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FICCI

Study on Pooling of Naphtha

October 2017

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Executive summary

Background

Naphtha, a mixture of aliphatic, cyclic and aromatic hydrocarbons, is one of the widely processed parent feedstock for producing host of petrochemicals. In the absence of adequate consumption capacities in the domestic industry, refiners exported around 7.0 million metric tonne (MMT) of naphtha each year in 2014-15 and 2015-16[1]; on the contrary, there is an acute short supply of the commodity polymers – especially ethylene derivatives – prepared from naphtha, requiring their imports in bulk. While the urgent need for developing ethylene capacities requires no further emphasizing, availability of the feedstock at single location for meeting the minimum economic size remains a challenge. So there is a need for studying the aspects for pooling naphtha at common place(s) to develop naphtha based ethylene cracker(s).

Federation of Indian Chamber of Commerce & Industry (FICCI), with support from the Ministry of Chemicals & Fertilizers, and Department of Chemicals & Petrochemicals, has retained Mott MacDonald to undertake a study for analysing the aspects for pooling naphtha in India.

This report analyses the supply of naphtha vis-à-vis demand from the domestic petrochemical industry – mainly crackers. It also analyses the direct and indirect constraints involved in envisaging new naphtha cracker(s), and hence reconciling the likely measures for overcoming the constraints. Benefits have also been discussed at gross magnitude.

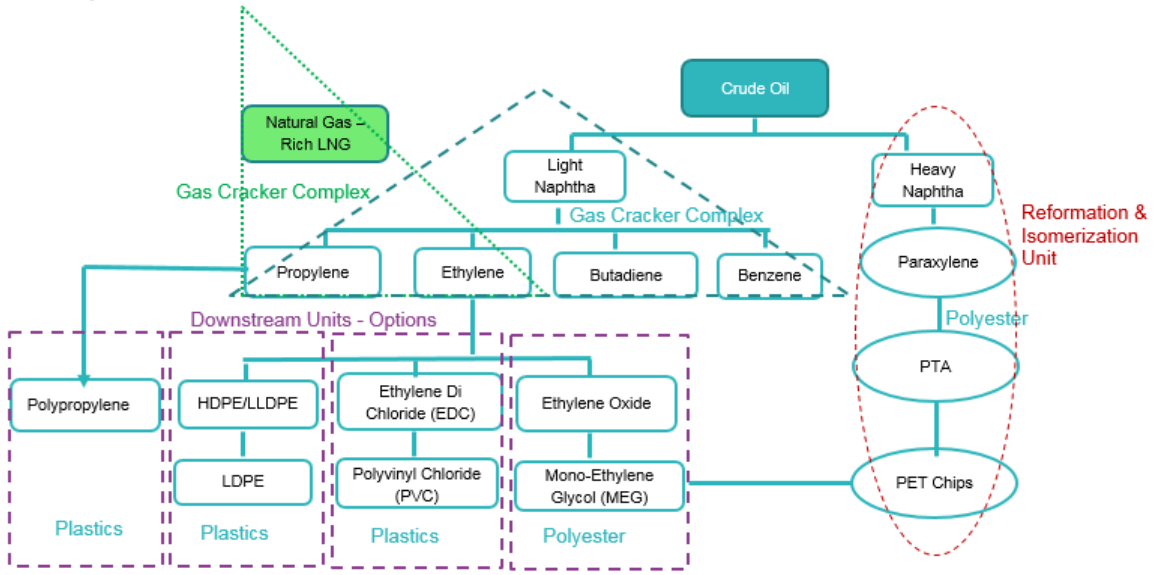
Value Chain

Naphtha, a complex mixture of hydrocarbons possessing 4 to 12 carbon atoms, is produced along with straight run gasoline in the atmospheric distillation column during refining of crude oil. The distillate is split into light naphtha (LN) and heavy naphtha (HN) in a splitter.

Value chain of naphtha is shown in Figure Ex.1

1 In 2015-16, export was marginally higher at 7.12 MMT

Figure Ex. 1: Value Chain of Naphtha



Source: Compiled by MM

Demand-Supply

No refineries are producing HN unless it is required for making PX; thus, naphtha surplus necessarily denotes LN, not HN – except for NGL. **Analysis ahead in this report is mostly focused around LN. The term 'naphtha' has been used in generic context, except where categorisation into HN & LN is desired.**

Naphtha production in 2015-16 aggregated to 17.67 MMT; 0.21 MMT higher than in previous year; consumption in the same period grew nearly by 2.40 MMT to 13.34 MMT. As production and exports almost remained unchanged in 2015-16, it is apparent that the additional demand was fulfilled through imports – mostly by Haldia Petrochemicals Ltd (HPL).

Consumption of naphtha is driven by crackers followed by fertilizer and power industry. IOCL's Panipat (0.86 MMT), HPL's Haldia (0.70 MMT[3]), and RIL's Hazira (0.90 MMT) and Vadodara (0.13 MMT) crackers are instrumental in consuming naphtha. Substitution of naphtha by natural gas as feedstock in both fertilizer and power industry has depleted the naphtha demand from these segments post 2010; present consumption results from the units awaiting natural gas connectivity. Higher price of domestic

3 Ethylene capacity

naphtha has even compelled these units in importing naphtha, thus further affecting the demand. Eventually, naphtha requirement from existing consumers is not likely to grow further.

Given the depleted demand from industries other than crackers, refiners have been back-blending portion of surplus LN with MS to increase its yield; In proportion with its perceived importance in petroleum value chain, share of naphtha in refining product slate declined from 13% to 7.64%; thus, share of MS in the product slate increased from 8% in 2005-06 to 15.37% in 2015-16. Referring to the higher realisations from mainstream products, Refiners' approach of controlling naphtha yield appears justified.

Table Ex.2: Petroleum Refining Fraction & Commercial Importance

Sl No	Fraction	Refining Throughput 2015-16 (MMT)	Share in refining throughput %	Relative Selling Price (₹/Kg)
1	LPG	10.60	4.58%	14.2*
2	Light Naphtha	17.86	7.64%	43.0
3	Motor Spirit	35.32	15.37%	54.0
4	ATF	11.79	5.10%	43.0
5	SKO	7.50	3.24%	16.0*
6	HSD	98.59	42.64%	49.0
7	LDO	0.43	0.19%	35.0
8	Lubes	1.04	0.45%	45.0
9	Furnace Oil	10.32	4.46%	35.0
10	LSHS	0.37	0.16%	36.0
11	Bitumen	5.16	2.23%	27.0
12	Others	32.25	13.95%	33.0
	Total	231.23	100.00%	

Source: PPAC * - Subsidized prices

The situation may remain same as the refiners are enhancing isomerisation capacities to adhere to the BS V/VI norms, so as to maintain yield of MS.

However, considering that only C-5 and above can only be isomerized, it is felt that LN would still be available in surplus.

Petrochemicals

As against demand of around 6.93 MMT ethylene in 2015-16, domestic manufacturing capacity is 3.93 MMT[4]. This includes 1.35 MMT from gas

4 Without considering Bramhaputra Cracker & Polymer Ltd's (BCPL) 0.22 MMT capacity as it was commissioned in February 2016

based crackers: GAIL's (0.45 MMT), and RIL's Gandhar (0.50 MMT) and Nagothane (0.40 MMT) cracker.

India could augment the ethylene capacity as increasing shortfall (3.00 MMT) rises the import bill which increased by nine folds in last eight years to reach nearly ₹27,400 crore in FY 16. Demand of ethylene is growing at a rate of 0.62 MMT every year, and it is estimated, domestic supply would continue to fall short of demand by end of 2016-17. To address this 3.17 MMT of greenfield projects are planned -

- OpaL-1.1 MMT,
- BCPL-0.22 MMT,
- RIL Jamnagar -1.4 MMT,
- GAIL -0.45 MMT
- 0.28 MMT capacity for debottlenecking projects.

