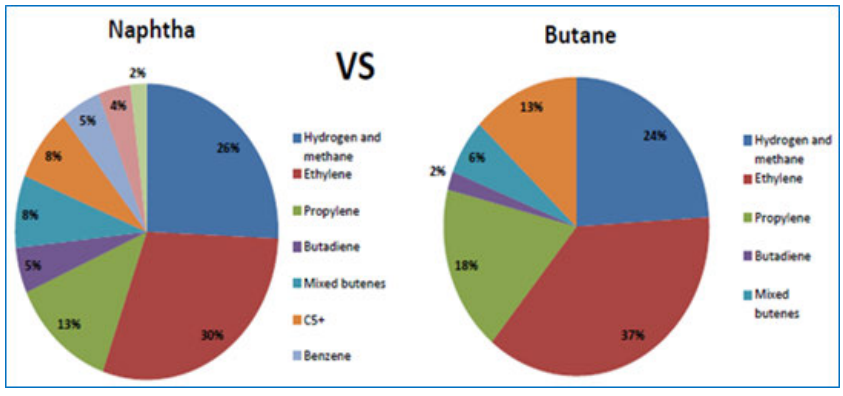


Fig 7: Comparison of distribution of products from stream crackers using Naphtha and Butane as feedstock (Source: S&P Global Plats analytics)

5. Butadiene production: Traditional and Emerging on-purpose routes

At present butadiene is produced commercially by three processes [1].

- Extractive distillation of crude C4 stream of steam cracking of paraffinic hydrocarbons
- Catalytic Dehydrogenation of n-butane and n-butenes (Houdry Catadiene Process).
- Oxidative dehydrogenation (ODH) of n-butane/n-butenes

Currently, a vast majority of butadiene (around 95%) is produced based on steam cracking followed by extractive distillation (Fig. 4) to get the desired grade of butadiene for production of polymers while on-purpose production routes based on dehydrogenation and oxidative dehydrogenation contribute a small fraction (Table 2) to overall production. However, this scenario is changing because of the change in the steam cracker configuration which is discussed in following section.

4.1 Extractive distillation of crude C4 stream

In the steam cracking process hydrocarbon feedstock such as naphtha, gas oil, butane etc are fed to a pyrolysis (steam cracking) furnace where they are combined with steam and heated to 790-830 0C. Within this temperature range, the molecules in the feedstock are cracked to produce hydrogen, ethylene, propylene, butadiene, benzene and other important olefins co-products (Fig. 7). This mixture may contain 5-15 vol% 1,3-butadiene depending on the properties of hydrocarbon feedstock. An average butadiene yield of around 13.5% of ethylene production is archived in the naphtha cracking, which may be recovered from a raw C4 stream. After the pyrolysis reaction is quenched, the rest of the plants separate the desired products into streams that meet the various product specifications. Process steps include distillation, compression, process gas drying, hydrogenation (of acetylens) and heat transfer [2]. The butadiene is separated from the product mixture through a process called extractive distillation.

Extractive distillation technology is a mature technology and has been improved over the years to employ new and more effective solvents which minimize utility requirements and lower capital costs.

A typical butadiene extractive distillation plant consists of four primary process sections:

- Extractive Distillation
- Conventional Distillation
- Solvent Degassing
- Solvent Regeneration

The leading technology licensors for the extractive distillation for butadiene production are BASF, Shell and Nippon-Zeon. The BASF butadiene extraction technology was first commercialized in 1968 using N-Methylpyrrolidone (NMP) as the solvent. The BASF-NMP based butadiene extraction process licensed by Lurgi (currently Air Liquide) and Lummus Technology since 1990s, is the preferred technology and are in use in more than 38 plants worldwide. The Nippon-Zeon process is a two stage process using dimethylformamide (DMF) as the solvent. The feedstock for the process is normally the C4 fraction from an ethylene steam cracker. Shell Process is similar to Nippon-Zeon and BASF processes and the primary difference in Shell process is that it uses Acrylonitrile (ACN) as the solvent.

The steam cracking process although is a well-established route for olefin production, it has several limitations such as, high temperature operation and large amounts of undesired co-products are formed, which makes the process highly energy intensive and requires high Capex and Opex. The separation of BD from C4 streams through an expensive extractive distillation with a selectivity of only 4–5% due to its azeotrope formation with butane further adds cost to the butadiene production. On the other hand, as refiners move to the lighter feedstocks for ethylene and propylene production, less of the byproduct butadiene is produced, creating a growing "gap" between supply and demand. This gap can be closed with technologies to produce "on-purpose" butadiene. The catalytic dehydrogenation of n-butane/n-butenes and oxidative dehydrogenation of n-butane/n-butenes are the two major on-purpose butadiene production technologies increasingly being used to fill the gap.

4.2 Catalytic dehydrogenation

Because of the availability and relatively low price of light alkanes, dehydrogenation of n-butane to 1,3-butadiene is an attractive choice for the on-purpose production of butadiene [2]. The catalytic dehydrogenation of n-butane is a two-step process; initially going from n-butane to n-butenes and then to butadiene or a single-stage process using n-butane/n-butenes (Houdry Catadiene process).In this process, n-butane is dehydrogenated over chromium/alumina at 600-680^{0}C and 12-15 centimeters of Hg absolute pressure. Three or more reactors can be used in the continuous operation; while the first reactor is on-line, the second is being regenerated and the third is being purged prior to the regeneration. Residence time for feed in the reactor is approx. 5-15 mins. As the endothermic reaction proceeds, the temperature of the catalyst bed decreases and a small amount of coke is deposited. In the regeneration cycle, this coke is burned with preheated air, which can supply essentially all of the heat to bring the reactor up to the desired reaction temperature. The reactor effluent goes directly to a quench tower, where it is cooled. This steam compressed before feeding to an absorber/stripper system, where a C4 concentrate is produced to be fed to a butadiene extraction system for the recovery of high purity butadiene.

The CATADIENE® dehydrogenation process licensed by Lummus Technology is a reliable, proven route for the production of 1,3 butadiene from n-butane or a mixture of n-butane/n-butenes. Catadiene is the only commercial technology available for on-purpose production of butadiene and butylenes from n-butane. The catadiene unit can be operated to co-produce butylenes and butadiene or to produce only butadiene. There are two butadiene plants operating in Russia producing about 270 KTA of butadiene based on the catadiene process.

The use of high temperatures in catalytic dehydrogenation presents several disadvantages such as difficulty in controlling undesirable reactions that decrease selectivity (such as cracking of hydrocarbons) and coke formation over the catalyst, which decreases activity, are the most significant. Chromia–alumina based catalysts used in a commercial process require regeneration after a few minutes of operation. The highly endothermic nature of the reaction is another disadvantage due to the need to supply heat, which can be partially obtained in practice by burning coke in the regeneration process.

4.3 Oxidative dehydrogenation of n-butane/n-butenes:

Catalytic oxidative dehydrogenation (ODH) is much more promising than dehydrogenation route as ODH is irreversible, exothermic and can be carried out at lower temperatures ca.300-400^0 C and with the higher per pass conversion [2,3]. Thus, the process is expected to reduce the costs of butadiene production relative to those of non-oxidative process. Moreover, the presence of oxygen limits coking and extends the catalyst lifetime. However, ODH technology is highly guarded and most of the plants are located in USA. A comparison of steam cracking, dehydrogenation and oxidative dehydrogenation routes is provided in Table 2.

Different catalyst systems have been developed for the oxidative dehydrogenation of n-butane and n-butenes as feedstock (Table 2). Butenes are much more reactive and require less severe operating conditions than n-butane to produce an equivalent amount of product. However, purified butenes feed is much more expensive than normal n-butane feedstock. In general, in an ODH process, a mixture of n-butane/n-butenes, air and steam is passed over a fixed catalyst bed generally at low pressure and approximately 300-400°C. The heat from the exothermic reaction can be removed by circulating molten heat transfer salt, or by using the stream externally for steam generation. An alternate method is to add steam to the feed to act as a heat sink. The heat can then be recovered from the reactor effluent. Reaction yields and selectivity can range from 70-90%, making it unnecessary to recover and recycle feedstock. Moreover, since the reaction is exothermic, any increase in accidental reaction temperature can drastically result to yield losses towards CO_2 production. Valorization of n-butane, which is a cheaper feedstock and readily available from various sources viz. refineries, natural gas liquid, shale gas etc. to butadiene in a refinery complex would improve gross refinery margins and help to meet the growing demand for butadiene.

Table 2: Comparison of current butadiene production technologies

Parameters	Steam cracking/Extractive distillation	Catalytic dehydrogenation	Catalytic oxidative dehydrogenation
Operating temperature	790-830 °C	600-680 °C	300-400 °C
% contribution in world's BD production	95%	3 % (mostly in China)	2% (in USA)
Catalytic/Non catalytic	Non Catalytic	Catalytic	Catalytic
Capex	High	Medium	Medium
BD yield	Low and feedstock dependent	30-40 %	70- 80%
Whether on-purpose	No	Yes	Yes
Current trends in feedstock use	Lighter feeds; lower yield of butadiene	n-butane or mix of n-butane and n-butenes	C_4 mixture
Catalyst system	-	Cr_2O_3 supported on Al_2O_3 (for n-butane dehydrogenation) Fe_2O_3-K_2CO_3-Cr_2O_3 or $Ca_3Ni(PO_4)_3$-Cr_2O_3 (for n-butene dehydrogenation)	Mo-V-MgO Ni-Mo-O V/Al2O3 or SiO2 Mg-Ni-Sn-O
Reactor Type	-	Multiple adiabatic fixed bed reactor	Fixed bed or fluidized bed

Some of the leading companies active in the area of ODH are TPC-UOP, Wison, Mitsubishi Chemicals and BASF-Linde.

- OXO-D technology is a commercially proven (developed and operated for more than 40 years) ODH technology for converting n-butene to butadiene. UOP in partnership with TPC Group is currently licensing OXO-D™ technology.
- Mitsubishi Chemicals has developed BTcB process (Butene-To-crude-Butadiene)
- BASF and Linde are working on developing on-purpose butadiene production technology based on butane to butadiene via n-butenes)

Mitsubishi Chemical's BTcB process is based on oxidative dehydrogenation of n-butene to 1,3-butadiene. The key features of BTcB technology include proprietary catalyst which ensures both high butene conversion/ butadiene selectivity and almost all of the industrial C4 hydrocarbon mixtures such as Raf-2, FCC C4, and 1-butene can be processed by the BTcB technology. A schematic of the BTcB process in shown in Fig 8.

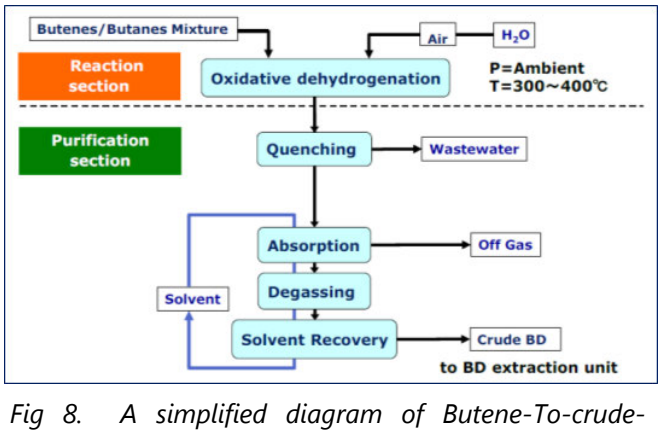


Fig 8. A simplified diagram of Butene-To-crude-Butadiene(BTcB) process (Source: Mitsubishi Chemicals)

Chinese companies are making significant progress in developing technology for OPBD to meet the growing demand for butadiene. China has already installed two OPBD production units based on the indigenous technology and producers from China have announced plans for constructing 18 plants producing 2.1 MTPA OPBD by 2020 (Source : S&P Global Plats analytics). Recently, Nanjing Chengzhi Yongqing Energy Technology Co has started production of butadiene from a 100 KTPA plant based on proprietary ODH technology licensed by Chinese EPC Wison. The ODH technology and catalyst were developed by Wison in 2013 and commercialized in 2016. The propriety catalyst technology enables 80.0% n-butene conversion with 93% butadiene selectivity and over 74% butadiene yield making the process economically attractive.

