A MULTI-MODAL APPROACH TO NATURAL GAS TRANSPORTATION

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SUMMARY

India is expected to grow at a rate of more than 6% over the next two decades [1]. A growing economy requires increasing quantities of fuel to satisfy its energy needs. Natural gas is expected to take up a noteworthy share of the total energy consumption in India. Pipelines are the arteries of our gas distribution system. They are reliable, versatile, and justify economies of scale in the long term. Together with regasification facilities, they significantly contribute in fuelling the Indian growth story. However, experts in the industry predict a significant gap to be formed between the demand for gas infrastructure and its development. Investment decisions, market volatility and safety concerns are among the reasons. In light of the Government efforts to improve the connectivity between different modes of transport, an alternate multi-modal transport system consisting of coastal ships, inland barges, trucks and trains is envisaged to support the pipeline network for gas transport. The idea is not to develop a parallel system to pipelines, but to complement the network for reliability, supplement the network for surge in demands, and to substitute the network where pipelines are not viable. Intermodal transport of LNG has several advantages including lower investment, greater flexibility, optimal redundancy and faster implementation. Intermodal transport can also develop the gas market by adding smaller consumers, who are otherwise unconnected to pipeline networks. Instead of relying on a single mode of transportation, we need to think about diversifying the gas infrastructure for our own strategic interest. The article explores the advantages of inter-modal transport of LNG, discusses about the economics and government policies favoring this option, and concludes with a case study on using barges to supply LNG to the NTPC plant at Kayamkulam, Kerala.

1. GAS: FUELING INDIAN GROWTH STORY

For a developing country like India, ‘Energy Security’ is analogous to National Security. Oil and Coal are the dominant fuel sources in India, accounting for more than 80% of the total fuel consumption [1]. One of the key priorities in the Government policy towards energy security is the diversification of energy mix. Natural gas is considered the right choice for expanding the Indian energy portfolio in terms of availability, calorific value, market stability and environment friendliness. The share of natural gas in India is expected to increase to 20% of the overall fuel consumption by 2030 [1]. In addition to being used as fuel in industries like power, cement and tea; natural gas is used as feedstock in petrochemical and LPG industries as well as industries producing fertilizers, methanol and sponge iron.

The domestically sourced gas cannot meet the present demand, and without a new major find will find its share diminishing by the day, to imported and re-gasified LNG. The imported LNG is re-gasified and pumped through pipelines to the end consumers or smaller liquefaction and storage facilities. Development and upkeep of the regasification facilities and pipelines for the projected gas demand is important in ensuring the continued growth of India without hindrance.

While this is how the story should ideally be, there are huge challenges blocking the infrastructure development in this region; for instance the public perception against pipelines, fluctuation of demand with price, credit crunch, burgeoning interest rates, policy paralysis, and so on. This leads one to think about the alternatives available; not as a complete replacement for pipelines, but as a substitute where economics do not favour huge investments as well as to offer a complementary option to improve redundancy of the system.

Intermodal transport involving water, road, and rail is a likely contender. With more than 7500 kilometres of coast line, 14500 kilometres of navigable inland waterways, 65000 kilometres of railways and close to 100,000 kilometres of national highways intersecting each other, India has a huge untapped potential in transport connectivity. Lack of strategic vision, inadequate coordination between the departments, dearth of investments, insufficient planning, as well as some geographical and environmental reasons have always pulled the idea down. However, there is a major policy shift in favour of developing connectivity between the different modes of transport, and to develop many inland water bodies into navigable waterways. These developments have succeeded in creating a renewed interest in the marine transport sector and it is worth investigating the feasibility of this option for gas transport.