This indicates requirement for new cracker(s).

Economic Capacity

Being host to commodity bulk products, present day minimum economic capacity of a naphtha cracker is 0.90-1.00 MMT of ethylene, requiring 2.50-3.00 MMT feedstock. As naphtha cracks are gases at ambient conditions, these must be liquefied (refrigerated) for transportation over long distance, which call for special infrastructure involving high costs. Hence, setting an integrated complex along with the downstream capacities of plastics is demanded. However, as the integrated units will be capital intensive and also attract higher operating cost, it was thus requested by the Ministry to check the international trends of setting-up crackers.

Possibility of developing crackers with capacity less than 0.30 MMT for producing high margin speciality products was thus explored. Review of information on such crackers listed in International Survey of Ethylene Steam Crackers 2015 indicated that all such small crackers were commissioned between 1970 and 2000, and hence either been revamped, expanded or mothballed by now. All the crackers were/are backed up by back-end supply of naphtha, hence reducing fiscal obligations. Only few had special polymers or chemicals under their product slate, ruling out possibility of reducing economic capacity by way of value addition. The review of ethylene capacities under implementation in China, released by Platts International in September 2014, indicates

that the capacity of new crackers starts from 1.0 MMT and are more than that.

Refer Annexure I for details.

Present & Future Surplus

The present surplus naphtha of 7.00 MMT would effectively reduce to 3.00 MMT considering requirement of naphtha by upcoming crackers and the export obligations[5].

By 2021-22, additional 6.80 MMT of naphtha is expected to be added resulting from planned[6] expansion in oil refining capacity by 64.00 MMT. The total surplus naphtha in 2021-22 effectively would be 4.20 MMT as 2.22 MMT naphtha would either be isomerised or used for captive consumption in debottlenecking of existing crackers.

A summarised analysis on present surplus and the likely availability of naphtha in 2021-22, duly discussed with IOCL, is tabulated as under–

Table Ex.1: Indicative Naphtha Availability in 2012-22, MMT

Refinery	Existing Available Surplus	Additional Supply	Total Available Supply [8]	Region
IOCL Barauni	0.05	0.10	0.10	East@
IOCL, Haldia	0.05	0.05	0.10	East
IOCL, Koyali	0.27	0.43	0.60	West
BPCL, Mumbai	0.35	0.30	0.20	West
BPCL, Kochi	0.30	0.90	0.10	South
HPCL Vishakhapatnam	0.25	0.70	0.90	East
HMEL Bhatinda	0.05	0.22	0.20	West#
CPCL, Chennai	0.35	0.05	0.40	South
NOCL Cuddalore	NIL	0.60	0.40	South
MRPL	1.0	NIL	0.80	South
Essar Oil	0.40	NIL	0.40	West
Total	**3.07**	**3.35**	**4.20**	

Source: IOCL, Guideline Document on Naphtha by Ministry of Petroleum & NG, MM Analysis
@ Can be transported to Haldia/Paradeep Port, # Can be transported to Mundra Port,

5 New crackers of OPaL and BCPL are likely to consume 1.70 MMT naphtha from the current surplus naphtha by 2016-17. Further out of remaining 5.30 MMT, 1.90-2.00 MMT produced by RIL's refinery in Jamnagar SEZ would need to be exported under export obligation. After adjusting domestic sales of around 0.30 MMT, the net actual surplus of naphtha is 3.07 MMT

6 Includes IOCL's 15.0 MMTPA Paradip refinery as it was commissioned in last quarter of 2015-16 and was not into full-fledged operations till end of the financial year

8 Indicated supply takes cognizance of BPCL and HPCL's plans for setting isomerisation units which would consume the major part of 2.2 MMT of surplus naphtha.

NOCL's production in 2021-22 will be proportional to capacity utilization

Part of MRPL's LN might be converted to reformate suitable for PX

Naphtha from Rajasthan refinery is not considered in the plan as the refinery has exclusive plans of setting-up a cracker.

Naphtha from HPCL's grass root Rajasthan refinery and Vishakhapatnam refineries are not considered as both are in planning stage.

The Consultants note naphtha availability, by 2021-22, is estimated to be scattered in different regions, 1.1 MMTPA in East, 1.4 MMTPA in West and 1.7 MMTPA in south, and there could be a possibility of variation in the estimated availability based on inclination of any refineries to participate in the pool. Thus, only one 1.00 MMTPA ethylene cracker can be envisaged at this stage.

The Consultants reviewed the pooling options and respective costs at locations of major availability.

Pooling Cost – New Pipeline Infrastructure

It has been estimated that around 2,600 running km pipeline would be required for pooling of 3.0 MMT naphtha, entailing a capital outlay of about ₹3,400 Crore[9]. Operations and maintenance costs are estimated to be around ₹285-300[10]/ Tonne, which is around 6.00-6.50% of gross block per annum[11].

However, the proposal was not considered viable as the piping network becomes a subject of techno-commercial feasibility in itself.

Pooling Cost – Coastal Shipping & Existing Pipelines

As nine of the eleven locations are coastal refineries, shipping was considered along the coastal lines rather than spending the additional capital costs on laying the pipelines. After plotting the nautical miles (Nm) and estimating approximate transportation cost per MT-Nm for shipping distances from the naphtha sources, the weighted average cost per MT for pooling of entire surplus naphtha at each location worked out to be[12] as follows:

- Kochin – ₹785/T
- Mangalore - ₹922/T
- Chennai - ₹926/T
- Mumbai – ₹928/T

9 Benchmarking cost with IOCL's on-going pipeline projects like Paradip-Raipur, Ennore-Trichy, Paradip-Haldia-Durgapur indicate capital cost between ₹1.30 to 1.50 Crore/running Km

10 MM Estimates

11 This include consumables, utilities (power) at 1.50%, repair & maintenance cost of 1.0%, general O&M expenses of 1.0%, finance cost & interest of 0.50%, insurance cost of 0.1%, salaries, admin & overhead cost of 0.30% and marketing expense of 0.30% of gross block. Adding 15% operating profit margin and duties to above, overall cost sums up to 6.50% of gross block

12 The figures are indicative, and to be used for comparison between the two locations. Case specific cost has been discussed under planning section in the Executive Summary

- Dahej (Koyali) - ₹1,240/T
- Vishakhapatnam - ₹1,283/T and
- Paradip/ Haldia - ₹1,333/T

Refer Appendix J for supporting calculations.

Pooling Operator

No dedicated pooling operator for naphtha can be envisaged unlike in natural gas pooling. The mechanism of natural gas pooling may not hold good in case of naphtha as the earlier is driven by demand (one supplier-multiple purchasers) whereas the latter is driven by surplus supply (one purchaser-multiple suppliers). As surplus supply as well as willingness to participate in pooling may differ for suppliers, prices are to be governed by market forces rather than Administered Price Mechanism (APM).