5. On-purpose butadiene from renewable feedstock: Emerging trends

As thrust for the circular economy is gaining attention to reduce the environmental problems, demand for the chemicals production from the renewable sources with lower carbon footprints will become relevant [4-7]. As a result, significant R&D efforts are underway for the development of "green" butadiene process based on bio-based feedstocks. Genomatica, a San Diego based biotechnology firm, is working on the development of a fermentation-based route for butadiene production. Braskem (Sao Paulo, Brazil), one of the largest butadiene producers in North America has been collaborating with Genomatica for the development of process technology for the production of biobutadiene. As per recent Scopus search report, there is renewed interest in the ethanol-to-butadiene process (Fig 9).

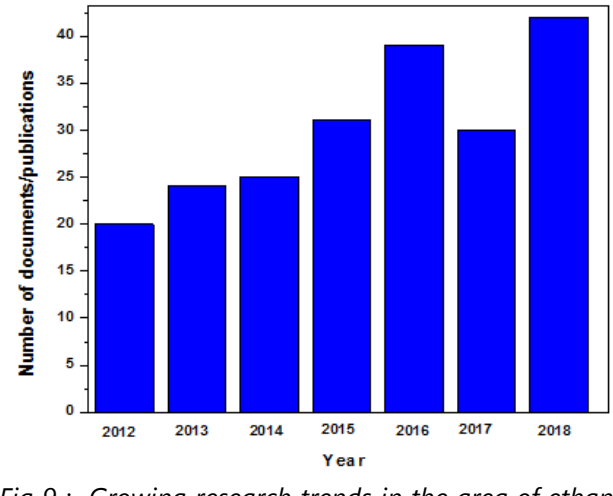


Fig 9 : Growing research trends in the area of ethanol to butadiene (Source : Scopus)

Synthos S.A.(Oswiecim, Poland), one of the world's largest manufacturers of synthetic rubbers, is working on the development of butadiene process from ethanol through dehydrative coupling of two equivalents of ethanol.

Butadiene production from ethanol is not new. The one-step catalytic process of butadiene production from ethanol had been developed by S. Lebedev and was used in the production of butadiene in the USSR in the beginning of the 1920s. Later on, the Carbide and Carbon Chemicals Corporation, USA commercialized a two-stage process,featuring acetaldehyde as an intermediate product. These routes lost their competitiveness due to the arrival of butadiene extraction associated with naphtha crackers products and all 'ethanol-to-butadiene' plants were shut down after the 1960s.

However, in order to be economically attractive, the 'ethanol-to-butadiene' technologies require substantial improvement in the selectivity for butadiene.The complex reaction chemistry includes the ethanol dehydrogenation into acetaldehyde, followed by adol coupling into C4 precursors, finally dehydration leading to butadiene. For the single step process, all of the above reactions need to be governed by use of a single catalyst with extremely high conversion, selectivity, and stability. ETB Catalytic Technologies LLC, Russia is working on the development of ethanol based energy efficient single step process for the production of on-purpose butadiene. The company claims that its novel polyfunctional heterogeneous catalyst offers superior selectivity to butadiene (over 80%) compared to the "Lebedev's process" due to the decrease of side products formation. The process operates at lower temperature (320^0 C) and atmospheric pressure and has low energy consumption than previous processes.

Tetrahydrofuran (THF), another bio-based feedstock can be used for the butadiene production (Fig. 10). THF can be obtained from the bio-based furfural by a single or two step conversion of Furfural. The first is decarbonylation of furfural to furan and the second step is hydrogenation of furan to THF. A research group from the USA, has shown that THF can be converted to butadiene with selectivity of 85–99% at both low (9%) and high (89%) conversion of THF through dehydra-decyclization process in the presence of a phosphorus-containing siliceous self-pillared pentasil (SPP) or MFI zeolites (ACS Sustainable Chem. Eng. 2017, 5, 5, 3732-373).

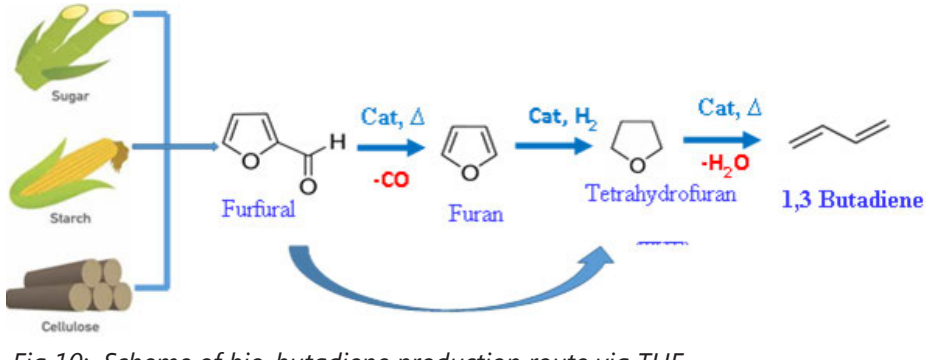


Fig 10: Scheme of bio-butadiene production route via THF

Versalis (Eni)–Genomatica have developed a breakthrough technology for the production of bio-butadiene from renewable 1,3-butanediol (BDO). The technology is based on Genomatica's propriety technology to produce bio-fuels along with 1,3 butanediol from first and second generation sugars integrated with Versali's process on dehydration of 1,3-butanediol to 1,3-butadiene. It is worthy to note that bio-butadiene (bio-BDE) technology developed by Versalis (Eni) in partnership with Genomatica won the Environmental Achievement of the Year Award in 2017 within the "Tire Technology International Awards for Excellence and Innovation" the European independent award program for the tire industry.

Axens in partnership of Michelin, the world's largest tire producer, is also working on the development of bio-butadiene technology based on alcohol intermediates derived from biomass by fermentation. The project called "BIOBUTTERFLY" aims to reduce the environmental impact of butadiene production by replacing fossil-based products with bio-based ones. As per the project milestone, Axens has planned to construct a bio-based butadiene pilot plant (first of its kind) by 2020.

LanzaTech has developed a proprietary gas-based fermentation technology for the production of ethanol from industrial waste gases from steel industries and other CO_2 emitting industries. In this process, 2,3-butanediol is produced as a by-product, which can be converted to butadiene. The development of efficient technologies for the production of butadiene from bio-based feedstocks would drastically improve the carbon footprint of the butadiene production process and will reduce dependency on the petroleum based feedstocks in the future.

6. Summary and Future outlook

Extractive distillation associated with steam cracking to remain as a major route for butadiene production in the foreseeable future in India and the world. The arrival of new steam crackers based on the lighter feedstocks has drastically reduced the butadiene output and has created favorable context for the development of new on-purpose butadiene process. In the short to midterm, on-purpose butadiene production from butane through dehydrogenation and oxidative dehydrogenation routes will increasingly contribute to the supply of butadiene to meet its growing demand.

In the long term, butadiene production from renewable sources will be attractive proposition. The leading tyres manufacturing companies in the world namely Sumitomo rubber industries, Continental, Bridgestone, Nokian Tyres, Pirelli have committed to the production of tyres from the non-fossil resources, which will further promote the production of green butadiene. Renewable feedstock such as ethanol and other bio-derived chemicals such as 1,3-butanediol, 2,3-butanediol and THF will be explored further in the development of economically attractive green butadiene process.

However, bio-based processes would require very selective catalysts and efficient reactors to achieve industrially relevant activity and selectivity for the production of butadiene. The economics of bio-based processes will play significant role before considering large scale adoption of these technologies. Thus, significant R&D focus to be given for designing and developing new catalyst which can achieves high selectivity to dienes and produces butadiene at a high yield.

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TECHNOLOGY

Indigenization of Instrumentation & Control System Manufacturing "A step towards Atmanirbhar Bharat"

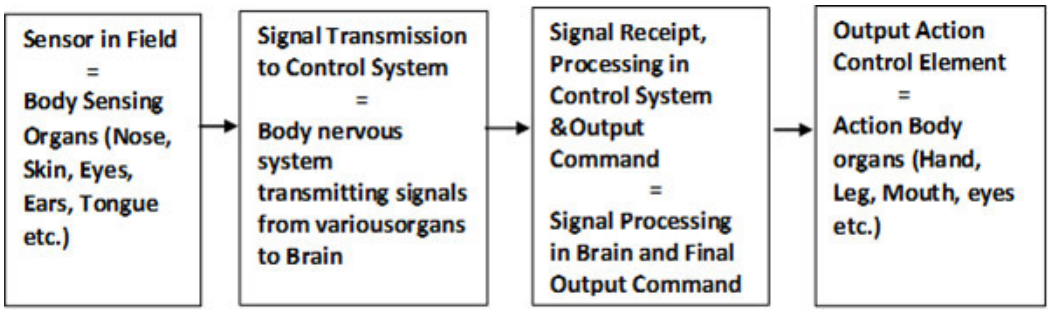
Manish Kumar
Asst. General Manager (Instrumentation)

Engineers India Limited

Introduction:

Instrumentation and Control System is the MIND & HEART for all Process Industry and Manufacturing Industry starting from Oil and Gas industry, Metallurgy plants, Cement industry, Power industry, Food & Pharmaceutical as well as Hospitality industry. Though cost wise it is approx. 7% to 10 % of Mega project / Process Plants, efficiency of the whole Plant depends on the optimum use of Instrumentation & Control Systems.

Instrumentation and Control System is analogically related to our Human Body.



Instrumentation and Control System (I&C Systems) not only provides the control and monitoring signals from field plant units to control rooms but also plays a major role in the plant safety and protection systems. It also provides all the information for calculation of production, plant efficiency, inventory management and also predictive & preventive maintenance.

Since Instrumentation and Control Systems require processing of information for taking decision for automatic action in the operating plants, it uses the programmable devices such as microprocessor based Field I&C Systems and it also involves firmware / software and hardware. Hence this requires special service supports experts for both hardware and firmware/software for service maintenance of I&C Systems.

Both Continuous Process Industries as well as Batch Process Industries always demands for prompt availability of service engineers as well as service part components to avoid any major breakdown and loss of production. ***This in turn demands for indigenization of components of I&C System manufacturing and services for maintenance.***

It had been our approach since the beginning to encourage indigenization. Government of India policy starting in 2014 has just given a quantum boost to this policy of ***Make in India (MII)***. We wish to highlight that in the field of Refinery the indigenization from early 1980s till date has risen from around 10-15% to about 90% and in Petrochemical plant from almost negligible to around 60% and 75% – 80% for other industries in the same period.

Instrumentation and Control System comprises of many important components based on numerous technologies which has gone through several evolutionary changes and also subtle developments since its inception. Some of the major components are listed below:

a. Sensors and Transmitters for measurements of Pressure, Temperature, Level, Flow, Vibration, Current, Voltage, frequency etc.,

b. Sensors for Fire and Gas Detection Systems for plant protection

c. Control elements for process control like Control Valves, Shutdown Valves, Variable Frequency Drives

d. Analyser Systems (pH Analyser, Conductivity Analyser, Gas composition Analyser, Flue Gas Analyser, Ambient Air Quality Measurement Analyser etc.)

e. Microprocessor based Control Systems (DCS - Distributed Control System, PLC - Programmable Logic Control Systems etc.)

f. Tank Farm Management System (TFMS) and Metering Skid System

g. Supervisory Control and Data Acquisition Systems (SCADA)

h. Remote Telemetry Unit (RTU)

i. Fire and Gas Detection System

j. Fire Suppression and Protection System

k. Closed Circuit TV System for surveillance

l. Fencing and Intrusion protection system

m. Junction Boxes and Control Panels with terminals for connectivity of field sensors/transmitters from field to control system in control room.

n. Cables for signal transmission from field sensors/ transmitters to Junction boxes / Control Panels and finally to control systems.