2. THE DEMAND-SUPPLY GAP

Several agencies have published their projections on the use and availability of gas in India for the next couple of decades. The Petroleum and Natural Gas Regulatory Board (PNGRB) has corrected the projection made by the Government in its 12th five year plan, and expects the supply of gas to fall short of the demand by approximately 272 MMSCMD (million metric standard cubic metres per day) by 2029-30 [1]. The IEA
(International Energy Agency) and EIA (Energy Information Administration of the United States) predict a much lower demand-supply gap owing to lesser demand. The divergence in the assessments is due to the contrasting assumptions considered by these agencies in their studies, which is a result of lack of clear price signals and the extreme sensitivity of gas demand in India to its price [2]. Figures 1 and 2 depict respectively the demand and supply projections of natural gas, in billion cubic metres.

Without significant investment, a substantial demand-supply gap is expected in all markets in regasification capacity. The investors are finding it harder to make commitments due to slowdown in the global economy, rising interest costs, and tax uncertainties [3].

Poor connectivity between regasification facilities and pipeline grids is yet another cause of concern. Laying of pipes in some sectors is indefinitely delayed due to public apprehensions, local legislations, court interventions, and regional political issues. A good example is the Petronet terminal at Kochi, which is reported to be grossly underutilized at present.

2.2 FORECAST BY EXTERNAL AGENCIES

Projections by external agencies like IEA and EIA are more conservative when compared to that of PNGRB. The supply forecasts of the Government and external agencies converge at around 100-112 Bcm (Billion cubic metres). However, the PNGRB forecast places potential demand in 2030 at nearly 400 Bcm, whereas, the IEA and EIA forecasts place it much lower in the 90-200 Bcm range [2]. While the drivers and assumptions considered by the various agencies are beyond the scope of this discussion, a significant reduction in demand from the official figures can put pressure on the pipeline infrastructure viability.

In brief, there is a noticeable skew in pipeline infrastructure against some markets and large gaps in the national gas grid [3]. There is ambiguity in the projected demand for gas infrastructure. Yet, the development of infrastructure, being time-consuming and capital-intensive, cannot wait for the picture to become clearer; or else, the market might starve from non-availability of gas. A smarter approach is to distribute the investment between fixed assets like pipelines and movable assets like multi-modal transport so that, the advantages of economies of scale as well as the agility to realign the resources with demand can both be ensured.

3. THE MULTI-MODAL ALTERNATIVE

India can utilize the existing and developing Coast–Inland waterways – Road – Rail network to transport LNG to its consumers. With the government aligning its priorities with the logistics requirements of the industry, the time is ripe to think of an integrated inter-modal alternative for gas consisting of ships, barges, trucks, and trains.

The idea is to create a network of:
- Small scale LNG carriers/barges to transport LNG along the coast
- Barges with Type-B/Type C/membrane tanks to serve those consumers located in the vicinity of major waterways with significant demand. IMO IGC Code (International code for the construction of gas carriers)
and equipment of ships carrying liquefied gases in bulk) differentiates the LNG tanks for marine use into integral tanks and independent tanks. Independent tanks are further generally segregated into Type A, Type-B, and Type-C tanks based on the need for a full, partial, or no secondary barrier for the carriage of LNG respectively. In addition to the above, several players have introduced their own LNG containment systems: the most widely used being the membrane tank of GTT.

- Barges which can carry standard ISO LNG containers, which can be transferred to trucks/trains as appropriate for consumers away from waterways. This arrangement also suits those consumers along the waterways with low demand. ISO LNG containers are type-approved, portable, standard sized, insulated cryogenic containers made to the strict specifications of international standards.

Connectivity between the above modes is to be through inter-modal hubs at suitable locations.

4. POLICY FRAMEWORK

Sending the right signals through strong policies is important for gaining the confidence of the industry. There are indeed some positive proposals from the Government, and it is important that all stakeholders work together to make maximum benefits out of these developments. There are a number of acts, policies, and initiatives worth mentioning in this regard such as:

- Integrated National Waterways Transport Grid (INWTG),
- National Inter-modal grid,
- Sagarmala project,
- Jal Marg Vikas,
- National Waterways Act 2015,
- Dedicated Freight Corridors, and
- MOUs between different transport Corporations and Ministries.