Pooling Locations

Shortlisting of pooling location has been done by comparing locations on a set of benchmark criteria. Pooling cost, forming insignificant portion of naphtha landed costs, was similar across locations, thus was not considered as a factor for shortlisting. Following factors were considered for shortlisting:

- Locations with/without existing crackers:
  - western region having overcapacity was ruled out;
  - huge unaddressed demand from the end-use industry in south India is an enabling factor for locating the cracker in southern part
- Port-connectivity and congestion: ports with necessary spare handling capacity and relatively less traffic were considered, which ruled out Haldia and Mumbai ports
- Proposed LNG terminal for receiving imported LNG: no concrete plans were noted for Paradip and Haldia
- Notwithstanding above considerations, integration of cracker with refinery operations is likely to provide higher synergies of operations, and thus the locations with largest availability of naphtha with existing refinery were shortlisted – Mangalore and Vishakhapatnam

Industry Challenges

The key challenges in planning a petrochemical cracker on pooled naphtha, on stand-alone basis, include -

- High cost of capital and higher production costs in comparison with the existing petrochemical units and their locations - That's why HPCL's one MMT cracker, even after being announced as the anchor tenant for the APPCPIR, has not made any progress - absence of investment partner.
- Naphtha will always be an expensive raw material vis-à-vis natural gas due to the inherent manufacturing process, thereby the products based on these two raw materials will have their own economic dynamics
  - Disparity in pricing mechanism leads to conflict interest between rich LNG and naphtha'; price of naphtha is built on import parity[13] rather cost plus basis.
- Higher import duty on naphtha increases the price of feedstock and adversely impacts the commercial viability of setting up of the cracker based on imported naphtha in India
- While inappropriate duty structure of naphtha increases its landed cost, lower duty differential [14] between naphtha and polymers indirectly encourages importing polymers instead of processing them in-house
- Lack of enabling infrastructure and absence of common utilities increase the operational cost when compared with global crackers
- Scope for improvement in implementation support (co-ordination during land acquisition and timely processing of statutory clearances) without which projects get delayed adding to its capital costs;

It can be noticed from Table Ex.2 and Ex.3 that cost of capital and the duties in India are among the highest in surrounding nations in the ME and SEA.

Table Ex.2: Comparative Analysis of Factor Costs in India

Country	Location	Land Rate# (US$ /m^2)	Power (US$/KW)	Water (US$/m^3)	Interest Rate (%)
India	Mangalore/ Vishakhapatnam	40-90	0.14	0.53	12.0%
Singapore	Jurong	~300	0.20	0.90	5.4%

13 India being net importer of crude oil, all petroleum products are priced on import parity basis instead cost plus basis. In import parity basis market price is determined as cost of import + custom duty, whereas in cost plus basis it is calculated as manufacturing cost + excise duty + interest, depreciation & taxes + profit

14 Difference between import duty on naphtha and derivative petrochemical

Country	Location	Land Rate# (US$ /m^2)	Power (US$/KW)	Water (US$/m^3)	Interest Rate (%)
Malaysia	Penang	30-70	0.11	0.43	4.6%
Thailand	Amata Nakorn	144	011	0.37	6.8%
Japan	Around Tokyo	800	0.24	1.85	0.1%
China	Around Beijing	~160	0.11	0.82	5.5%
Saudi Arabia	Jubail/Yanbu	1.30*	0.04	6.0	5.0%
Oman	Sohar/Rusayl	1.30*	0.06	2.06	5.0%

Source: Compiled from World Bank and Industrial Devpt Authorities of Respective Countries # - purchase * - lease rental

Table Ex.3: Comparative position of Indian Import Duty on Naphtha & Derivatives (2015)

Product	India		China/Taiwan	Japan	South Korea	Saudi Arabia	United States
	Basic	CVD & Cess					
Naphtha (HS Code 2707)	2.50%	14.86%	0%	NA	NA	5%	NA
Naphtha (HS Code 2710)	10.00%	16.26%	2.50%	0.00%	0%	0%	0.20%
EDC	5.00%	13.67%	3.50%	3.90%	5.50%	5.50%	5.50%
VCM	5.00%	13.67%	3.50%	3.90%	5.50%	5.00%	5.50%
MEG	7.50%	18.93%	7.50%	4.60%	5.50%	5.50%	5.50%
PVC	7.50%	18.93%	7.50%	4.10%	5.50%	6.50%	5.50%
LDPE	7.50%	18.93%	7.50%	6.50%	6.50%	6.50%	6.50%
LLDPE	7.50%	18.93%	7.50%	6.50%	6.50%	6.50%	6.50%
HDPE	7.50%	18.93%	7.50%	6.50%	6.50%	6.50%	6.50%
Duty Differential	**(2.50%)**	**2.67%**	**5.00%**	**6.50%**	**6.50%**	**5.00%**	**6.50%**

Source: CPMA, Customs Tariff Departments of Respective Countries # - Basic duties at discounted tariff

Since naphtha is not particularly defined in customs' tariff, it is being traded under different harmonic system (HS) codes. Import duties for different categories have been noted to be different. Higher duty differential in leading countries enables importing naphtha for value addition rather than importing finished products as such.

Eventually, **preliminary response from the refiners was not in support of setting up a new cracker under the present circumstances. The analogy got further supported when economic analysis was carried out**.

Economics

Given the barriers on pricing of naphtha and obvious techno-commercial advantage of natural gas over naphtha, a gas cracker holds competitive edge over naphtha based cracker. However, as there are challenges in availability as well as with respect to preferential (need based) allocation of

natural gas in India, a dual feed cracker with naphtha as major feed was considered for analysis. As a standalone cracker shall not be technically viable due to challenges in product storage and handling[15], a downstream complex housing polymer unit was considered.

Economics for a 0.90 MMT cracker with configuration similar to IOCL's Panipat cracker (but excluding the MEG unit) were evaluated with set of assumptions as discussed under section 6.5 at prevailing capital cost (2015-16) estimated at around ₹18,800 Crore.

Irrespective of whether naphtha is pooled or made available at back-end refinery, the scenario considering naphtha priced on retail basis was not found economically viable with only 5% PAT margin and negative cash flow. Hence, the proposal is not conducive for investment under the present circumstances.

It is pertinent to note that the pooling cost, which constitutes just 3-4% of landed naphtha price, is not very significant in deciding the viability.

Thus, the situation finally demands concessions to live up to the requirements under the 'Make-in-India' policy, supported by socio economic rationale.

Conclusion & Recommendation

Despite at its best integration with refinery operations, and even after treating naphtha on transfer price, domestic crackers operate with costs 6-7% higher than global average. It is well known that Saudi Arabia and UAE possess competitive inherent advantage of gas based crackers. Natural gas which can readily be cracked after conditioning at the very source of its origin shall always be the preferred feedstock.

As the present case scenario is not favourable for investment, there is a need to explore the options for improving the operating margins in due discussion with the refiners. The opinion of refiners on materialising opportunities, and expectations in the form of fiscal, regulatory, and infrastructure facilitations could be invited.

An overview of the scenario is depicted below –

15 Both ethylene and propylene are gases at normal room & temperature. Ethylene needs to be transported at -60oC

Oy

Naphtha Availability - Present

- Naphtha Exports in 2014-15 and 2015-16: ~**7.0 MMT**
- Exports from RIL's SEZ Refinery: **1.9-2.0 MMT**
- Commitments to OPaL & Brahmaputra Cracker: **1.4 MMT; domestic sale: 0.6 MMT**
- Naphtha Surplus post 2016-17: ~**3.0 MMT**

Ethylene Shortfall

- Ethylene capacity: **3.93 MMT** (4 Naphtha & 3 Gas based crackers)
- Ethylene Demand in terms of consumption of derivatives: **6.93 MMT**
- Import Bill of Key Derivatives in 2015-16: **~₹ 27,300 crore**
- Likely Demand of ethylene in 2025: **13.14 MMT**
- Upcoming Capacities: 3.45 (execution stage) +2.05 (planning) MMT
- Shortfall in supply in 2025: **3.71 MMT**

Naphtha Availability - by 2021-22

- Expansion in refining capacity: **64.00 MMT**
- Likely Naphtha (LN) Throughput: ~ **6.80 MMT**
- Additional Quantity of that can be pooled for cracking **Only 1.0-1.2 MMT**
- Likely Total Naphtha Availability for Pooling: ~ **4.20 MMT**
- Major Locations of Availability: Koyali, Vishakhapatnam, Mangalore & Chennai