Past Trends:

Initially from the year 1950 to the year 1985, major Instrumentation and Control system components were imported including the Design & Engineering of I&C system done in the country of origin. Also installation & commissioning of the systems were done under the supervision of foreign representative experts.

We were also dependent even for the Standard Specification, Inspection and Test Plans, Factory Acceptance Test Procedure for Instrumentation and Control Systems from Foreign Consultants Companies.

Initiatives of Indian I&C System Industry:

We have been in the forefront of creating engineering specifications for the Field Instrumentation, Control systems (DCS, PLC and F&G Systems), Telecommunication systems, SCADA, EPBAX, Analyzers serving the Process and Manufacturing Industry and supporting the Indian manufacturing units to imbibe the same for promotion of indigenization.

Over the past few years ***India is emerging as a low-cost manufacturing hub for all Machinery, Instrumentation and Control Systems items.*** India has a dual advantage, low-cost labor and highly technically skilled devoted manpower. This is an enticing proposition for many multinational manufacturers to establish manufacturing facilities in our country.

"Make in India" policy is in line with Government of India policy and has been uniformly made applicable in procurement of Major Equipment and Instrumentation and Control Systems.

Its implementation with our approach to have indigenous manufacturing and support services for Instrumentation and Control System has given a big boost to Plant Automation industry. This has not only increased the operational efficiency of the plant but also improved the safety and reliability of the running plant avoiding unwanted shutdown.

Current Status:

As Instrumentation and Control System is based on various technology with many components, the process of Indigenization has been started step by step.

(i) Our first step started with "doing complete design and engineering indigenously"

(ii) Then manufacturing of accessories required for the main instrument, support services during installation and commissioning of I&C System,

(iii) Training and maintenance services for the instrumentation and control system

(iv) Finally we started manufacturing of the many Instrumentation and Control System components indigenously.

Following are the different categories in Instrumentation & Control system manufacturing:

Category-1: Original Equipment Manufacturer (OEM) is from foreign country and major component are supplied by the OEM. Complete engineering designs are done indigenously including manufacturing and supply of accessories for integrating the OEM supplied components.

In this category either OEMs have set up their own establishment in India or some OEMs have technical tie-up with established local representative having expertise in design engineering, integration of OEM systems.

Important examples of I&C Systems in this category are as follows:

a. Analyser Systems (AAQMS, Stack, Process and Water Quality Analysers etc.) Only Main Analyser which are developed and patented by OEM is imported. All other supporting major components like Sample Handling System (SHS), Analyser Shelter / Analyser Cabinet with HVAC suitable for Hazardous Area Classification, Junction Box, Power Supply Distribution for the complete Analyser Systems, Cables and Cable Trays etc. are supplied from Indian facilities.

b. Control Systems (DCS, ESD and F&G Systems).
In DCS, PLC Systems only main Processor Cards, Communication Modules, Input / Output Cards, Barriers and Relay modules are imported. We have more than seven OEMs who have set up their establishment for complete design engineering, Software and Logic development, Manufacturing of complete wired cabinets, testing facility for all mega projects in India. They also have complete team for installation, testing and commissioning at site. They are not only executing projects for India but they are also established for executing abroad projects as we have skilled hardworking manpower.

c. Field Sensors and Transmitters:
Only critical components like sensors and electronic cards which are patented are imported from OEMs manufacturing establishment. Enclosure for housing these electronics and sensors, manifolds integrated with field transmitters for process connection and also software/firmware are designed manufactured indigenously along with complete assembly, testing, calibration of the field sensors and transmitters.

d. Tank Farm Management System:
Major components like Radar / Servo Level Instruments, Communication Interface Units (CIU), TFMS Software are imported from OEM country of origin. Only TFMS panel is manufactured locally and imported components are installed in panel. Complete assembly of panel and testing is done in indigenously.

e. Ultrasonic Flowmeters:
Main Sensors and Transmitters are imported and only accessories like junction boxes, cables and cable glands etc. are supplied locally.

f. Multipoint Thermocouple:
Complete Assembly of Multipoint Thermocouple are imported.

g. Special Control Valves:
Special Control Valves for some special application in high temperature and pressure ratings are imported.

h. Nucleonic Instruments:
Main Source and Detectors are imported, only accessories like junction boxes, cables and cable glands etc. are supplied locally.

Category-2: Original Equipment Manufacturer (OEM) is from foreign country but OEMs have established complete manufacturing unit in India, i.e. design engineering, complete component manufacturing, assembly of components into final products, inspection and testing and service center in line with OEM quality control guideline and patented design guide. Major Instrumentation and Control System components under this category are:

a. Control Valves
b. On-Off Valves
c. Pressure Relief Valve / Safety Valves
d. PLC for Package
e. Magnetic Flowmeters, Turbine Flowmeters

And many more Instruments are completely manufactured here with technology, quality control guidelines provided by OEMs.

Category-3: Our own indigenously developed manufacturing company having complete expertise and facility for design engineering, manufacturing of all components, integration, testing, supply, installation and commissioning, service after sales in India. Most successful Instrumentation and Control System components under this category are:

a. Pressure Gauge and Temperature Gauge
b. Level Gauge
c. Servo Level Instruments
d. Pressure Safety Valves and Pressure Relief Valves
e. Control Valves and On-Off Valves
f. Orifice Plates along with Flange Assembly, Venturi meters, Flow Nozzles etc. for DP Type flow measurements
g. Control Panel and Operator Console Panels
h. Metering Skids
i. Temperature Elements (Thermocouple, RTD) including Multi-point thermocouple
j. Signal and Power Cables including special cables like Foundation Fieldbus Cables, Optical Fiber Cables, Fire resistant signal cables, Thermocouple Extension Cables, and many more types of signal cables
k. Junction Boxes and Terminal Blocks
l. Copper Tubes, SS tubes and Tube fittings

Category-4: System Integrators plays a major role in integration of specialized control system products where components of specialized Instrumentation systems are manufactured by OEMs (some components imported and some components are indigenously manufactured).

System integrators are very important in those cases where special Instrumentation & Control System OEMs are not willing to have an establishment in India or they are not willing to participate directly adhering Indian Geographical and Commercial laws.

Following are the specialized Instrumentation and Control System under this category:

a. Analyser Systems
b. PLC based Package Control System (for Burner Management System, Soot Blower System, Terminal Automation System, Material Handling System etc.)
c. SCADA and RTU System
d. Telecommunication and EPABX Systems
e. Fire Detection and Fire Alarm Systems
f. Closed Circuit TV System for surveillance
g. Fencing and Intrusion protection system

We have many System Integrators for Control Systems who get major components for above mentioned systems from OEMs and have expertise in integrating these components with many more bought out accessories and other components. *They have established integration facility, testing facility, expertise in installation, testing and commissioning at site and service after sales.*

These System integrators develop a long term tie-up agreement with OEMs. They provide a competitive platforms for many OEMs who does not want to take complete responsibility for end to end project execution as well as service after sales.

Category-5: The manufactures and fabricators for various erection materials like Instrument Cable Ducts and trays, Canopy, Conduits, Syphons, manifolds etc.

Category-6: Services for Instrumentation and Control Systems.

As we have many manufacturing companies for Instrumentation and Control Systems, we also need organization to provide the services for installation and commissioning and maintenance.

Indigenous Turnkey Instrumentation Contractors have been developed to execute the complete job of instrumentation on Turnkey basis starting from engineering, procurement, testing / inspection, supply, installation at site, testing and commissioning.

In some projects design engineering, procurement, inspection of I&C Systems for project site / Plant Units are done by Owner / Project Consultant. In such case we need only ***Installation and Commissioning Contractors*** for Installation and Commissioning of the Instrumentation and Control Systems.

Many contractors have been developed indigenously for installation and commissioning and post warranty maintenance of Instrumentation and Control Systems for executing small scale projects to mega projects and maintenance of plants in India.

Status of Indigenization:

Following are some data regarding status of indigenization:

There are only 21 items wherein only foreign supplier are enlisted, out of approx. total 150 Instrumentation and Control System Items. The balance items have either only indigenous suppliers /manufacturers or mixed of indigenous as well as foreign suppliers. Total no. of indigenous suppliers catering to these 150 items are more than 500 in numbers.

Following are some data regarding Business Scenario in Instrumentation and Control System (per annum) which depicts an approximate value of INR 35000 to 45000 Crores per annum depending upon the new projects and maintenance requirements in various field of industries:

Sl. No.	Items	Quantity. Nos.	Cost in INR (Cr.)	Indian %	Foreign %
A	Analysers				
	Stack Analyser	350 - 400	550 - 600	40	60
	Process Analyser	400 - 450	250 - 300	40	60
	Gas Chromatograph	20 - 30	80 - 100	35	65
	Oxygen Analyser	1650 - 1700	35 - 50	20	80
	Dust Monitors	1500 - 1800	30 - 54	55	45
B	Field Instruments				
	Field Sensors / Transmitter	150000 - 175000	550 - 575	70	30
	Pressure Gauge	420000 – 480000	160 – 180	100	-
	Temperature Gauge	280000 - 300000	180 - 240	100	-
	Thermocouple / Resistance Temperature with Thermowell	350000 - 450000	410 - 450	100	-
C	Control System:				
	DCS/ESD/F&G System (small to mega projects)	250 – 300 Projects (10 – 12 lakhs IOs)	1700 - 1800	70	30
	PLC Systems for OEM Package	3000 - 4000	500 - 550	70	30
D	Terminal Automation				
	Loading System Batch Controller	400 – 450	150 - 175	70	30
	Terminal Automation (Rail / Road)	20 - 25 Nos. (7-10 New & 12 - 15 revamp)	550 - 600	70	30
	Inline Meter Prover	2 – 3 (different sizes)	5 – 10	35	65
	Metering Skids	225 - 250	400 - 500	90	10
E	Flowmeters				
	Coriolis Mass Flowmeters	13500 - 15000	380 - 400	30	70
	Magnetic Flowmeters	45000 - 55000	800 – 950	85	15
	Ultrasonic Flowmeters for Flare	150 - 175	75 - 90	30	70
F	Level				
	Level Transmitter (Radar and Ultrasonic)	8000 - 8500	100 - 120	90	10
	TFMS Systems	50 – 60	110 – 130	30	70
G	Valves				
	On/Off Valves	175000	2200 -2500	95	5
	Control Valves	120000 - 150000	2100 - 2300	95	5
	Surge Relief Valves	4 - 6	15 -20	25	75
H	Nuclear Instruments (Level, Density, Switch)	150 - 250	30 - 45	30	70
I	Electronic Component				
	Relay	25 to 35 lakh pcs.	450 - 500	65	35
	Barriers / Isolators	20 to 25 lakh pcs.	410 - 450	25	75
J	Cables	1200000 Kilo Meters	19000 - 22000	100	0
K	Operator Console	18000 - 20000	65 - 80	100	0
L	Vibration System	1050 - 1200	370 - 400	35	65
M	CCTV Systems	550 - 650	2000 - 2500	55	45
N	FRP Cable Ducts and Trays	6500 – 7500 KMS	200 - 250	100	-

Note: Quantity and value indicated above are approximate data collected from various resources like I&C manufacturing company, contractors, end user etc.

Way Forward to Atmanirbhar Bharat:

We have been continuously engaged in the process of creating an opportunity leading to promotion of the Indian Manufacturing Industry for Instrumentation and Control Systems and thus ensuring compliance to ***Purchase Preference linked with Local Content (PP-LC).***

We have to stride to manufacture all the components of Instrumentation and Control system indigenously as step towards "Atmanirbhar Bharat".