Integrated National Waterways Transport Grid (INWTG) is an important project which seeks to connect various vital waterways to major highways to boost the overall transportation network in the country [4]. The proposed INWTG includes development of the National Waterways with at least 2.5m Least Available Depth (LAD), upgrading or setting up of priority terminals as well as establishing road, rail, and port connectivity [5].

The INWTG will connect four out of the six national waterways to form a network in the Eastern Region of the country. NW-1 can be connected to NW-2 and NW-6 using protocol route through Bangladesh. Similarly, NW-5 that extends up to Paradip Port can also be joined in the National Waterway grid through backwaters of Hooghly and Hijily tidal canal. Connectivity would further increase the area of influence of each waterway.

A National inter-modal grid is also proposed to optimally utilize the rail and road together with the waterways. National Inter-modal Grid, comprising rail, road and IWT spread over a total length of 4503 km is likely to serve 14 states and 137 civil districts under the primary hinterland [5].

The ambitious Sagar/mala project aims to connect twelve smart cities, major ports, and coastal economic zones, giving the long overdue prominence to coastal shipping.

Yet another ambitious mission is the ‘Jal Marg Vikas’, a World Bank assisted project to develop parts of National Waterway 1 (NW1) between Haldia and Allahabad with a ‘Least Allowable Depth’ of 3 metres for navigation of vessels with 1500 tonnes deadweight [6]. The project has the potential to serve a number of big cities such as Haldia, Howrah, Kolkata, Bhagalpur, Patna, Ghazipur, Varanasi and Allahabad, their industrial hinterlands, and several industries located along the Ganga basin. The waterway will be developed with modern River Information System (RIS), Differential Global Positioning System (DGPS), night navigation facilities and modern methods of channel marking. The completion of the project would provide a reliable and large barge fairway of about 1620 kilometres. Many industries including thermal power plants, cement companies, fertilizer companies, edible oil companies and Food Corporation of India have evinced interest in the usage of NW1, if it is developed with adequate infrastructure [6].

The Government is declaring 101 water bodies as National Waterways in addition to the existing 5 National Waterways under the National Waterways Act 2015 [7]. The development of fairways in these waterways is expected to attract a lot of private investment in the water transport infrastructure. The Ministry of Shipping estimates that 1000 new barges and its associated infrastructure such as cargo storage facilities, barge building and repair facilities, and bunkering facilities will be created with private sector participation in the next 5 to 6 years [8].

The Indian railway is significantly boosting its freight carrying capacity through Dedicated Freight Corridors (DFCs). Seven DFCs are envisaged, of which construction of two, the Western corridor and the Eastern corridor are underway with expected completion in 2016-17. The DFCs are dotted with market-oriented industrial areas, investment regions, industrial parks, ports, airports, and mega multi-modal logistic parks for integral development and management of the infrastructure.

A Memorandum of Understanding has been signed between the Inland Waterways Authority of India (IWAI) and the Dedicated Freight Corridor Corporation of India (DFCCIL) for creation of state-of-the-art logistic hubs at various locations that would lead to convergence.
of inland waterways with rail and road connectivity. The first such logistic hub will come up at Varanasi. IWA and DFCCIL will collaborate for the project and also facilitate business development in the hinterland and its feeder routes [9].

The ‘Institutions for Transport System Governance’ proposes an Office of Transport Strategy (OTS) for integration of the different modes of transport and co-ordination between ministries. The National Transport Development Policy Committee (NTDPC) recommends the formation of a ‘Bulk Transport Planning Group’ under the OTS that monitors developments and potential developments involving all stakeholders from power, railways and natural gas sectors [10].

There are clear policy initiatives which are at different stages of implementation for developing the transport infrastructure, with special onus on integrating different modes.

However, the approach has to be cautious to ensure that the mistakes of the past are not repeated. To give an example, India already has a Multimodal Transportation of Goods (MMTG) Act, which was enacted in 1993. Yet, with the lacunae in infrastructure, dearth of policies, and lack of mechanisms for co-ordination, the MMTG Act hardly brought any improvement in the statistics.