Industry Challenges

- **Invariably high minimum economic size/ capacity, Higher Capital Cost**: ~ ₹18,800 crore
- **Naphtha Pricing Mechanism**: Import parity (CIF) Vs export on FOB basis; considerable difference in naphtha & gas prices – even LNG
- **Technical Issues over gas**: high specific consumptions
- **Fiscal Disparity**: difference in excise duty imposed on Naphtha & Gas; highest customs duty (5%) & duty differential (2.5%) on naphtha
- **Location & Infrastructure**: LN availability scattered, lack of shared infra
- **Changing Priorities**: Higher preference to isomerization of LN **to MS**
- **Competitive imports; domestic industry operate with costs 6-7% higher than global average**
- **Unavailability of adequate Natural Gas or RLNG for cost competitive proposal**

Pooling Options & Economic Viability

Although coastal pooling seems viable, economic viability is not in favour of setting-up a naphtha cracker under present circumstances

1 Introduction

1.1 Background

Naphtha is one of the widely processed parent feedstock for host of products including petrochemicals, polyesters, polymers & plastics, surfactants & detergents, paints, adhesives, solvents and many speciality chemicals. It is produced as a co-product in certain percentage in the atmospheric distillation unit in a crude oil refinery. Natural gas liquid (NGL), produced during conditioning of natural gas in fractionating columns too is considered under the naphtha family. In 2014-15, naphtha production from refineries and fractionators in the country aggregated to 17.5 million metric ton (MMT), of which nearly 11.0 MMT was consumed domestically and rest exported.

Petrochemical industry is the largest consumer of naphtha in India followed by fertilizer and power industry. Depending upon type of naphtha, it is ether cracked to olefins or reformed to para xylene in petrochemical complexes. In the absence of adequate downstream consumption capacity in the domestic industry, refiners are exporting surplus naphtha. On the contrary, India faces short supply of the commodity polymers prepared from naphtha. Increasing demand of these polymers has compelled the domestic industry to import these polymers in large quantities involving huge foreign exchange (Forex) outflow.

Setting naphtha based crackers could be an option worth to be considered at this stage. However, economic size of an integrated naphtha cracker in terms of ethylene capacity is almost 0.9-1.0 MMTPA, requiring 2.5-3.0 MMTPA naphtha depending on its composition. As availability of such huge volumes of naphtha at any given location is a constraint, need was felt for evaluating possibilities for pooling excess naphtha to a common location(s) for setting-up naphtha cracker(s), and to analyse prima-facie viability of such units given the challenges being faced by the industry.

Federation of Indian Chamber of Commerce & Industry (FICCI), with support from the Ministry of Chemicals & Fertilizers and Department of Chemicals & Petrochemicals, has commissioned a study for analysing the aspects for pooling naphtha in the Country, and has retained Mott MacDonald for the purpose.

1.2 About FICCI

Federation of Indian Chamber of Commerce and Industry (FICCI) is a non-government and non-profit organisation. The organisation, established in 1927, is the largest and oldest apex business organisations in India. Its primary objective is to communicate the views and concerns of industry by interacting with civil society and policy makers to influence policy, and encouraging debate. It also works closely with the Government to enhance efficiency and competitiveness through a range of specialised services, which results in creating a conducive environment for businesses to grow and expand its business opportunities. FICCI has joint business councils with 79 countries around the world and its publications are widely known for its in-depth analysis and policy prescriptions.

Few of the many sectors catered by FICCI are

- Advertising and Marketing
- Agriculture
- Petrochemical
- Steel
- Defence
- Chemicals
- Food Processing
- Digital Communication
- Renewable Energy
- FMCG
- Tourism

1.3 Mott MacDonald

Mott MacDonald India ('MM' or 'the Consultants'), part of Mott MacDonald Group, is a leading multi-disciplinary management, engineering and development consultancy based in India, with offices spread across the country.

MM is engaged in planning and development touching many aspects of everyday life – from water, energy, industry, environment and transport to building, healthcare, tourism and social development. Across these sectors MM works for national and local governments, public and private utilities, industrial and commercial companies, investors, developers, banks and financial institutions, international and bilateral funding agencies and private entrepreneurs.

With about 900 professionals MM takes care of the entire process of the project – from concept to commissioning– including providing advice on the best procurement route and the optimum approach for maintaining the project once it enters service.

For the past three decades MM has been at the forefront of management, engineering and development consultancy in India, working on a wide variety of projects for an equally broad spectrum of clients – large public and private sector companies, state and central governments, multi-national companies and international funding agencies. Mott MacDonald is a powerful synergy built on the best domestic and international talent and expertise. This ensures MM clients benefit from an even greater range of skills and services, all meeting international quality standards.

1.4 Scope of Work

The Scope of Work (SoW) is elaborated below

Research and preparation of a concept paper covering the following aspects:

- Status of production of Naphtha by refineries and consumption pattern of Naphtha by downstream industries and status of production of Naphtha by various refineries in the country along with related logistics issues
- The Export and Import data of Naphtha (name of countries along with quantities imported and exported), its end usage in various countries that import or export it

- Import of value added products manufactured from Naphtha along with quantity exported and value from these countries
- Naphtha feedstock based projects under planning and implementation in the country
- Potential of utilizing Naphtha in the domestic market by pooling it from different locations
- Issues and constraints in pooling naphtha for value addition rather exporting it

1.5 Approach & Methodology

The approach initiated with the kick-off meeting with FICCI on 28th July 2015 to convey the Consultants' understanding of the scope and deliberation on the proposed action plan.

This was then followed by a preliminary desk based research in order to develop a framework for the study, and so develop a questionnaire. In the absence of up-to-date information from secondary data sources, a compiled data checklist was issued to FICCI seeking guidance in sourcing the information on production and consumption of naphtha from Petroleum Planning & Analysis Cell (PPAC).

With the basic information in hand, contact list and separate questionnaires were drafted for different industry segments. Request e-mails were initiated for primary survey through face-to-face or telephonic appointments. The intended contacts included oil corporations, their petrochemical wings, consumers from fertilizer and liquid fuel based power industry, industry association and the other petrochemical companies indirectly involved with cracker based petrochemicals. As on the date of submitting this draft report, the Consultants have covered following of the intended contacts –

Table 1: Primary Contacts Covered

Si No.	Company
	Oil Corporations
1	Indian Oil Corporation Limited (IOCL)
2	Mangalore Refinery & Petrochemicals Limited (MRPL)
3	HPCL - Mittal Energy Limited (HMEL)
	Industry Associations & Policy Analyst
4	Chemicals & Petrochemicals Manufacturers Association of India (CPMAI)
	End Users – Petrochemicals
5	ONGC Petro additions Limited (OPaL)
	End Users – Fertilizers
6	Mangalore Chemicals & fertilizers Limited (MCF)
	End Users – Power
7	PPN Power Limited (PPN)
	Industry Opinion
8	Sanmar Chemplst
9	ThyssenKrupp India Pvt Ltd
	Gas Based Petrochemical Manufacturer
10	Gas Authority of India Ltd (GAIL)

Interactions with the Industry helped the Consultants to strengthen their understanding and gathering cues for focused research. A focused desk based research was then undertaken compiling the necessary information. The compiled information was then analysed for drawing meaningful inferences and providing recommendations.

Primarily, the following information sources were referred for compiling data

Table 2: Data Source

Si. No.	Category of Information	Source
1	Production, Consumption, Import & Exports of Petroleum Products, including values	PNGSTAT 2012-13, 2013-14; Detailed data available at PPAC's website
2	Production, Consumption, Import & Exports of Petrochemicals, including values	Chemicals & Petrochemicals Statistics at a Glance 2014, published by Ministry of Chemicals & Fertilizers, Department of Chemicals & Petrochemicals
3	Capacities – Existing & Under Implementation	• Environment Clearances (EC) awarded to respective projects • Environment Impact Assessment (EIA) Reports prepared by the companies and • Information available on companies portals and in Annual Reports
4	Imports & Exports by Ports in India	M/s Seair
5	Global Prices & Global Capacities	• OPEC Statistical Bulletins 2014 & 2015 • BP Statistical Review of World Energy 2014 • International Survey of Ethylene for steam crackers, Oil & gas Journal 2015
6	Corporation wise information of production, export & domestic sale of naphtha	Primary survey, Annual Reports, and base paper provided by FICCI

A working draft report incorporating preliminary analysis on the subject was submitted on 25 October 2015 for comments from FICCI and the other stakeholders.