Presently Analyzers, DCS/PLC Processor, Input and Output Cards, Vibration Systems, Isolators and Barriers, Relays, Control Valve Positioner etc. are imported. These sub-components item needs immediate focus for complete manufacturing and assembly in India as a Way forward to "Atmanirbhar Bharat".

Our Ministries / Govt. Departments shall take initiative in promoting indigenization for the items where there is sufficient local capacity and competition and where public procurement shall be done only from local suppliers.

About the Author:

Mr. Manish Kumar is currently working as Asst. General Manager – Instrumentation, Engineers India Limited, New Delhi and having now 21 years of design, execution and commissioning experience in India and abroad. He has presented technical papers and also contributed in training of new engineers. He is also an active member of International Society of Automation – Delhi Section.

RELIABILITY

Tube skin temperature measurement techniques to enhance Asset life and optimise performance of Fired heaters in Refineries

Sourav Mukherjee
(Manager) Instrumentation Department

Engineers India Limited

Abstract

Fired Heaters are one of the most critical equipment in oil & gas industry. Fired heaters are a vital cog in operation of major process units like crude & vacuum distillation units, hydrocrackers, catalytic reformers, fluidised crackers and cokers and hence, their reliable operation have serious impact on productivity of refinery complexes. The major bottleneck in case of heater performance and asset management becomes the performance of heater skin thermocouples, which measures tube temperature and monitors coking and tube health. The traditional designs of the thermocouples are prone to failure and inaccuracies in measurement and industry has been looking forward to more robust alternatives for some time. These instruments are also extremely sensitive to high temperature sulphidation, especially in fuel fired heaters. Hence, material selection becomes very challenging.

The major aim of refiners has always been to operate the fired heaters in trouble free and safe manner, however, excess emphasis on safety compromises productivity. For example, if the margin between the heater tube's permissible operational temperature and high tube temperature alarm is kept at high value, it increases safety but compromises on productivity, hence such unreasonable margins are also not practical. The coking in heaters is also estimated from the heater tube temperature. Failures & Inaccurate measurement of the tube skin temperatures force the maintenance personnel to run the heaters at reduced capacity or take unnecessary shutdowns in heaters, which has severe financial impact.

To estimate the financial impact, a case study on the financial impact of inaccurate skin tube temperature sensors has been carried out in a Vacuum heater of a 9 MMTPA refinery and it has been found that early decoking exercises due to inaccurate skin temperature measurement typically result in loss of 4 days of operation in a year, which translates into losses of 3.6 Million USD / year (considering gross refining margin (GRM) of 5 $/ bbl for the refinery).

Instrument department of Engineers India Limited has carried out a detailed study on performance, reliability and availability of the heater skin thermocouples.

This paper aims to provide the industry a detailed review of tube temperature monitoring techniques for heaters in various units, categorised on their temperature of operation, possibility of coking & fuel used for firing. In this paper the traditional heater tube skin thermocouple designs have been studied in detail taking into consideration the metallurgical aspects, layout related constraints inside furnaces as well as statistical data from refineries across India and the gathered information has been used to develop new designs which are more robust to failures. The capability of Indian manufacturers has been taken in consideration while selecting the new designs which contributes to "Make in India" initiative.

1. Introduction

Traditionally, heater tube measurement has been done using heater skin thermocouples employing knife edge design. In this design (Figure-1), the tip of the thermocouple is welded to the heater tubes and then insulated with kaewool and covered with a heat shield. The material of construction of the skin tube thermocouple sheath is SS 446 and traditionally larger diameter and high thickness sheaths (typically sheath diameter of 12.7 mm with sheath thickness of 3.18 mm for knife edge design) are considered with the intent of providing robustness to the design. For temperature sensing, duplex K type thermocouples (chromel & alumel) of 16 AWG are used.

The tip is non-detachable, hence failures require outright replacement of the sensors at a new location.

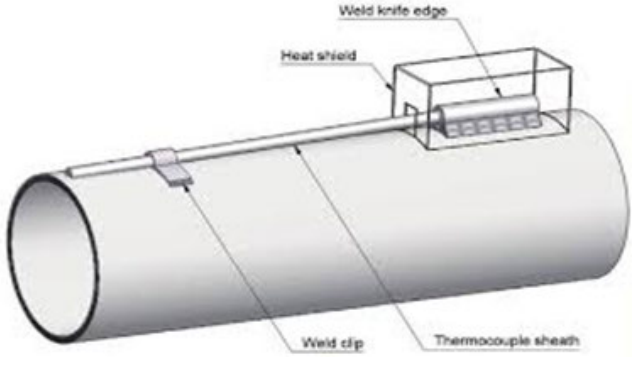


Fig. 1 : Knife Edge Design

In order to mitigate the problems associated with the welding of the tip, the weld-pad designs were introduced. In this design, a pad with a guide tube gets welded to the heater tube and the skin thermocouple is inserted to the pad. The sensor tip is covered with kaewool insulation and encapsulated in a heat shield. The dimensions of the heater tube skin thermocouple sheath are lesser than that of knife edge design (typically sheath diameter of 9.5 mm with sheath thickness of 2.2 mm). The material of construction of sheath and sensor are same as that of knife edge thermocouple design.

However, both the designs have high failure rate in terms of thermocouple reliability, sheath rupture, inaccuracies in temperature measurement and higher sheath dimensions cause layout related problems too.

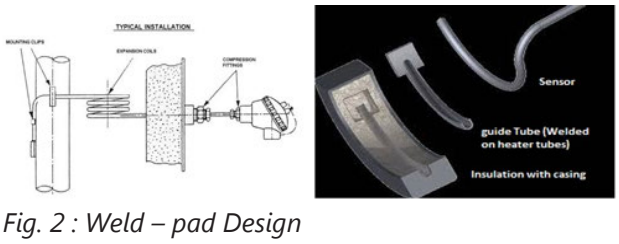


Fig. 2 : Weld – pad Design

In this paper the following step by step systematic approach has been adopted to identify the probable causes of failure and necessary strategies to mitigate the associated problems.

- Study of the various types of heaters in various units of refinery Complexes and their classification based on heater box temperature and corrosive constituents in the firing fuel.
- Study of the material of construction of skin type thermocouples sheath material , insulation material and accessories material and selection of most appropriate MOC with respect to the various heater categories.
- Study of the dimensions and layout of the current designs of skin thermocouple and its impact on the layout and modifications to mitigate problems associated with current dimensions.
- Studying manufacturer capabilities in India and ensuring that the modified designs are available with Indian manufacturers as well.

2. Classification of Fired heaters

In refinery complexes, Fired heaters differ substantially in terms of size , operation and configuration. In case of heater tube skin temperature monitoring, the principal parameters are heater box temperature in radiant section and corrosive constituents.

The Following table summarize the fired heaters in various units of refinery complex which has been considered as a part of this study

S.No.	Unit	Heater	Remarks
1.	CDU VDU	Crude heater	Operated under steady state. Crude composition can vary widely.
2.	CDU VDU	Vacuum Heater	Operated under steady state conditions. Coking is a major challenge in this heater
3.	CCR Unit	Reformer heater	Heats Naptha at high temperatures. Large amount of Three dimensional movement of tube is a challenge. Layout of tube skin thermocouples is very important in these heaters.
4.	Hydroprocessing units	Hydrotreater / hydrocracker heater	Steady state furnaces with some potential of coking.
5.	FCCU	FCCU furnace	Steady state furnaces.
6.	DCU	DCU heaters	Heating of DCU feed. This heater is extremely prone to coking.

Table 1

The major parameters which affect heater tube skin measurement have been identified as a part of this study and the following parameters have been identified :-

1. Heater Box temperature (temperature of flue gas leaving the radiant section + 100 Deg. C): This is classified as follows :-

a. Box temperature < 860 deg.C.
b. Box temperature between 860 deg C and 1000 Deg C.
c. Box temperature above 1000 Deg.C.

2. Percentage of sulphur in fuel : The major demarcation will depend upon whether the heater is fuel fired or gas fired. In case of dual fired heaters, the fuel with higher sulphur content shall govern the material selection. This parameter is classified as follows:

a. Sulphur content less than or equal to 0.5 %.
b. Sulphur content greater than 0.5 %.

3. Impact of Skin tube thermocouple material of construction

Sheath material

The traditional sheath MOC of SS 446 has been studied in detail and following are observed :-

Advantages :-

- This material shows strong resistance to high temperature sulphide and chloride stress corrosion.
- This material shows good oxidation resistance up to high temperatures of 1200 Deg.C.

Disadvantages :

- This material's ductile to brittle embrittlement point is quite low (473 deg.C) with respect to heater applications. As a result, in heaters where the sheath is subject to vibrations as well as expansion and contraction at elevated temperatures, the sheath dislocates.
- With the sensor element being K type thermocouple (constituting of chromel and alumel alloys), the coefficient of thermal expansion of this material is substantially lower than that of the sensing elements. This causes stress fractures in the sheath at higher temperatures as sensor and the encased sheaths expand at different rates.

A detailed analysis of the heater tube skin material has been carried out as per the heater classification done in section 2 and following table has been established as a material selection guideline for heater skin tube thermocouples.

S. No.	Temperature Range (T) deg. C	Sheath Material	
		S < 1%	S >= 1%
1.	T =< 870 Deg. C.	Inconel 625	Haynes HR 160 Alloy
2.	870 < T =< 1000 Deg. C	Inconel 625	Haynes HR 160 Alloy
3.	T > 1000 Deg. C	Pyrosil D / Alloy TD	Pyrosil D / Alloy TD

Table-2 **Sulphur content in fuel (S)**

Accessories

The skin thermocouple accessories are also traditionally considered of the MOC SS446, however, it has been found that accessories are quite robust in nature and no damages are usually encountered in them. Therefore, in place of SS 446, SS 310, which is a more economical alternative, has been recommended.

Insulation material

As an insulation material, better alternative to kaewool has been identified which prevents outside flame temperature to affect the readings of the tube temperature.

Ceramic moulded insulation which offers very low Thermal conductivity (less than 0.33 W/mK at [℃] at 1472^{0}C) is recommended.

4. Impact of Heater Skin tube thermocouple Dimensions

Traditionally the dimensions of the heater tube skin thermocouples are kept on the higher side. The traditional dimensions are typically sheath diameter of 9.5 mm with sheath thickness of 2.2 mm. The prevalent design was studied and on deeper inspection the following observations are found :-

Advantages :-

- The sheath dimensions and thickness being higher, this design is more robust in terms of strength.

Disadvantages :-

- Despite being more robust, the thicker dimensions mean that the expansion loops (Fig. 3) which need to be given inside the furnace become larger (larger O.D).

- This increases the chances of the tubes being exposed to direct flame from the burners.
- This substantially reduces the life of the skin tube thermocouples and causes failure.

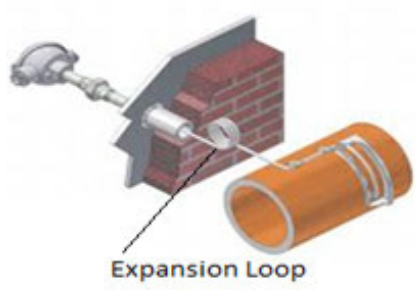


Fig. 3 : Expansion Loop

Hence, best possible life can be ensured if expansion loops are kept small with minimum possibility of exposure to direct flame.

All available dimensions used across the world have been studied. The final selected dimensions have been established as sheath O.D. of 8mm with sheath thickness of 1.3 mm.

These dimensions are found to be the best selection to ensure both robustness in design and proper layout.

5. Installation

The installation of heater skin tube thermocouples also plays a major role in their performance. Incorrect expansion loops lead to tube life reduction. However, in many cases, these devices are found malfunctioning due to wrong installation.