The present port handling and stevedoring charges at the coastal ports are high, which dents the competitive edge of the coastal and inland water transport against other modes. The government should introduce incentive schemes and carbon credits to reduce the loading and unloading charges for domestic transport, and encourage private sector investment in the water transport segment. In addition to investing in infrastructure augmentation and policy mechanisms, instruments should be put in place for clearing institutional impediments relating to customs, excise, insurance and liability for the smooth and seamless flow of goods.

5. MULTI-MODAL TRANSPORT ECONOMICS

Pipelines offer economies of scale, whereas, multi-modal alternative is ideal to serve stranded consumers with lower requirements and variable demand. Pipelines are only installed if there is sufficient volume to transport, and the capital cost of a pipeline is depreciated over a period of time. The inter-modal transport system on the other hand intends to utilize the existing network of waterways, roads and railways, and hence, no new capital is involved in developing the network. Therefore, a direct comparison of the capital investment will not do justice to either.

However, to give an indication, the capital cost of developing a water body into an inland waterway is estimated to be a mere 5-10% of developing an equivalent 4-lane highway or railway [11]. It is reported that the development of a kilometer of subsea pipeline costs as much as constructing a barge with LNG tank of 1000 cubic metre capacity.

The operation and maintenance costs can be more easily compared. Once the pipeline is depreciated, the cost of transportation is only its operation and maintenance. Operation cost of a pipeline is roughly 75% of the rail freight for the same distance [12]. 1 HP moves 150 kg on road, 500 kg on rail and 4000 kg on water. 1 litre of fuel moves 24 tonne-kilometres on road, 85 on rail & 105 on inland water [8]. In a comparison study conducted by TCS, the transport cost in Rupees per tonne kilometre for railway and inland waterway was found to be 0.65 and 0.3, making waterway less than 50% cheaper [11]. The maintenance cost of waterways is placed at just 20% of that of the roads [11].

Comparing the costs mentioned above, it can be inferred that the cost of operating waterways is less than two-thirds of that of the pipelines. It can also be concluded that, in a multi-modal proposal, inland waterways are to be used to the maximum extent feasible, followed by rail, and then roads. Roads are only used as last mile connectors and for reaching small scale consumers. In this way, the higher unit transportation cost and carbon footprint associated with road transport is minimized in the system.

In summary, the economics of intermodal gas transport depends on the share of waterways in the supply line. The routes are to be charted with least exposure to roads, for economy and environment friendliness.

6. SAFETY ASPECTS OF GAS TRANSPORT

Pipeline accidents are a reality. In the United States of America alone, there were 115 pipeline related incidents between 2012 and May 2015. The major reasons for a pipeline failure are weld defects, metal loss, pitting corrosion, stress corrosion cracking, fatigue, denting and hydrogen cracking. The statistics of the United States cannot be directly applied to the Indian scenario due to three reasons. The US has a huge pipeline network compared to India, and therefore the number of incidents may be higher. However, the US gas industry is matured with established pipeline maintenance, inspection and disaster management practices. In India, the gas industry is less experienced in preventing and dealing with disasters. The third and the most obvious dissimilarity is the population density, in which India overtakes the US by a huge margin. Therefore, it may be concluded that, even if the number of incidents in India might be lower, the repercussions might well be more severe and catastrophic.

Pipeline blasts are not unknown to India. It was reported that in June 2014, a blast in a gas pipeline owned by GAIL in Nagaram, Andhra Pradesh resulted in the loss of 22 lives and burnt down an area of 10 acres. There are
reports of other major and minor incidents, with or without the loss of lives, as recent as in April 2015.

While accidents like these cannot be predicted, a major catastrophe can result in the disruption of supply to an entire area for long periods. In the absence of redundant measures, end consumers with no backup plan or flexibility in using alternative fuel will be pushed into uncertainty. Unless the consumer is located in a well-connected network with options to use more than one pipeline, ensuring redundancy using pipelines can be an expensive affair.