A joint review was held between IOCL, FICCI and Mott MacDonald in IOCL's New Delhi office on 14 December 2015 to cross-validate the assumptions and inference in the draft report. IOCL, who has been leading Oil Corporations' panel for reviewing availability of naphtha.

As no more comments were received from other stakeholders till 3rd week of Mar 2016, MM submitted Final Draft of the Report on 31 March 2016. The report was subsequently reviewed and discussed with Hon. Joint Secretary, Ministry of Chemicals & Fertilizers on 5 April 2016.

The report addressing comments from Hon. Joint Secretary, Ministry of Chemicals & Fertilizers is issued on 29 April 2016 for final set of comments from all other stakeholders.

A presentation was held on 18 May 2016 to summarise the key findings to the Hon. Secretary, Ministry of Chemicals & Fertilizers. The discussions brought out few aspects which were not in-principally covered under the report.

Report addressing the minutes of meeting held on 18 May 2016 was submitted on 6 July 2016, covering presentation for which was held on 23 August 2016. The discussions demanded few key aspects to be elaborated with logical reasoning to close the instant study.

Report addressing the feedback during the discussions held on 23 August 2016 was issued on 7 October 2016. A presentation in front of Hon'ble Secretary, Ministry of Chemicals & Fertilizers, Department of Chemicals & Petrochemicals, to discuss the final findings was held on 8 February 2017.

This final report, after addressing relevant remarks and having arrived consensus on the findings, is being submitted on 9 February 2017.

1.6 Caveats

- Consultants have relied on proprietary information and their past experience in bridging the gap in information available from public domain or which could not be elicited during primary survey
- The specifications of crude input fluctuate in refineries. There are several factors influencing the configuration of refineries, throughput of reformate naphtha, and that of motor spirit (MS). This leads to variation in specifications of naphtha available across the refineries. Detailed specifications would be required to be obtained from the refineries before finalising cracker's configuration of pooled naphtha
- A framework, typically based on analysis of trends in production, captive consumption, domestic sale and exports of naphtha in the past three years, has been built by Consultants to analyse its distribution by region and oil refineries in 2015-16. While the framework incorporates the suggestions received from IOCL and HMEL, comments from other stakeholders have not been received
- Expected availability of naphtha after implementation of BS V/VI norms might undergo a change. However, the matter is still under deliberation and the finding may undergo a change when better clarity on the topic emerges at a later date
- Estimates on capital outlay, operating costs and economic viability are indicative, which can undergo change depending upon location, configuration of cracker complex, and specifications of feedstock

2 Naphtha Value Chain

2.1 Naphtha – in refinery operations

Naphtha is a nomenclature used for denoting mixture of aliphatic[16], cyclic and aromatic[17] hydrocarbons with initial boiling point (IBP) around 30°C and final boiling point (FBP) around 220°C. It is a complex mixture of hydrocarbons possessing 4 to 12 carbon atoms. The distillate is produced along with straight run gasoline[18] in the atmospheric distillation column during refining of crude oil. The distillate, termed as virgin or straight-run naphtha, is later split into light naphtha (LN) and heavy naphtha (HN) in a splitter. Light fraction mostly containing hydrocarbons with less than six carbon atoms is low in aromatic and naphthenic content. Heavy naphtha as contain more than six carbon items is rich in aromatic and naphthenic content.

In terms of inherent usage, HN, after stripping off aromatics i.e. benzene, toluene & xylene (BTX), is catalytically reformed (platformed) to restructure the naphthenes to high-octane aromatics (normally called as reformate) desired for Motor Spirit (MS) pool. Reformer also produces valuable hydrogen, required in hydrotreating the other refinery fractions to desulphurise them to finished products. When not reformed, it can be used for manufacturing para-xylene (PX). Portion of HN also goes to hydrotreater unit for desulphurisation and then to HSD to increase its cetane number.

LN, which also forms feed to hydrogen unit, cannot be reformed for use in MS pool as it tends to crack to butane and lower hydrocarbons on reforming, and cannot provide the high octane number desired for MS. LN rich in paraffins can be used in crackers to produce ethylene, propylene, butadiene and pygas, or in fertilizer complexes as a source of hydrogen in making ammonia and subsequently urea. C-5 portion of LN can be isomerised to high-octane components (isomerate) useful in MS pool, thus increasing the yield and quality of MS.

It is implied that the naphtha surplus necessarily denotes LN, not HN

Production of HN is not disclosed if it is directly absorbed in the auto fuels, but is disclosed if it goes in making PX. As such, no refineries are producing HN unless it is required for PX. Thus, it is implied that the naphtha surplus necessarily denotes LN, not HN.

Apart from straight-run naphtha, refinery's secondary units[19] also produce naphtha in certain quantities. Heavy portion of this naphtha, being rich in aromatics, is diverted to MS or PX pool. But the lighter fractions are normally found lean in paraffin content[20] , and are not readily suitable

16 Straight chain alkanes, also called as paraffins

17 Cyclic hydrocarbons possess ring structure, but with all single bonds (naphthenes); aromatic compounds possess ring structure with double bonds

18 Motor Spirit

19 Such as fluidized catalytic cracker (FCCU), hydrocracker (HCU), visbreaker units (VBU), diesel desulphurisation unit

20 Light fractions of naphthas from secondary refining units tend to crack in secondary units to produce olefins (propylene, butylene etc), making it unsuitable for further cracking

for steam cracking. These can be used as a fuel in industrial furnaces or liquid fuel based power plants, or transformed to paraffinic state by hydrogenation[21].

The intent of any refiner towards the product-mix shall depend on the National Policies on automotive fuels and business plan of the refinery

Normally, LN with paraffin content more than 65% is considered suitable for cracking, and hence this report analyses availability and other aspects related to such grade of LN. However, production and quality of naphtha in a refinery is a function of multiple factors, including configuration of the refinery and assay of crude processed. Typically, sour crude [22] gives naphthenic and aromatic naphtha, whereas sweet crude[23] produces paraffinic naphtha. Refiners, in general, have been blending crudes to manage the economics with respect to the configuration of the refineries[24]. Thus, it could be said that each refinery produces naphtha with unique composition, thus increasing the challenges for dedicated use in a common cracker. Naturally, the intent of any refiner towards the product-mix shall depend on the National Policies on automotive fuels and business plan of the refinery. Given an option, any refiner will choose the product configuration in order to improve the bottom line.

As a consequence, understanding suitability of surplus naphtha cuts with individual refineries can be a matter of independent research. However, considering demand from this study, in broad sense, it has been assumed that the surplus with refineries can mostly be utilized by converting olefinic naphtha to paraffinic naphtha. It is true that naphtha of desired quality could also be managed by compromising certain yield of automotive fuels. However, apart from sacrificing the reformate, there are other important aspects which needs to be looked into. Same have been discussed in Chapter 5 and 6.

The analysis ahead in this paper is mostly focused around LN. The term 'naphtha' has been used in generic context, except where categorisation into HN & LN is desired.

Figure 2 gives overview of basic refinery operations and source of generation of heavy and light naphtha.