On deeper investigation it has been found that during construction work, due to large scale of operation, a large part of heater assembly happens at construction site. The tube skin thermocouples are generally installed by the heater fabrication and installation contractor at site without any supervision of the tube skin thermocouple manufacturer. This results in improper layout, wrong expansion loops which comes to direct exposure to flame, incorrect welding of the guide channel and all of them lead to measurement inaccuracies and failures.

Hence, it is strongly recommended to deploy tube skin thermocouple manufacturer's supervision services to ensure correct installation (fig. 4).

Fig. 4 : proper installation of sensor and expansion loop

6. Manufacturer capabilities

The new designs are at par with the designs followed across the globe and once new designs have been fully implemented, Indian manufacturers have also come up showing good progress which can be taken under observation. At each stage, detailed inputs have been taken from the manufacturers and final design has been established keeping in mind the manufacturing capabilities of the Indian manufacturers. The availability of raw material, knowhow and facilities of manufacturing of all the manufacturers across board has been considered in selecting the material and dimensions of the heater skin tube thermocouples. Also, all manufacturers have the necessary capability of providing expert supervision services during installation, commissioning and maintenance from India itself.

7. Conclusion

The performance of heaters is one of the most important pre-requisite for trouble free operation of refineries. Proper functioning of heaters and its asset life monitoring needs efficient performance of heater tube skin thermocouples and best performance from these devices can only be expected if all the aspects of design, selection, installation, commissioning and maintenance are properly taken care of. Most optimum design of the heater tube skin thermocouple has been identified in this paper considering performance, reliability and availability. The new designs can be adopted suitably in new heaters as well as in heater revamps. Layout related considerations have also been covered and best installation practices have been recommended.

The selected design is readily available with Indian suppliers, also the capability of Indian suppliers to provide expert supervision services have been established contributes to the make in India initiative.

OIL & GAS IN MEDIA

India Gets its First Natural Gas Trading Exchange

On 15th June 2020, Minister of Petroleum and Natural Gas & Steel Shri Dharmendra Pradhan launched India's first nationwide online delivery-based natural gas trading platform in an e-ceremony.

Speaking on the occasion, Shri Pradhan said that the launch of the new electronic trading platform for natural gas has opened a new chapter in the energy history of India and help the nation move towards free market pricing of natural gas. He said that with this landmark, India is joining the club of progressive economies which will see a market driven pricing mechanism for gas. He also said that the government has no business to be in business and the consumer is the king in a free market, and through this initiative, India's vision on mega investments on LNG terminals, gas pipelines, CGD infrastructure and permission for market driven price mechanism will be materialized.

Referring to the various initiatives taken to make India a gas-based economy, the Minister said that Indian gas market has multiple price bands for assets including pre-NELP, NELP, High Temperature and High pressure (HTHP) and Deepwater and Ultra Deep Water blocks. He said that the country will soon have 50 MMT LNG terminal capacity. He said that the country has long-term gas contracts with many countries like Qatar, Australia, Russia and the US, and has made investments abroad in strategic assets in Mozamibque, Russia and other countries. He also mentioned about various ongoing projects to strengthen the gas infrastructure in the country like Urja Ganga, Eastern India grid, Indradhanush project in the North-east, Dhamra-Dahej pipeline, coal gasification and CBM policy and the country will have more than 30,000 km of pipeline in next few years. He further said that the government of India is taking steps to move Indian gas pricing closer to market based prices and the inauguration of IGX will be a new chapter in India's market based gas pricing mechanism.

Secretary, Ministry of Petroleum and Natural Gas Shri Tarun Kapoor, PNGRB Chairperson Shri D. K. Saraf were also present on the occasion. Shri DK Saraf, said that "PNGRB has been working on regulations to provide full access to pipelines, reforming pipeline tariffs and other steps to facilitate a gas trading hub in the country".

The trading exchange for physical delivery of gas was launched by Indian Gas Exchange (IGX), a wholly owned subsidiary of Indian Energy Exchange (IEX). To begin with, trading is proposed at the physical hubs at Hazira and Dahej in Gujarat and Oduru/Kakinada in Andhra Pradesh while new hubs would be introduced ahead. IGX will seek time scheduled bids from buyers and sellers for price discovery. On this, a price discovery mechanism will operate to settle delivery of gas. The exchange will provide six market products — day-ahead, daily, weekly, weekdays, fortnightly and monthly.

India's gas consumption is almost split evenly between domestic gas production and LNG imports. A large portion of the gas is allowed to be marketed freely in the country is RLNG and currently around 30% of LNG available for trade in the short term spot market. Price of domestically produced natural gas is regulated and is sold at fix price set by PPAC on a half yearly basis. For the first phase of the launch there will be three nodes, with ex-terminal prices at two of India's busiest LNG terminals Dahej and Hazira in Gujarat on the west coast along with some domestic gas in Oduru, Andhra Pradesh on the east coast.

Within the first two days of its operation, IGX has got a market- discovered price of $4.07 per mmBtu, which is around 70% premium to the present domestic natural gas price of $2.39 per mmBtu, which most producers have cited as unviable.

JMMC urges OPEC Plus Members to Adhere to Cut Commitments

Following through on the commitments made by various countries to cut production, the Joint Ministerial Monitoring Committee (JMMC) has pointed out that the commitments made to reduce crude production is critical to ensure the stability of oil market and economic recovery as the world recovers from COVID-19 pandemic and the resulting economic downturn.

The JMMC is co-chaired by Russia and Saudi Arabia's energy ministers, and is tasked with assessing energy market conditions, especially as it relates to conformity levels with oil output cuts agreed to at OPEC-plus meetings. The JMMC recommends adjustments if needed, or staying the course.

At the recently concluded meeting over teleconference, on 6 June, members of OPEC and their allies, including Russia and Mexico agreed to extend the production cuts of 9.7 Mbpd through the end of July, hoping to encourage stability in energy markets hard hit by the coronavirus-induced global economic crisis. The group further emphasized the critical importance of adhering to full conformity, and compensating the overproduced volumes in the months of May and June, during the months of July, August and September" JMMC, in its recent report published on 18 June underlined that "100% conformity from all participating countries is not only fair and equitable, but vital for the ongoing and timely rebalancing efforts and helping deliver a sustainable oil market stability". JMMC's recent comments are in light of the OPEC's monthly oil market report for June, which shows that the group's crude oil production decreased only by 6.3 per cent in the month of May, averaging at 24.19 Mbpd. Meanwhile, the demand estimate for OPEC crude this year was revised down by 700,000 bpd to 23.6 million bpd.

The JMMC noted that there was only 87 per cent adherence to the new production limits in May, chiefly due to the lack of follow through by some OPEC plus participants. To ensure 100% per cent compliance, these countries will have to make additional cuts on top of their pre-determined allotment in July, August and September to compensate for the shortfalls recorded in May and June.

FIPI EVENTS

FIPI-EY Webinar on Gas Market Outlook - Navigating the Challenges

The outbreak of COVID-19 pandemic all over the world has disturbed the political, social, economic and financial structures of the whole world. The strongest of the economies around the globe are struggling to cope with the situation in the aftermath of an unprecedented demand shock and a complete shutdown of all economic activities that drive growth. This unexpected pandemic presents profound challenges for the Global Natural Gas Industry, as it does for the energy system as a whole and the economy at large.

Recognising the need to bring the gamut of issues surrounding the pandemic on the forefront, the Federation of Indian Petroleum Industry (FIPI) in association with EY organized a webinar on navigating the challenges in the current gas market on May 01, 2020. The webinar saw attendance of over 350 participants from more than 75 companies. In his opening remarks, Dr. R.K. Malhotra, DG FIPI stated that the outlook for global natural gas demand was optimistic before COVID-19 pandemic backed by steady growth throughout the world, however if delayed stabilization happens, the global demand in 2020 will take a hit and may fall well below the 2019 levels. He further stated that oversupply and demand shrinkage have led to collapse of global prices of LNG and this can compete with coal for power generation in favour of gas in India. Among the gas consuming sectors, CGD was the most impacted with restricted transportation, non-essential industries are shutdown. However, domestic-PNG demand had gone up while fertilizer, power and petrochemical sectors were moderately impacted. After the opening remarks by Dr. Malhotra, EY's experts shared their views on the Global and Indian gas fundamentals and outlook. This was followed by an interactive panel discussion with eminent leaders from the gas industry and finally the Chairman PNGRB shared the regulatory perspective towards the end of the webinar.

FIPI organises CFO Meeting to Discuss Liquidity Constraints of Oil Companies

A virtual meeting was held on May 11, 2020 at 11:30 am with Chief Finance Officers of oil and gas companies that are member of Federation of Indian Petroleum Industry to discuss the liquidity constraints of oil companies during these trying times and to pave a way forward. The meeting was attended by Mr. Subhash Kumar, Director (F) ONGC, Mr. Sandeep Kumar Gupta, Director (F) IOC, Mr. A.K. Tiwari, Director (F) GAIL, Mr. Harish Madhav, Director (F), OIL, Mr. Harak Banthia, CFO HMEL, Mr. Anup Vikal, CFO Nayara Energy, Mr. Vivek Rathi Dy CFO Cairn Oil & Gas and Ms. Sujata Londhe, CGM, HPCL. Dr. R.K. Malhotra, DG FIPI and Mr. Rajiv Bahl, Director (F) FIPI also participated in the meeting.

The agenda of the meeting was to discuss two issues - Liquidity issues faced by the oil companies due to fluctuating oil prices and the downward trend in sales volume and additional Strategic Storage capacity over and above the existing one.

Dr. R.K. Malhotra, DG FIPI in his opening remarks gave a brief over view of the current crisis situation created by COVID-19 and the difficult phase the oil and gas industry is going through at present as also the serious challenges being encountered by the oil companies during the lockdown period. He assured the participants that FIPI would take up the issues that may be flagged during the meeting and seek support from the Govt wherever required.

Mr. Rajiv Bahl Director (F) FIPI, welcomed the participants to the meeting and gave an overview of the Agenda. The discussion was moderated by Mr. Bahl.

It was discussed that the ongoing worldwide health emergency caused by the COVID-19 pandemic has brought about a series of unforeseen challenges for us as a country. The unprecedented disruption of this scale has affected every sector and industry across the globe and has seriously affected the operations of the oil and gas companies in India in view of drop in demand, logistical constraints and sharp price drop.

The upstream sector is in its worst ever form, considering that sustaining operations is proving to be difficult. At the current low oil and gas prices, upstream companies are not able to cover their costs. Unsustainable prices coupled with incidence of Royalty & Cess and Government's share in profit petroleum is seriously hindering the performance in terms of cash flow and liquidity management for upstream companies.

The refineries are also faced with a unique set of challenges, especially being capital-intensive low margin businesses. Specifically, there has been huge fuel demand erosion and consequent large revenue losses resulting from the lockdown. The impact is larger for inland refineries, which do not have ability to export. Further, the oil prices have collapsed leading to unmitigated inventory losses, impacting working capital, liquidity and cash flow in the immediate and shorter term, leading to massive increase in borrowings.

A variety of suggestions were made both by the upstream as well as the downstream sector in terms of the support that is required from the government.

It was desired that support form Govt. should be solicited in getting flexibility of end-use restrictions & hedging requirement on external commercial borrowings (ECB) for 3 and 5 years, similar to new ECB notification issued in October 2018 allowing Oil Marketing Companies (OMCs) to raise ECBs for working capital by extending the facility private sector refineries also. Support from Government of India was also requested for allowance of temporary retention of excise duty payments on domestic sales of oil products which would generate near term liquidity for the oil companies and would ease the tight liquidity situation currently being faced.

It was felt that Government of India should provide medium term liquidity support to the oil industry through placement of oil sector specific Sovereign Guarantee Bonds which could be issued by the oil companies with relatively modest covenants in the backdrop of current challenges in demand and profitability.