The multi-modal alternative has an advantage here. Barges with Type-B/Type-C tanks are designed with intrinsic safety features, and are used internationally. With proper risk analysis, hazards can be mitigated effectively. The water mode enjoys a safer track record and takes the risk away from inhabited land masses. The ISO LNG transport tanks for trucks and trains are designed to withstand impacts and are resistant to tank rupture. The double wall construction and structural supports make them extremely robust to physical damage and the effects of external fire [13]. The trucks carry only a limited calorific content and any contingency can be contained relatively easily. LPG carriers and CNG fuelled vessels are already using the Indian roads. LNG has lower vapour specific gravity (approximately 0.55) when compared to LPG (approximately 1.55). The vapour clouds resulting from a possible leakage of LNG quickly gather heat and becomes lighter than air. This makes the LNG vapour easier to dissipate when compared to LPG vapour, which is denser than air. LNG should therefore be a safer prospective on the Indian roads when carried in purpose-built ISO containers and operated by trained crew.

The only downside to this approach is that LNG passes many hands before reaching the end consumer, and maintaining the strictest level of international safety standards by every player in the chain is not easy. This has to be achieved through routine training and drill, implementing safe work practices and ensuring strict adherence to the established procedures.

7. ADVANTAGES OF THE ALTERNATE MODEL

7.1 PROXIMITY TO INDUSTRY

Many major LNG consumers are located along the National Waterways. As an example, there are seven fertilizer plants and eleven thermal power plants in the vicinity of National Waterway 1. Ten more power plants are expected to come up by 2020. With the Indian coal not able to meet the demand and imported coal becoming expensive, many of these players can look to gas as the alternative.

7.2 LOWER CAPEX AND OPEX

The capital expenditure and operating expenditure of multi-modal transport is significantly lower compared to pipelines. The existing IWT infrastructure, which offers an assured draft of two meters, is being under-utilized and therefore, further investment on infrastructure in this region may not be too significant [14]. There are areas where modifications are required to suit LNG transport. However, these additions are minimal compared to laying new pipelines.

7.3 FASTER IMPLEMENTATION

Once the basic infrastructure including barges and standardised containers is established, a multi-modal service network can be organized quite fast. Projects with lower CAPEX and which result in no significant displacement of people have lower procedural and political hurdles to surpass, and are generally faster to implement.

7.4 INDEPENDENCE FROM REGASIFICATION

LNG can be stored and vaporized within the consumer premises. This removes the burden of regasification at source from the already stretched capacity for gasification in India.

7.5 ADJUSTABILITY IN LINE WITH DEMAND

Demand from certain sections of gas consumers is highly sensitive to the price of gas [15]. Electricity tariffs are generally government regulated, and the power plants running on gas have to absorb the gas price fluctuations. The plants are run at lower capacities or switched to alternate fuels like naphtha when gas operation is unviable. Fertilizer plants also face the same issue. Pipelines can easily adjust to such demand variations with reduced pumping; however long term operations with reduced capacity can question the viability of the project. As of now, the paucity of LNG volume is threatening several projects under development with reports of underutilization of the existing 15000km gas transmission. Further, the huge variations in gas demand forecasts by different agencies reflect the lack of clarity in terms of the gas pricing and gas utilization policies of India. The risks associated with investing in capital-intensive pipeline grids increase multi-fold when there is a chance for over-estimation of the requirement. The multimodal transport offers a cost-effective alternative, with options to relocate the assets from price-inelastic consumers to those who can absorb higher LNG prices relatively easily.

7.6 AVOIDANCE OF PROPERTY ACQUISITION

Difficulty in land acquisition is a major stumbling block in laying pipelines. For example, public dissent in Kerala and Tamil Nadu has indefinitely delayed the laying of
Routing pipelines through the coastal seabed to the gas fired power plant of NTPC ran into rough weather following agitations by the local fishing community. The multimodal gas transport solution on the other hand requires minimal land acquisition for new terminals and hubs in addition to the existing infrastructure.