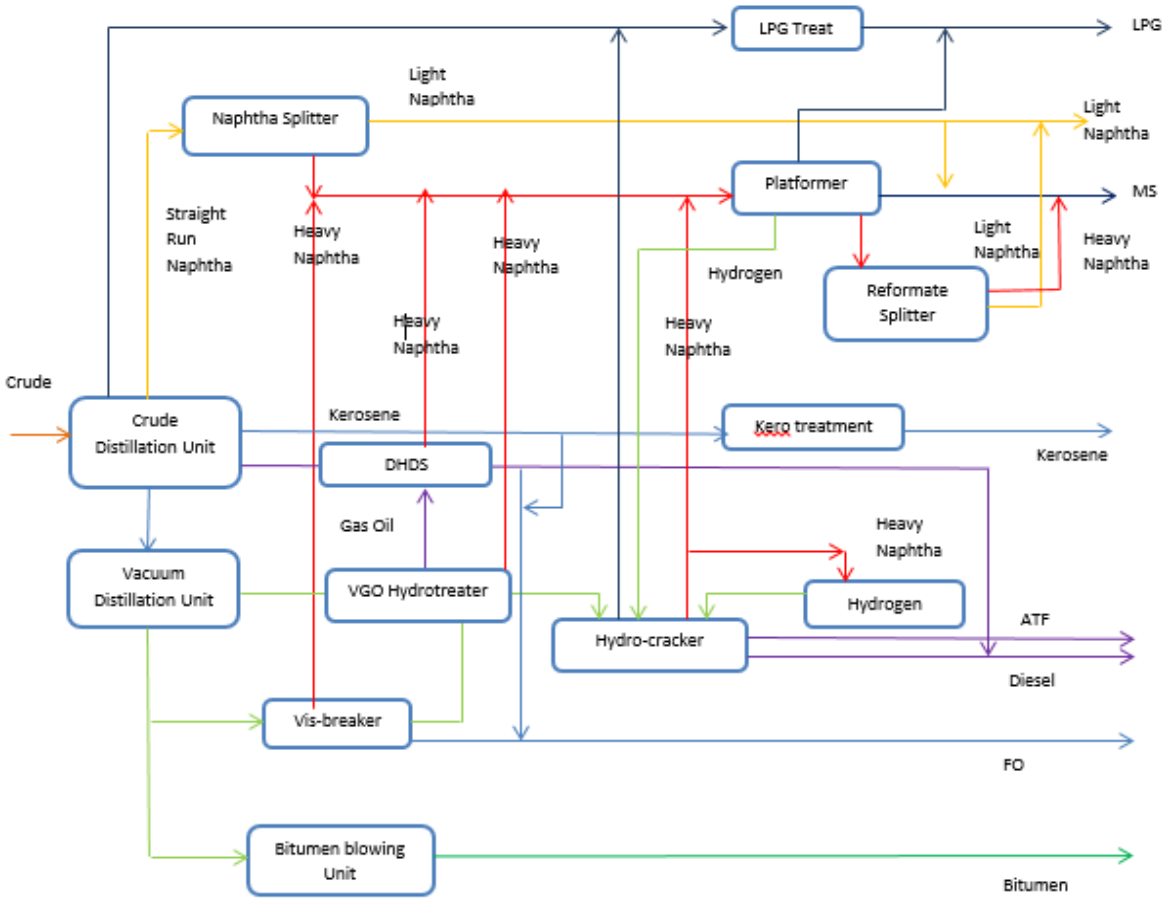
21 Olefins being unsaturated compounds, can be converted to paraffins by hydrogenation i.e. by breaking the double bonds to single bonds

22 Sulphur content higher than 1%; good for higher yield of HSD (but not mandatory)

23 Sulphur content less than 0.5%; normally desired for maximising yield of MS

24 Sweet crude, with higher composition of straight run gasoline and middle distillates, and comparatively lower proportion of heavy fuel oils, can be processed with high yields even in primary refining units – atmospheric distillation & vacuum distillation – and thus save cost required for setting up secondary treatment units; whereas, sour crude, with higher proportion of heavy fuel oils, require higher capital & operational expenditure on secondary & tertiary units like reformer, isomerization, delayed coker units to have better yield of MS and HSD

Figure 2: Process Flow of Refinery's Basic Operations



Source: Compiled by MM

Basics of occurrence of crude oil, with composition and boiling ranges of distillate fractions and detailed specifications of different grades of naphtha can be referred in Appendix A.

2.2 Uses

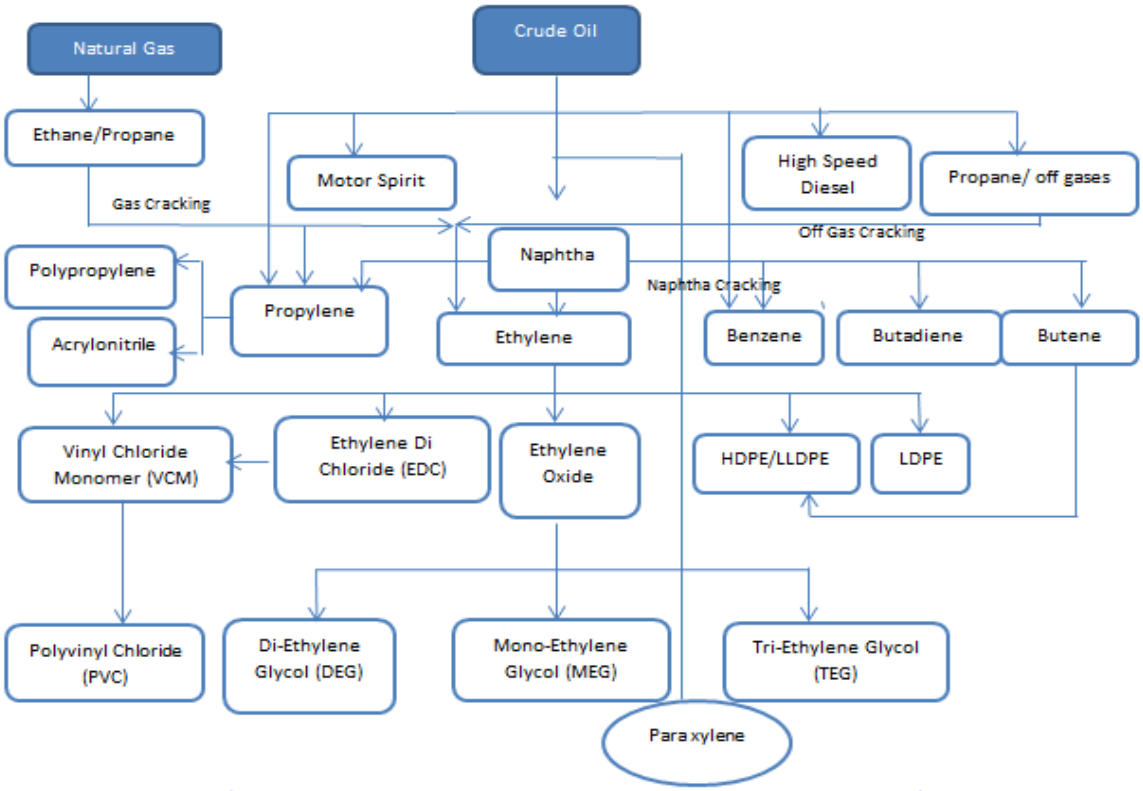
The largest use of LN is in making ethylene in steam based crackers, followed by urea manufacturing units, liquid fuel based power plants, or as a fuel for firing furnaces in the steel or ceramic industry. HN is used in petrochemical aromatic complexes for making PX through reformation and isomerisation.

The Largest use of LN in making ethylene is steam based cracker

2.3 Petrochemicals

Value chain of naphtha in petrochemicals till third level of derivatives is shown in Figure 3.