The country imports about 80% of its crude oil requirement and the remaining 20% is supplied by domestic crude oil producers. While there is a general perception that the refiners enjoy tariff protection to the extent of basic customs duty on petroleum products, it was observed that the refinery tariff protection has consistently fallen over the last few years. The overall tariff protection is just about 1 % on two fuels namely MS and HSD. It was suggested that the tariff protection should be increased from the current around 1% to at least 5 %.

It was also discussed that since petrochemicals is an important cog in the entire value chain, it is important to protect the petrochemical business for the sustenance of the value chain. An added concern was the fact that most petrochemicals plants set up in SEZs were required to pay customs duty in order to sell within the country. This meant that most companies were being forced to sell outside the country even though the Indian market is more lucrative. This situation needs to be corrected.

From the mid-stream point of view, it was discussed that a unified tariff for transportation of gas should be brought about and hence PNGRB should change the methodology of calculation for the same.

It was decided that post lockdown, a study can be undertaken on increasing strategic oil storage. Building or capacity addition of strategic oil storage is a sovereign decision and not a company decision. There are various operational costs involved in maintaining a strategic storage facility. It was also suggested to explore options for building strategic storage for natural gas.

FIPI organises Webinar on COVID-19 Crisis Management – Challenges in Oil Marketing

Over the long history of oil, the market has endured multiple shocks, but none comes closer in ferocity and severity to what it is facing today. The market has been hit by a double whammy of falling prices and shrinking demand. The increasing number of COVID'19 cases and the sweeping lockdowns and travel bans across all major demand centres, resulted in an unprecedented shrinkage in demand of crude oil and products.

In India, the nationwide lockdown that came into effect on 24 March, 2020 brought the entire economy to a standstill. As result of massive fall in fuel demand, oil marketing companies (OMCs) are facing the challenge of drying revenue streams and acute liquidity constraints. The fact that Indian OMCs maintained uninterrupted

supply in spite of the threat of the pandemic and nationwide lockdown, stands testament to the sector's commitment to the larger objective of national welfare.

With this background, the Federation of Indian Petroleum Industry (FIPI) joined hands with I-ten Media to organize the webinar on 'COVID-19 Crisis Management – Challenges in Oil Marketing'. The objective of the webinar was to provide the India's Oil Marketing Companies (OMCs) with a unique platform to share their experiences of circumventing barriers to ensure uninterrupted supply; to highlight bottlenecks and future challenges; and to cull out areas, where Government support will be imperative for OMCs to successfully tide over the COVID inflicted crisis. The esteemed panel for the webinar comprised of Mr Sunil Mathur, Executive Director (LPG), IndianOil; Mr P S Ravi, Executive Director – Retail, BPCL; Mr Madhur Taneja, CEO – Oil Retail, Nayara Energy and Mr Raj Bhan, Senior Vice President, RIL. The discussion was moderated by Mr Anish De, National Head – Energy & natural Resources, KPMG.

The opening address at the webinar was delivered by Dr R K Malhotra, Director General, FIPI. Mr Malhotra pointed out that lockdowns due to COVID-19 have created havoc for the global economy and India is no different. Some recent estimates by agencies indicate zero to negative growth in 2020 as well but majority find it within positive scale. He highlighted that liquidity has emerged as a major issue for Indian Oil Marketing Companies (OMCs) as they continued to incur expenses during the lockdown while the revenue witnessed a sharp fall. He further reiterated that the Federation of Indian Petroleum Industry (FIPI) stands firmly by the ailing Indian industry at this time of crisis and assured that FIPI has been working closely with the Government to create a supportive policy ecosystem for the industry to grow.

During the panel discussion, it was pointed out that the overall consumption of liquid fuels fell by as much as 60 per cent in April. Industry has witnessed a demand destruction of over 12-14 KL per day due to the COVID induced lockdown. The objective of the OMCs during this period was to ensure business continuity while ensuring safety across the entire value chain. However, a recovery in the sale of liquid fuel was recorded in both urban and rural markets in the month of May. Panellists highlighted that during the lockdown an increase in nationwide consumption LPG was recorded. Against an annual growth of 6.6 per cent in FY'20, LPG consumption grew by over 12 per cent in the month of April, 2020 alone.

There was a consensus among the panellists that the liquidity and cash flow situation has emerged as a major challenge for all Indian OMCs. To deal with the increasingly difficult cash flow situation, many Indian OMCs adopted the cash and carry approach. OMCs have also encouraged franchisee partners, whose profitability has also been impacted due to reduced sales, to ensure that the cash flows remain intact for them. Panellists agreed that during these challenging times, it is of utmost importance to ensure that the entire set of resources at all levels are safe and available for business activities. Companies are coming up with Standard Operating Procedures (SOPs) to ensure safety of employees and customers at all points. Many marketing companies are making use of this time to train and reskill their employees to better tackle the future challenges and operate in a changing business environment. Many OMCs are also focussing on process improvement and investing in cutting edge digital technologies.

The webinar received an overwhelming response and was attended live by over 300 participants. The webinar was attended by a wide spectrum of participants ranging from Ministry, regulators, OMCs to media. The panel discussion proved extremely engaging and witnessed some very insightful replies to the questions raised by the participants.

Webinar on Impact of COVID 19, Lockdown & Depressed Oil Price Scenario on Upstream Operators and Service Providers

The Global Oil & Gas Industry has been reeling under immense pressure of the extremely adverse impact of COVID-19. The upstream operations, which had not fully recovered from the previous oil shock of 2014 have now been hit hard by the double whammy of depressed oil prices and shrinking demand. The situation is 'unprecedented' and will require focussed action from operators, service providers and the government to tide over the current crises.

Post lockdown in India on 24 March 2020, the Indian Oil & Gas Industry has had to navigate through a mesh of challenges ranging from measures to ensure workforce safety to managing resource movement within lockdown rules. However, what has been commendable is the strong resolve and determination of all the major stakeholders who have risen to the challenge and ensured continuity of business operations. Government by awarding the status of essential services to the sector, has also played a vital role in supporting field operations.

To address some of these challenges, the Federation of Indian Petroleum Industry (FIPI) joined hands with I-ten Media and Boston Consulting Group, to organize a webinar on 'Impact of COVID 19, Lockdown & Depressed Oil Price Scenario on Upstream Operators and Service Providers'. The objective of the webinar was to provide India's Oil & Gas Upstream Operators and Service Providers with an opportunity to share the challenges of managing the current situation and to highlight the key areas where Government support and intervention was required. The esteemed panellists included Dr. Rajesh Kumar Srivastava, Director (Exploration), ONGC, Dr. P Chandrasekaran, Director (Exploration & Development), OIL, Mr. P Elango, MD, HOEC Ltd. , Mr. Sai Subramanian, President (Rajasthan Operation), Cairn Oil & Gas Vedanta Ltd., Mr. Rajeev Kumar, Director (Regulatory Affairs & Upstream Business Development), BP India and Mr. K Gautam Reddy, MD (India & Bangladesh), Schlumberger.

The session was moderated by Mr. Kasutav Mukherjee: India Energy Practice Lead, MD and Senior Partner, Boston Consulting Group. The opening address was delivered by Dr R K Malhotra, Director General, FIPI. Dr. Malhotra at the very outset laid out some of the key challenges being faced by the sector in terms of risks to workforce health & safety, restrictions owing to COVID-19 lockdown, and the impact of low oil prices due to subdued demand. He also complimented the effort & determination of the industry to ensure continuity of business operations under such challenging times. He reiterated the continued support from FIPI for the industry and assured continuous engagement with the Government to ensure a more supportive policy framework, targeted towards long term industry growth.

During the panel discussion it was pointed out that the recovery in oil prices may not be that quick and demand is expected to pick up at a slow pace. Major CAPEX cuts upto 25 – 30%, have been undertaken by majors across Europe & USA. Further production cuts upto ~28% are also expected by end of calendar year 2020. Panellists highlighted that the COVID-19 lockdown had not only created challenges in terms of resource deployment, but also higher costs owing to increased safety norms.

There was consensus among the panellists that immediate support was needed from the Government in terms of reduction in taxes and cess, funding support specifically for smaller independent operators and improved policy framework. A need was also felt for increased collaboration between the Operators and Service Providers to come up with innovative risk sharing partnership models and to invest in niche technologies to address the individual needs of the operators. Liquidity concerns were echoed by all the panellists and each pointed towards an increased need for a capex prioritization framework focused at long term sustainability of the industry. Some of the upstream operators have engaged in price negotiations for key consumables such as polymers, to reduce their OPEX spend. The panellists also emphasized the need of frequent employee engagement and increased safety measures to ensure the well-being of the employees on ground.

The webinar received an overwhelming response and was attended live by over 300 participants. The webinar saws attendance of large number of Operators and Service Providers from the Upstream industry and senior Government Functionaries, Regulators and Media were also present at the event. The panel discussion was not only engaging, but also proved to be invaluable in terms of the great ideas shared by the panellists to address the current scenario.

Shell India – FIPI collaborate to deliver Road Safety Virtual Workshop 26th June 2020

Introduction: As part of FIPI HSE committee (Health, Safety and Environment), Shell India offered to conduct online Road Safety Workshop for FIPI members and other Industry players to spread awareness on best practices. Globally Road Safety is a priority in Shell as they clock more than 500 million km every year in land transport as part of business, and thus they have Robust practices to manage Road Safety.

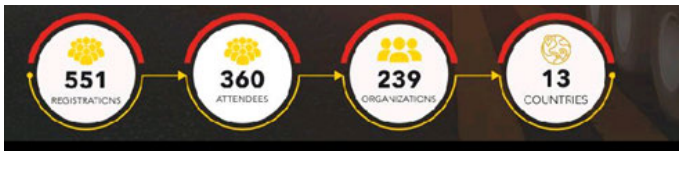
Background: Indian road witness one death every four minutes, with almost 80% attributed to human error. Road transport is the dominant mode of transport for Petroleum products and safety standards for transportation dangerous goods govern by local rules and regulations, still Indian roads have potential for high consequence road accidents with multiple fatalities or fire or spill, involving road tankers.

Case for Change: In Oil & Gas Industry, land transportation of fuel is last leg of value chain and plays an important role in safe & efficient operations. Thus, as part of FIPI safety committee, Shell and FIPI encourage members to come forward to collaborate and contribute to safe operations on Indian roads. Mr. Swapnil Kamulkar from Shell took lead to initiate the program.

Shell India and FIPI jointly organized a four hours workshop of Road Safety online for Oil and Gas companies in India including National Oil companies and private players. The aim of the workshop was to create an eco-system that promotes safe road behaviors on Indian roads by collaborating with like-minded corporate and government

Session Highlights:

- The session was delivered successfully on 26th June with **four hours of virtual awareness session**, which was attended by more than **360 participants**. This was followed by Q&A session on HSSE/Contract, Driver, vehicle and Journey Management.
- Opening session from FIPI side was delivered by Mr. T. K. Sengupta, Director (E&P), Mr. N.K. Bansal , Director (oil Refining & marketing) and Dr R.K. Malhotra , DG , FIPI
- In his opening address, Dr R.K Malhotra said that oil industry has moved to BS6 fuel standards considering the carbon emission .
- These clean fuels can improve the air quality and going ahead renewables, biofuels, hydrogen will be give much cleaner air.
- Dr. Malhotra said that, Digitalisation & technology advancements like GPS tracking, speed monitoring can be applied for safe running of vehicles considering the fact that oil companies transport dangerous goods. Use of data analytics for analysing vehicle speed, route , driver behaviour can improve the safety, he further added.
- Opening session from Shell side was delivered by Mr. Suresh Nair (Distribution Ops manager India) and Mr. Swapnil Kamulkar (GM Downstream Land Logistics) and Mr. Pramod Srivastava (Road transport manager)
- Faculty for workshop/presentations were Mr. Abhilash Verma (Global Road Safety Advisor), Mr. Sabyasachi Bhattacharya (RT program manager), Dr. Kumkum Roy (Road Safety Lead, India)
- Mr. Abhilash Verma has presented the Award winning initiative "Eye camps for commercial Drivers" as part of Shell India CSR project. This initiative is successfully running since 2019 and more than 180000 Industry drivers are covered in India.