7.7 SERVICE TO SMALLER CONSUMERS

With focus on cleaner burning fuels in the coming years, a new segment of consumers with smaller consumption levels are expected to turn to natural gas. Unless located in an industrial area with pipeline connectivity, these small scale consumers cannot get access to natural gas in the absence of a distribution network involving water, rail or road.

7.8 REDUNDANCY AT REASONABLE COST

Intermodal transport offers cost-effective and reliable redundancy to pipelines, especially when the consumer is located in the vicinity of a waterway.

7.9 REVERSAL OF MARKET SKEW

The pipeline infrastructure is under developed in the Eastern and North Eastern Markets. There is a visible skew in investment against these markets for the development of pipeline infrastructure. This offset can be easily reversed using waterways. The Eastern and North Eastern states are blessed with plenty of navigable waterways with rail and road connectivity. The proposed National Waterways Grid will also give a shot in the arm to this region.

7.10 WIDER DISPERSION OF BENEFITS

Except for a few pumping facilities in between, pipelines connect the facilities of seller and buyer, with no intermediate players. On the other hand, the multi-modal transport can attract investment and generate employment in a wider spectrum.

To give an example, if the estimation by Ministry of Shipping on one thousand new barges becoming operational is realized, around twenty thousand people are expected to get direct employment. Besides this, barge building, barge repairing, and manning of terminals has huge employment potential. Development of waterways and connectivity with other modes of transport can potentially attract private sector investment to the tune of Rupees one lakh crore (one trillion) and create more than one lakh direct employment opportunities [8].

8. CASE STUDY: LNG TO NTPC FACILITY

The Petronet LNG storage and regasification terminal at Puthuvype, Kochi (Petronet Kochi terminal) has a regasification capacity of 5 mmtpa (Million Metric Tonnes per Annum). The utilization of the total capacity was planned in several phases. The first phase customers such as FACT plants at Udyogmandal and Ambalamugal, BPCL Refinery, TCC, BSES Reliance Energy and KSEB Brahmapuram were selected on the basis of their proximity to the terminal. The major second phase customers are located along the envisaged pipelines to Mangalore and Bangalore [16]. The National Thermal Power Corporation (NTPC) owned ‘Rajiv Gandhi combined cycle plant’ at Kayamkulam, Kerala was identified as another major end user.

NTPC in turn floated a tender to procure 1.75 mmmscmd (million metric standard cubic metres per day) of regasified LNG to its 350 MW power plant at Kayamkulam from the fourth quarter of 2014. This is equivalent to approximately 0.45 mmtpa [17]. GAIL was tasked with laying pipes to the plant from the LNG regasification facility at Puthuvype, Kerala, with a total distance of approximately 120 kilometres. To avoid land acquisition, the pipes were planned to be laid along the coast in the sea bed. However, due to stiff opposition from the fishing community, the plan is inordinately delayed.

The plant is located on the banks of the Kollam–Kottappuram National Waterway (NW3), making it ideal to deliver LNG through water. This brief study looks into the specific case of delivery of LNG from Petronet Kochi terminal to NTPC power plant at Kayamkulam using barges. The additional infrastructure requirements for this arrangement include a barge with Type-B/Type-C LNG cargo tanks as well as LNG storage tanks, and sufficient LNG vaporizing/compressing units at the NTPC facility.

The NW3 is connected to the Arabian Sea from North to South at Munambam, Kochi, Kayamkulam and Neendakara. The focus of this study is the Kochi-Kayamkulam stretch of the waterway. This stretch can be divided into three sections. The first section is open to sea at Kochi in the North and is bounded by Thanneermukkom lock in the south. The second section is between the locks at Thanneermukkom and Trikkunnapuzha. The third section lies between Trikkunnapuzha and Kayamkulam, and is open to sea at Azheekal, south of Kayamkulam.

The NTPC plant is located a few kilometres north of the waterway opening to sea near Azheekal beach at Kayamkulam. This opens up two possibilities to transport LNG:

- Using inland barges
- Using coastal barges

By virtue of plying in protected waters, inland barges have lower structural requirements, and therefore require less structural steel for the same cargo capacity.
However, there are several limitations. The size of an inland barge is limited by the width and depth of water available, height of bridges, size of the locks, turning radius available at bents, and so on.