Figure 3: Naphtha Value Chain in Petrochemicals



Source: Compiled by MM

Of all building blocks, only ethylene and butadiene are exclusively produced in crackers, whereas rest are primarily produced in refineries

Family of petrochemicals comprise of ethylene, propylene, butadiene, benzene and xylene – normally termed as building blocks – and their derivatives. Of all building blocks, only ethylene and butadiene are exclusively produced in crackers, whereas rest are primarily produced in refineries[25]. In short, LN is critical for production of ethylene, and thus plays a vital role in growth and competitiveness of the ethylene industry[26].

Thus, naphtha, depending upon its type, is used in following type of petrochemical complexes –

- Those housing ethylene crackers will use LN
- Aromatic complexes housing reformer and isomerisation units will use HN

25 As stated earlier in footnote 3, olefins are produced during cracking of the refinery heavy stock in FCCU or HCU; a major portion of this is propylene.

Governmental regulations limit amount of benzene in finished products due to its carcinogenic nature, as a result of which it is mandatorily stripped off from the MS stream.

26 Ethylene cannot be produced without a cracker – be LN or gas based

- Standalone propylene based petrochemical complexes source propylene from refineries, and thus do not directly deal with naphtha.

2.4 Fertilizers & Power

LN can be also be used in the reformers in an ammonia plant as a source of hydrogen. This hydrogen is then reacted with nitrogen over catalyst to form ammonia, which is subsequently processed to urea in combination with carbon dioxide.

In the absence of considerable demand for LN in domestic or export segment in 1980s, it was promoted in fertilizers and power generation sectors to recover at least its salvage cost. In the decade of 2000, use of LN as the source of hydrogen[27] in all naphtha based urea plants was progressively taken over by natural gas due to economies of production; basis of subsidy to these units was also converted to gas. But, owing to the constraints in connectivity to natural gas or imported liquefied natural gas (LNG), three units in Southern India were exempted from this shift, and thus have been using subsidized naphtha. These units have continued getting subsidy at the rates normalized with respect to the gas prices. However, such subsidy shall continue till connectivity to natural gas is established.

Consumption of LN in power sector has declined significantly due to higher costs of domestic naphtha affecting operating margins; all the three naphtha based fertilizer companies are importing it too for the same reason

Additionally, LN is also being used in the gas and liquid fuel based power units as the fuel feed for generating power. But the consumption has declined significantly due to unreasonable cost of production resulting from high costs of domestic naphtha. Apparently, in the last 3-4 years, these units are being operated only during peak demands, when selling charges per unit are on the higher side than rest of the year. It is understood that in 2014-15 the landed cost of power generated from naphtha had reached ₹6.0 per unit as against selling rate of ₹5.0-5.5 per unit.

2.5 Other Uses

Other uses of LN include use as fuel in firing furnaces and as an ingredient for manufacturing solvents for paint, rubber and adhesives industry. Though the use as fuel has declined due to increasing cost vis-à-vis natural gas or LNG, use for solvents has seen to be increasing.

In summary, it could be said that LN will continue to be predominantly consumed in petrochemicals involving crackers and HN in reformers. The consumption in fertilizer and power sector will further reduce from the present levels on account of their shift to natural gas. Other uses like furnace fuel and as a solvent would remain, but shall be limited to 2-3%.

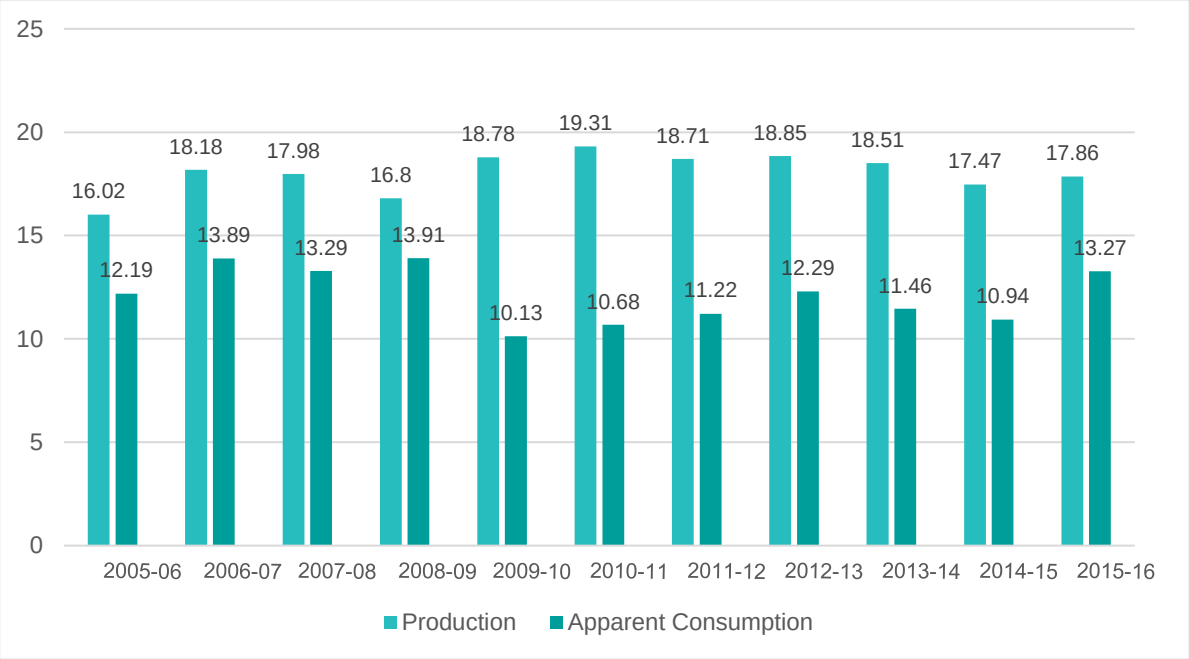
[27] The policy for conversion of non-gas based units to R-LNG was introduced under the New Pricing Scheme III (NPS III) in 2004. Non-gas based fertilizer plants were switched as per connectivity to natural gas from 2007-08 to 2013-14.

3 Naphtha Industry

3.1 Demand – Supply

Trend of domestic production and consumption of naphtha since 2005-06 is shown in Figure 4

Figure 4: Trend of Production of Naphtha (in MMT)



Source: Petroleum Planning and Analysis Cell (PPAC)

Naphtha production in 2015-16 has nearly remained constant, but consumption has grown to around 13.54 MMT due to increased demand

Naphtha on overall basis constitutes around 17-20% of the crude refining throughput, equally distributed between LN and HN. However, as most of this HN is diverted to MS pool, a clear segregation of total production into HN and LN is not available.

HN goes to making of para xylene in a reformer, and hence has no preference in ethylene cracker

Observing the trend of PX production till 2014-15 – Appendix C – it is believed that HN constitutes around 16-17% of the total naphtha production, and 25-27% of the consumption. It is also noted that the share of HN has remained in the given range for the last 2-3 years. As production of PX (and thus HN) is moving steadily, it is apparent that the fluctuation in production and consumption of naphtha as whole has mainly been on account of LN.

3.1.1 Production

Not being a mainstream product in the refineries, performance of naphtha cannot be looked at standalone basis. Production has been a function of demand of the mainstream products like MS, which have over the years determined the refining throughput mix[28] . As a result, production of naphtha has neither remained proportional to refining throughput nor to its own demand; it has been varying in contrast with production of MS.

Reference to the depleted demand from fertilizer and power industry, refiners have been back-blending portion of surplus with MS to increase its yield; isomerisation of C-5 fraction in naphtha paved way for further improvement in MS yield. Over the years, efforts gone in maximising the yields of mainstream products controlled the generation of naphtha resulting in reduction of share of naphtha in refining product slate.