Content highlights	
1. HSSE and Contract management ▪ Meeting started with safety briefing and refreshing anti-trust matters. ▪ Importance of structured road transport management system (PDCA cycle) ▪ Challenges and risk of Indian road/logistics environment ▪ Setting up robust contract management process (evaluation to on-going)	**3. Vehicle management** ▪ Importance of vehicle standards and structured maintenance management ▪ Structured regime of daily and monthly inspection ▪ New technologies to make vehicle safe and improve comfort and performance ▪ Use on In -vehicle monitoring system (IVMS) and on-board camera
2. Driver management ▪ Importance of drivers in value chain and current challenges ▪ Driver selection and onboarding, human factors, care and respect ▪ Defensive driving training and remedial training program for year ▪ Driver empowerment and welfare programs	**4. Journey management** ▪ Importance of Structured route hazard management and route planning ▪ Updating and communicating JMP (Journey management plan) ▪ Safety, security and emergency are part of JMP ▪ Authorized halt point and monitoring of duty/driving/rest periods

Outcome: Shell India encourage members of Oil and Gas industries to come forward & join road safety initiatives like Driver Eye camps, Driver skill building or emergency response. The next FIPI safety committee meeting will take agenda of the joint efforts forward.

NEW APPOINTMENTS

Shrikant Madhav Vaidya takes over as Chairman of Indian Oil Corporation Ltd.

Mr. Shrikant Madhav Vaidya has taken over as the Chairman of Indian Oil Corporation Ltd. On 1st July 2020. Concurrently, he will also be Chairman of Chennai Petroleum Corporation Ltd., a stand-alone refining subsidiary of IndianOil and Indian Oiltanking Ltd another joint venture providing 'terminalling' services apart from being on the board of Hindustan Urvarak & Rasayan Ltd., a joint venture setting up three world-scale fertiliser plants. Mr Vaidya who is on the board of Ratnagiri Refinery & Petrochemicals Ltd. will be taking over as its Chairman and will also be Director on the Board of M/s Petronet LNG Limited. Prior to his elevation, Mr. Vaidya was the Director (Refineries) on the IndianOil Board, since October 2019.

A Chemical Engineer from the NIT, Rourkela, Mr. Vaidya has over 34 years of extensive experience in refining & petrochemicals operations. He has had a decade-long association with India's largest cracker plant - the Panipat Naphtha Cracker Complex, a major driver of IndianOil's petrochemicals business - right from the drawing board stage. He is among the select technocrats in the Indian oil & gas industry who are proficient in all facets of refinery-petrochemicals integration, desirable for the sustainability of the oil & gas industry in the long-term. We also welcome Mr. S.M. Vaidya as Chairman of Federation of Indian Petroleum Industry (FIPI).

Om Prakash Singh takes over as Director (Technology & Field Services) of ONGC

Mr. Om Prakash Singh has taken over charge as Director (T&FS) of ONGC on 1st April 2020. A Mechanical Engineer with more than 32 years of experience, Mr Singh has built a deep industry understanding and proven management experience across the technical and commercial roles he undertook during his career.

Mr Singh has a distinguished track record as a drilling engineer and has demonstrated dynamic leadership and vision, as he progressed through various roles within the company. He is well-versed with national and international Exploration & Production business and carries an extensive experience of offshore and onshore operations. With a focus on performance metrics and a continual drive for excellence, Mr Singh spearheaded Tripura Asset as the Asset Manager. During his tenure, the Asset made significant improvements – as he was instrumental in a number of initiatives and enhanced the overall performance of the Asset by fast-tracking projects and synergizing resource mobilization and its utilization.

Anurag Sharma takes over as Director (Onshore) of ONGC

Mr Anurag Sharma has taken over charge as Director (Onshore) of Oil and Natural Gas Corporation Ltd on 1st June 2020.

A Mechanical Engineer (MNREC, Allahabad) and MBA (FMS, Delhi), Mr Anurag Sharma joined ONGC in 1984. Since joining he has held various positions in ONGC and ONGC Videsh in Asset Management, Operations and Services.

Mr Anurag Sharma has a rich experience of overseas operations leading OVL's Vietnam projects, MD RIG Russia, besides contributing in Business Development activities in CIS and SE Asia.

Mr Sharma has a strong track record for delivery of the projects with his excellent project execution skills. He believes in Safe work practices and is well-known for his interpersonal skills.

NEW APPOINTMENTS

Pankaj Kumar Goswami takes over as Director (Operations), OIL

Mr Pankaj Kumar Goswami takes over as Director (Operations) of Oil India Limited, India's second largest National Exploration & Production Company on 1st June 2020.

Prior to taking over as Director (Operations), Mr Goswami was in the Projects Department at OIL's Field Head Quarter, Duliajan as Chief General Manager (Projects), where he looked after implementation of a large number of complex and high-value projects related to production of Oil & Gas of the Company.

With over 31 years of experience in oil & gas production activities at Assam-Arakan basin in Northeast India, Mr Goswami has conceptualized many out-of-box ideas. He has headed various high-level committees and task forces to oversee critical projects and activities related to oil and gas production, infrastructure facility implementation, operational issues and technology initiatives.

Mr Goswami joined OIL in the year 1988. He did his schooling from Digboi and acquired BE in Mechanical engineering from Assam Engineering College, Guwahati and has also completed an advanced Post Graduate Diploma in Maintenance Management in 2001.

Sanjay Varma takes over as Director (Refinery) of MRPL

Mr. Sanjay Varma took charge as Director (Refinery) of Mangalore Refinery and Petrochemicals on 9th June 2020.

Mr. Varma, Bachelor of Engineering (Mechanical) from Government Engineering College Jabalpur. He has a diversified experience of 30 years in Petroleum Refining, Petrochemicals and Fertilizer sectors. He has rendered more than 25 years of service at MRPL, Mangalore with cross-functional work exposure in Project, Operations, Utilities, Materials and HSE.

He has led as Group General Manager (I/c Refinery) for the last two years. He is on the Board of Mangalore STP Ltd (MSTPL) as MRPL Nominee Director. He has previously served in reputed organizations like Indo Gulf Fertiliser and Reliance Industries Ltd (Petrochemical Div.) Hazira, Gujarat before joining MRPL.

A. K. Jana takes over as Managing Director of IGL

Mr. A.K. Jana took over as Managing Director of Indraprastha Gas Ltd. (IGL), on 16th June 2020. IGL is the largest CNG distribution company of the country.

Mr. Jana, a Production (Mechanical) Engineer from Jadhavpur University, brings to IGL a rich experience of over 35 years in leading, managing and implementing large projects and business solutions in the oil and gas sector in the fields of Marketing, Pipeline Projects, CGD and Operations & Maintenance.

Before taking up his new assignment, Jana was posted as Chief Executive Officer of GAIL Gas Limited, a wholly owned subsidiary of his parent organization and natural gas major GAIL (India) Ltd.

STATISTICS

INDIA: OIL & GAS

DOMESTIC OIL PRODUCTION (MILLION MT)

		2013-14	2014-15	2015-16	2016-17	2017-18 (P)	2018-19 (P)	2019-20 (P)	
									% of Total
On Shore	ONGC	6.7	6.1	5.8	5.9	6.0	6.1	6.1	37.7
	OIL	3.5	3.4	3.2	3.3	3.4	3.3	3.1	19.2
	Pvt./ JV (PSC)	9.4	9.1	8.8	8.4	8.2	8.0	7.0	43.1
	Sub Total	**19.6**	**18.5**	**17.8**	**17.6**	**17.5**	**17.3**	**16.2**	100
Off Shore	ONGC	15.5	16.2	16.5	16.3	16.2	15.0	14.5	90.8
	OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pvt./ JV (PSC)	2.7	2.7	2.5	2.1	1.9	1.9	1.5	9.2
	Sub Total	**18.2**	**18.9**	**19.1**	**18.4**	**18.1**	**16.9**	**16.0**	**100**
Total Domestic Production		37.8	37.5	36.9	36.0	35.7	34.2	32.2	100.0
	ONGC	22.3	22.3	22.4	22.2	22.2	21.0	20.6	64.1
	OIL	3.5	3.4	3.2	3.3	3.4	3.3	3.1	9.7
	Pvt./ JV (PSC)	12.1	11.8	11.3	10.5	10.1	9.9	8.4	26.2
Total Domestic Production		**37.8**	**37.5**	**36.9**	**36.0**	**35.7**	**34.2**	**32.2**	**100**

Source : PIB/PPAC

REFINING

Refining Capacity (Million MT on 1st May 2020

Indian Oil Corporation Ltd.	
Digboi	0.65
Guwahati	1.00
Koyali	13.70
Barauni	6.00
Haldia	8.00
Mathura	8.00
Panipat	15.00
Bongaigoan	2.35
Paradip	15.00
Total	**69.70**

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

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

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

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

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

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

CRUDE PROCESSING (MILLION MT)

PSU Refineries	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	2019-20 (P)
IOCL	53.13	53.59	58.01	65.19	69.00	71.81	69.42
BPCL	22.97	23.20	24.10	25.30	28.20	30.82	31.53
HPCL	15.51	16.20	17.20	17.80	18.20	18.44	17.18
CPCL	10.70	10.70	9.60	10.30	10.80	10.69	10.16
MRPL	14.60	14.60	15.53	15.97	16.13	16.23	13.95
ONGC (Tatipaka)	0.10	0.05	0.07	0.09	0.08	0.07	0.09
NRL	2.60	2.78	2.52	2.68	2.81	2.90	2.38
SUB TOTAL	**119.61**	**121.12**	**127.03**	**137.33**	**145.22**	**150.96**	**144.71**

JV Refineries	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	2019-20 (P)
HMEL	9.27	7.34	10.71	10.52	8.83	12.47	12.24
BORL	5.40	6.21	6.40	6.36	6.71	5.71	7.91
SUB TOTAL	**14.67**	**13.55**	**17.11**	**16.88**	**15.54**	**18.18**	**20.15**

Pvt. Refineries	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	2019-20 (P)
NEL	20.20	20.49	19.11	20.92	20.69	18.89	20.62
RIL	68.03	68.10	69.50	70.20	70.50	69.14	68.89
SUB TOTAL	**88.23**	**88.59**	**88.61**	**91.12**	**91.19**	**88.03**	**89.51**

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	2019-20 (P)
All India Crude Processing	**222.40**	**223.26**	**232.90**	**245.40**	**251.90**	**257.17**	**254.38**

Source : PIB Release/PPAC

CRUDE CAPACITY VS. PROCESSING

	Capacity On 01/05/2020 Million MT	% Share	Crude Processing Million MT 2019-20 (P)	% Share
PSU Ref	142.6	57.1	144.7	56.9
JV. Ref	19.1	7.6	20.2	7.9
Pvt. Ref	88.2	35.3	89.5	35.2
Total	**249.9**	**100**	**254.4**	**100**

Source: PIB/PPAC

POL PRODUCTION (Million MT)

	2013-14	2014-15	2015-16	2016-17	2017-18 (P)	2018-19 (P)	2019-20 (P)
From Refineries	216.4	217.1	227.9	239.2	249.8	257.4	258.2
From Fractionators	3.9	3.7	3.4	3.5	4.6	4.9	4.8
Total	**220.3**	**220.7**	**231.2**	**242.7**	**254.4**	**262.4**	**262.9**

DISTILLATE PRODUCTION (Million MT)