As per the latest waterway notice (NW3/06/2015) of IWAI, albeit a LAD of 2 metres in most sections of the NW3, the narrow stretches between Trikkunnapuzha and Kayamkulam offers a LAD of 1.4 metres only. There are 20 bridges in the waterway, more than half of which are between Kochi and Kayamkulam. The critical bridge clearance above the High Flooding Level (HFL) in the second section of the stretch is 4.6m at Kovilthottam foot bridge. The Trikkunnapuzha lock limits the air draught of the barges with the east and west gates having dimensions of 6.1m × 25.5m × 4.7m (head room) and 9.2m × 39.0m × 4.6m (head room) respectively. The horizontal clearance available is about 9 metres between Thakazhi jetty and Thrikkunnapuzha in the second stretch. The barges are also advised to run at slow speeds near the fishing stake nets and china nets, while passing country boats, and near the locks for safety reasons. The vessels are also to run with collapsed masts where cables and power lines cross the waterway at low heights. The maximum dimensions of the barges in NW3 are typically 50m (L) × 8.5m (B) × 1.5m (T) with a cargo capacity of 350 tonnes [18]. However, the dimensions may have to be further reduced considering the sharp bends especially in the second and third sections of the stretch, safety considerations for the flammable cargo, and lock sizes.

Using coastal barges solve most of the above issues. The barges can enter the waterway at Azheekal from the sea and travel northwards to the NTPC plant, which is around 12 kilometres in the waterway. This stretch between Azheekal and the NTPC plant is a part of the Kayamkulam Lake, and has a minimum width of around 200 metres. The only bridge north of Valiazheekal has a clearance of 7m from the HFL. Accordingly, the barge dimensions can be increased in consultation with the IWAI. The barrage at Azheekal connecting the waterway to sea has been permanently opened with break waters on either side to facilitate fishing vessels to enter the waterway. The draught of the barge has to be fixed based on the depth of this channel and the segment of waterway between the Azheekal break water and NTPC plant, taking tidal variations into consideration.

Figure 4 shows the entire route of approximately 120 kilometers from Petronet terminal at Puthuvype to NTPC plant near Kayamkulam. Figure 5 shows a closer view of the entry into the National Waterway 3 at Azheekal from the Arabian sea, and the subsequent journey through the NW3 to reach the NTPC plant premises.

The above route is proposed considering the present requirement of 1.75 mmscmd, for the 350 MW plant. There was a proposal to expand the capacity of the plant to 1950 MW, with a requirement of 12.5 mmscmd of gas. Supply of such high volume of gas would have required the development of LNG receiving facilities in the coast, and bigger vessels with capacity of around 20000 cbm for transport. With the expansion of the combined cycle plant kept in abeyance due to the prohibitive price of LNG in offer, further discussion on supplying 12.5 mmscmd of gas has no merit.
Coastal barge can also be designed to operate as bunker barge for LNG fuelled vessels, with minor modifications in the design. In this way, the barge can be utilized during periods of low demand. With the marine emission regulations becoming stricter, more vessels are expected to turn to LNG. The Cochin Port Trust envisions promoting Cochin as a LNG bunkering destination. Having a bunker barge strengthens the position of the Port to cater to the needs of the vessels at anchorage. Given the proximity of the Port of Cochin to the international shipping channel, a number of vessels will find Cochin attractive for LNG bunkering in the future. Having a bunker barge is an added advantage for the port, since this will enable the vessels to avoid a major detour from their charted course, thus saving precious time.

Like all power and fertilizer plants in India, the demand for LNG at the NTPC facility at Kayamkulam is highly dependent on its price. In the absence of a long term viable price agreement, and with the associated flickering in demand, the heavy investment in laying pipelines to supply RLNG carries huge risks.