	2013-14	2014-15	2015-16	2016-17	2017-18 (P)	2018-19 (P)	2019-20 (P)
Light Distillates, MMT	62.7	63.2	67.1	71.0	74.7	75.4	76.8
Middle Distillates , MMT	112.8	113.4	118.3	122.5	127.5	130.8	130.2
Total Distillates, MMT	175.5	176.6	185.4	193.5	202.2	206.1	206.9
% Distillates Production on Crude Processing	**78.9**	**79.1**	**79.6**	**78.9**	**80.3**	**80.2**	**81.3**

Source: PIB/PPAC

PETROLEUM PRICING

OIL IMPORT - VOLUME AND VALUE

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	2019-20 (P)
Quantity, Million Mt	189.2	189.4	202.9	213.9	220.4	226.6	227.0
Value, INR ₹000 cr.	864.9	687.4	416.6	470.6	566.0	783.4	716.6
Value, USD Billion	143.0	112.7	64.0	70.2	87.8	112.0	101.4
Average conversion Rate, INR per USD (Calculated)	60.5	61.0	65.1	67.0	64.5	70.0	70.7

OIL IMPORT - PRICE USD / BARREL

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	2019-20 (P)
Brent (Low Sulphur - LS-marker) (a)	107.5	85.4	47.5	48.7	57.5	70.0	61.0
Dubai (b)	104.6	83.8	45.6	47.0	55.8	69.3	60.3
Low sulphur-High sulphur differential (a-b)	2.9	1.7	1.8	1.7	1.6	0.7	0.6
Indian Crude Basket (ICB)	105.52	84.16	46.17	47.56	56.43	69.88	60.47
ICB High Sulphur share %	69.90	72.04	72.28	71.03	72.38	74.77	75.50
ICB Low Sulphur share %	30.10	27.96	27.72	28.97	27.62	25.23	24.50

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

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	2019-20 (P)
Gasoline	114.3	95.5	61.7	58.1	67.8	75.3	67.0
Naphtha	100.2	82.2	48.5	47.1	56.3	65.4	55.1
Kero / Jet	121.2	66.6	58.2	58.4	69.2	83.9	70.4
Gas Oil (0.05% S)	122.0	99.4	57.6	58.9	69.8	84.1	74.1
Dubai crude	104.6	83.8	45.6	47.0	55.8	69.3	60.3
Indian crude basket	105.5	84.2	46.2	47.6	56.4	69.9	60.5

CRACKS SPREADS ($/ BBL.)

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (P)	2019-20 (P)
Gasoline crack							
Dubai crude based	9.7	11.7	16.1	11.1	12.0	5.9	6.7
Indian crude basket	8.8	11.3	15.6	10.6	11.4	5.4	6.5
Diesel crack							
Dubai crude based	17.4	15.7	12.0	12.0	13.9	14.8	13.8
Indian crude basket	16.5	15.3	11.5	11.4	13.4	14.2	13.6

DOMESTIC GAS PRICE ($/MMBTU)

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

Source: PIB/PPAC/OPEC

GAS PRODUCTION

Qty in MMSCM

	2015-16	2016-17	2017-18 (P)	2018-19 (P)	2019-20 (P)
ONGC	21177	22088	23429	24675	23746
Oil India	2838	2937	2882	2722	2668
Private/ Joint Ventures	8235	6872	6338	5477	4766
Total	**32250**	**31897**	**32649**	**32873**	**31180**

		2015-16	2016-17	2017-18 (P)	2018-19 (P)	2019-20 (P)
Onshore	Natural Gas	8845	9294	9904	10046	9893
	CBM	393	565	735	710	655
	Sub Total	**9237**	**9858**	**10639**	**10756**	**10549**
Offshore		23012	22038	22011	22117	20631
	Sub Total	**23012**	**22038**	**22011**	**22117**	**20631**

	2015-16	2016-17	2017-18 (P)	2018-19 (P)	2019-20 (P)
Total	**32249**	**31897**	**32649**	**32873**	**31180**
(-) Flare loss	1120	1049	918	815	923
Net Production	31129	30848	31731	32058	30257

	2015-16	2016-17	2017-18 (P)	2018-19 (P)	2019-20 (P)
Net Production	31129	30848	31731	32058	30257
Own Consumption	5822	5857	5806	6019	6053
Availabilty	25307	24991	25925	26039	24204

AVAILABILTY FOR SALE

	2015-16	2016-17	2017-18 (P)	2018-19 (P)	2019-20 (P)
ONGC	16076	17059	18553	19597	18532
Oil India	2314	2412	2365	2207	2123
Private/ Joint Ventures	6917	5520	5007	4235	3549
Total	**25307**	**24991**	**25925**	**26039**	**24204**

CONSUMPTION (EXCLUDING OWN CONSUMPTION)

	2015-16	2016-17	2017-18 (P)	2018-19 (P)	2019-20 (P)
Total Consumption	46695	49677	53364	54779	57884
Availabilty for sale	25307	24991	25925	26039	24204
LNG Import	21388	24686	27439	28740	33680

GAS - IMPORT DEPENDENCY

	2015-16	2016-17	2017-18 (P)	2018-19 (P)	2019-20 (P)
Net Gas Production	31129	30848	31731	32058	30257
LNG Imports	21388	24686	27439	28740	33680
Import Dependency (%)	40.7	44.5	45.3	45.7	52.7
Total Gas Consumption*	**52517**	**55534**	**59170**	**60798**	**63937**

* Includes Own Consumption

Source:PIB/PPAC

SECTOR WISE DEMAND AND COMSUMPTION OF NATURAL GAS

Qty in MMSCM

		2017-18 (P)	2018-19 (P)	2019-20 (P)											
				April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan	Feb	Mar	Total
Fertilizer	R-LNG	7781	8711	611	716	769	784	815	784	750	803	878	933	893	803	9539
	Do-mestic Gas	6862	6258	541	525	499	519	588	574	598	577	602	525	479	492	6519
Power	R-LNG	2645	2869	265	336	687	313	272	321	248	267	247	218	272	149	3595
	Do-mestic Gas	9375	9194	711	700	641	620	646	598	657	611	578	591	569	551	7473
City Gas	R-LNG	3881	3981	290	322	328	447	449	423	416	442	415	419	394	401	4746
	Do-mestic Gas	4659	5240	471	472	463	492	486	478	490	488	514	517	489	376	5736
Refine y Petro-chemical Others	R-LNG	11109	12650	1021	1056	1030	1131	1116	1008	1109	1019	1124	1169	1201	1185	13169
	Do-mestic Gas	5225	5225	432	438	448	502	635	449	481	426	434	365	334	341	5285

Source:PPAC

Member Organizations

S No	Organization	Name	Designation
1	Axens India (P) Ltd.	Mr. Philippe Bergault	Managing Director
2	Baker Hughes, A GE Company	Mr. Ashish Bhandari	CEO (Oil & Gas) South Asia
3	Bharat Oman Refineries td.	Mr. Mahendra Pimpale	Managing Director
4	Bharat Petroleum Corporation Ltd.	Mr. D. Rajkumar	Chairman & Managing Director
5	BP Group	Mr. Sashi Mukundan	Regional President and Head of Country, India
6	Cairn Oil & Gas, Vedanta Limited	Mr. Prachur Sah	Director (New Ventures)
7	Chandigarh University	Mr. Satnam Singh Sandhu	Chancellor
8	Chennai Petroleum Corp. Ltd.	Mr. S.N. Pandey	Managing Director
09	CSIR-Indian Institute of Petroleum, Dehradun	Dr. Anjan Ray	Director
10	Deepwater Drilling & Industries Ltd	Mr. Naresh Kumar	Chairman & Managing Director
11	Delonex Energy Advisors India Private Ltd.	Mr. Rahul Dhir	Managing Director
12	Dynamic Drilling & Services Pvt. Ltd.	Mr. S. M. Malhotra	President
13	Engineers India Ltd.	Mr. J.C. Nakra	Chairman & Managing Director
14	Ernst & Young LLP	Mr. Rajiv Memani	Country Manager & Partner
15	ExxonMobil Gas (India) Pvt. Ltd.	Mr. Bill Davis	CEO
16	GAIL (India) Ltd.	Mr. Manoj Jain	Chairman & Managing Director
17	GSPC LNG Ltd.	Mr. Anil K. Joshi	President
18	Haldor Topsoe India Pvt. Ltd.	Mr. Alok Verma	Managing Director
19	Hindustan Petroleum Corporation Ltd.	Mr. M.K. Surana	Chairman & Managing Director
20	HPCL Mittal Energy Ltd.	Mr. Prabh Das	MD & CEO
21	IHS Markit	Mr. James Burkhard	Managing Director
22	IIT (ISM) Dhanbad	Prof. Rajiv Shekhar	Director
23	IMC Ltd.	Mr. A. Mallesh Rao	Managing Director
24	Indian Oil Corporation Ltd.	Mr. S.M. Vaidya	Chairman

S No	Organization	Name	Designation
26	Indian Strategic Petroleum Reserves Ltd	Mr. H.P.S. Ahuja	CEO & Managing Director
27	Indraprastha Gas Ltd.	Mr. A.K. Jana	Managing Director
28	Indian Oiltanking Ltd.	Mr. Vivek Venkatachalam	Managing Director
29	IPIECA	Mr. Brian Sullivan	Executive Director
30	Invenire Petrodyne Ltd.	Mr. Mannish Maheshwari	Chairman & Managing Director
31	Jindal Drilling & Industries Pvt. Ltd.	Mr. Raghav Jindal	Managing Director
32	LanzaTech	Dr. Jennifer Holmgren	Chief Executive Officer
33	Larsen & Toubro Ltd	Mr. S.N. Subrahmanyan	CEO & Managing Director
34	Maharashtra Institute of Technology (MIT), Pune	Dr. L.K. Kshirsagar	Principal
35	Mangalore Refinery & Petrochemicals Ltd.	Mr. M. Venkatesh	Managing Director
36	Megha Engineering & Infrastructures Ltd.	Mr. P. Doraiah	Director
37	Nayara Energy Ltd.	Mr. B. Anand	Chief Executive Officer
38	Numaligarh Refinery Ltd.	Mr. S.K. Barua	Managing Director
39	Oil and Natural Gas Corporation Ltd.	Mr. Shashi Shanker	Chairman & Managing Director
40	Oil India Ltd.	Mr. Sushil Chandra Mishra	Chairman & Managing Director
41	Petronet LNG Ltd.	Mr. Prabhat Singh	Managing Director & CEO
42	Pipeline Infrastructure Limited	Mr. Akhil Mehrotra	Chief Executive Officer
43	Rajiv Gandhi Institute of Petroleum Technology	Prof. A.S.K Sinha	Director
44	Reliance Industries Ltd.,	Mr. Mukesh Ambani	Chairman & Managing Director
45	SAS Institute (India) Pvt Ltd.	Mr. Noshin Kagalwalla	CEO & Managing Director-India
46	Schlumberger Asia Services Ltd	Mr. Gautam Reddy	Managing Director
47	Shell Companies in India	Mr. Nitin Prasad	Country Chair
48	South Asia Gas Enterprise Pvt. Ltd.	Mr. Subodh Kumar Jain	Director
49	Total Oil India Pvt. Ltd.	Mr. Alexis Thelemaque	Chairman & Managing Director
50	University of Petroleum & Energy Studies	Dr. S.J. Chopra	Chancellor
51	UOP India Pvt. Ltd.	Mr. Mike Banach	Managing Director
52	VCS Quality Services Private Ltd.	Mr. Shaker Vayuvegula	Director
53	World LPG Association	Mr. James Rockall	CEO and Managing Director

FIPI

3rd floor PHD House, 4/2, Siri Institutional Area, August Kranti Marg, New Delhi, 110016
Tel: +91-11-26535697 | Fax: +91-11-26964840
Email: fipi@fipi.org.in | website : www.fipi.org.in
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