Delivering LNG using barges gives the flexibility to divert the supply to other consumers when there is a diminishing demand from one consumer. The barges can also be relocated to other terminals like Dabhol or Gangavaram, should the need arise. The utilization ratio can be increased if the barges are also designed for bunkering operations.

It is reported that the cost of an LNG carrier barge is around 9 Crore Rupees. This is roughly equivalent to the cost of laying one kilometre of pipeline. With an estimated transport cost of 750 crores using coastal barges, and with approximately 120 kilometres of pipeline required to supply RLNG to NTPC, the pipeline project will cost roughly 4 times more, compared to delivering LNG using barges. There are LNG tank manufacturers, LNG system suppliers, ship designers with experience and capability to develop LNG barge designs, and shipyards with good track records operating in India. The project, if materialized, will be a realization of the ambitious ‘Make in India’ initiative, from drawing board to delivery. The project will also resolve a deadlock plaguing the LNG supply in Kerala and will be a welcome relief to the underutilized LNG terminal at Cochin.

With the advantages and flexibility offered by the alternative approach of using barges to deliver gas to NTPC, it is hoped that the authorities will evince interest in this option. The case study demonstrates the technical and economic viability of delivering LNG to a stranded consumer with a small demand, using coastal barges. The transport model can be reasonably generalized to similar small scale consumers in India, who are not connected to pipeline networks.

9. THE WAY FORWARD

Similar to diversification of the energy basket, broadening of the transportation segment is crucial to ensuring uninterrupted supply of energy during times of war and peace. Since fuel is a strategic commodity, decisions to support the pipeline infrastructure with multi-modal transport options are to be taken at the policy framing level. The industry and the government should realize and utilize the prospects of multi-modal transport for distribution of natural gas.

10. IMPORTANT ABBREVIATIONS

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<tr>
<th>BCM</th>
<th>Billion Cubic Metres</th>
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<tr>
<td>BPCL</td>
<td>Bharat Petroleum Corporation Ltd.</td>
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<td>DGPS</td>
<td>Differential Global Positioning System</td>
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<td>EIA</td>
<td>Energy Information Administration</td>
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<td>FACT</td>
<td>Fertilizers and Chemicals Travancore Ltd.</td>
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<td>GAIL</td>
<td>Gas Authority of India Limited</td>
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<td>GTT</td>
<td>Gaztransport &amp; Technigaz S.A.</td>
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<td>HFL</td>
<td>High Flooding Level</td>
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<td>IEA</td>
<td>International Energy Agency</td>
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<td>IMO</td>
<td>International Maritime Organization</td>
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<td>IWAI</td>
<td>Inland Water Authority of India</td>
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<td>KSEB</td>
<td>Kerala State Electricity Board</td>
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<td>LAD</td>
<td>Least Available Depth</td>
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<td>LNG</td>
<td>Liquefied Natural Gas</td>
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<td>LPG</td>
<td>Liquefied Petroleum Gas</td>
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<tr>
<td>MMSCMD</td>
<td>Million Metric Standard Cubic Metres / Day</td>
</tr>
<tr>
<td>MOU</td>
<td>Memorandum of Understanding</td>
</tr>
<tr>
<td>MMTG</td>
<td>Multi-Modal Transport of Goods (Act)</td>
</tr>
<tr>
<td>MMTPA</td>
<td>Million Metric Tonnes Per Annum</td>
</tr>
<tr>
<td>MW</td>
<td>Mega Watt</td>
</tr>
<tr>
<td>NTPC</td>
<td>National Thermal Power Corporation</td>
</tr>
<tr>
<td>NW</td>
<td>National Waterway</td>
</tr>
<tr>
<td>OTS</td>
<td>Office of Transport Strategy</td>
</tr>
<tr>
<td>PNGRB</td>
<td>Petroleum &amp; Natural Gas Regulatory Board</td>
</tr>
<tr>
<td>RIS</td>
<td>River Information System</td>
</tr>
<tr>
<td>RLNG</td>
<td>Re-gasified Liquefied Natural Gas</td>
</tr>
</tbody>
</table>

11. REFERENCES

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