Production of LN varies with production of MS

Assay of crude determines the product mix and thus configuration of a refinery. No two refineries in India possess crude with similar assay, and thus do not have the same configuration. Refining technologies and configuration are chosen in order to maximise yield of mainstream products – MS, LPG, HSD, Kerosene, aviation turbine fuel (ATF) – through primary, secondary and tertiary treatment units. The other factors determining product mix are –

- Government's energy policies, and national priorities also have bearing on product mix
- Long term business plans, including thrust on petrochemicals and downstream integration
- However, as level of integration, be it in refining or petrochemicals, largely depends upon scale of investment, product mix is always a function of investment, and
- Profitability aspects/ ratios between two petroleum products
- Expanse of oil corporation's business with respect to local or regional demand i.e. a refinery may
- Expanse of oil corporation's business with respect to local or regional demand i.e. a refinery may think of considering a petroleum product provided regional demand for mainstream products is being conveniently fulfilled for near future

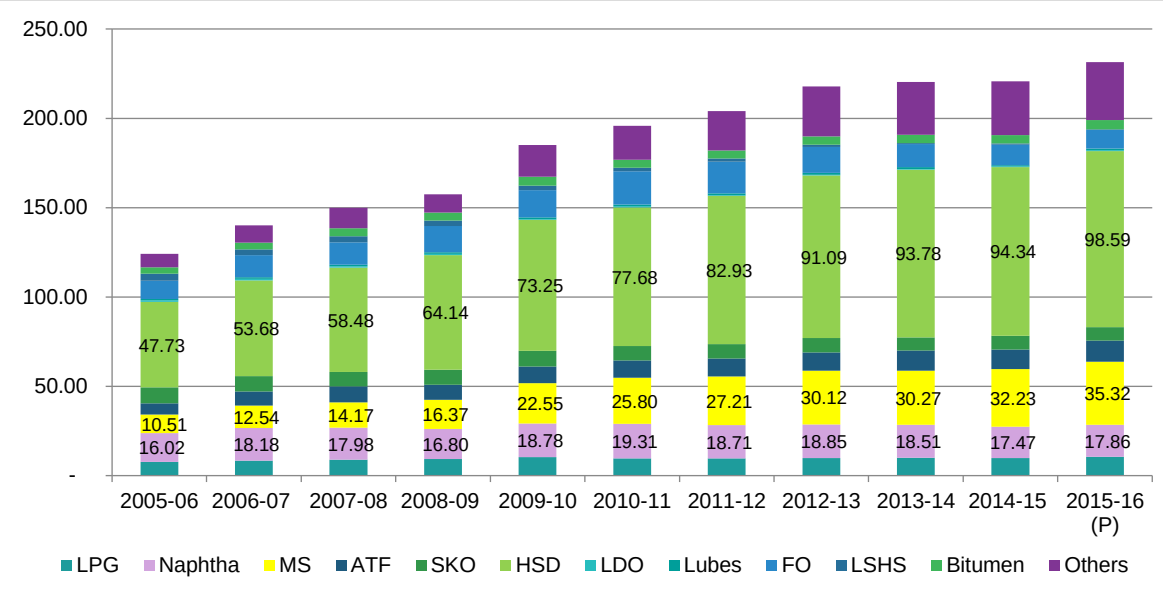
In the past ten years, production of MS (CAGR of 12.9%) and HSD has driven the growth of the domestic petroleum industry. Growing refining throughput at CAGR of 6.4% has fuelled the need for additional refining capacities. Not only domestic, but exports demand from neighbouring countries has contributed equally to the spur in refining demand. Naturally, proportional efforts have gone in setting up new capacities and maximising the yields of mainstream products in the existing refinery configurations. Yields of MS have thus been improved significantly by

- adjusting the crude blends
- improving the extraction efficiencies by setting up secondary and tertiary refining units, and
- isomerizing the higher portions of LN into MS

[28] Share of different products in a refinery's throughput

As a result, share of MS in India's refining product slate increased from 8% in 2005-06 to 15.37% in 2015-16, whereas that of naphtha declined from 13% to 7.64%. Changing pattern of crude refining throughput in past ten years can be seen in Figure 5.

Figure 5: Trend of Refinery Product mix (in MMT)



Source: PPAC, PNGSTAT 2015-16

Table 8 justifies refiners' approach, in value terms, to maximise yield of mainstream products.

Table 3: Refining Fractions & Commercial Importance

Sl No	Fraction	Refining Throughput 2015-16 (MMT)	Share in refining throughput %	Relative Selling Price (₹/Kg)#
1	LPG	10.60	4.58%	14.2*
2	Light Naphtha	17.86	7.72%	43.0
3	Motor Spirit	35.32	15.28%	54.0
4	ATF	11.79	5.10%	43.0
5	SKO	7.50	3.24%	16.0*
6	HSD	98.59	42.64%	49.0
7	LDO	0.43	0.19%	35.0
8	Lubes	1.04	0.45%	45.0
9	Furnace Oil	10.32	4.46%	35.0
10	LSHS	0.37	0.16%	36.0
11	Bitumen	5.16	2.23%	27.0
12	Others	32.25	13.95%	33.0
	Total	231.23	100.00%	

Source: PPAC, #tentative prices in Delhi as on 15 Jan 17;
* - subsidized rates

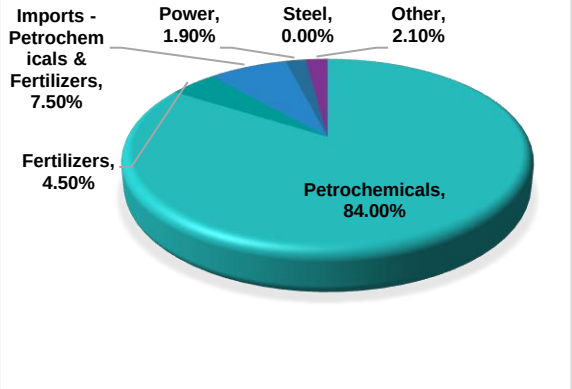
Referring the considerable variation in selling prices[29], despite near similar input feedstock prices (as the petroleum fractions are priced on 'import parity' basis, not on 'cost plus' basis), higher preference to mainstream products appears justified.

However, the preference of isomerising naphtha for achieving higher yields of MS has not been equally applicable for the refineries with downstream naphtha crackers and/or PX units – Indian Oil Corporation Limited's (IOCL) Panipat refinery and Reliance Industries Limited's (RIL) Jamnagar refinery. In general, naphtha production from refineries varies between 3-17% of the refining throughput depending upon the demand downstream petrochemical units. While IOCL's and RIL's concerned refineries have been producing naphtha respectively at an average of 10% and 17% of the refining throughput[30] , production at most of the other refineries is less than 5% of their refining throughput.

3.1.2 Consumption

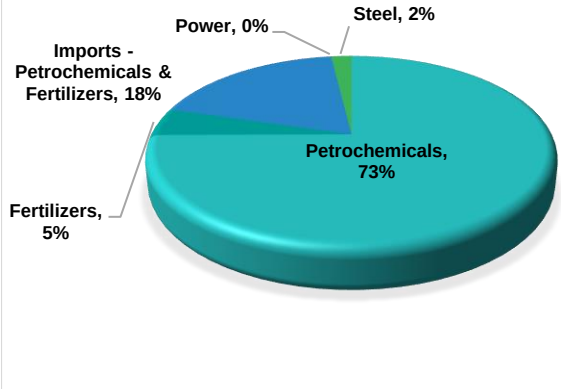
Petrochemical industry has accounted more than 90% consumption of naphtha. Since 2007-08 share of petrochemical sector in overall naphtha consumption has increased from 78% to 91%; contrary, share of fertilizer sector has reduced from 13% to 4.5% and power from 6% to 2%. Figure 6 and 7 provide drill down of naphtha consumption by share of the user industry for 2014-15 and 2015-16.

Figure 6: Consumption Pattern of Naphtha – 2014-15



Source: PPAC

Figure 7: Consumption Pattern of Naphtha – 2015-16



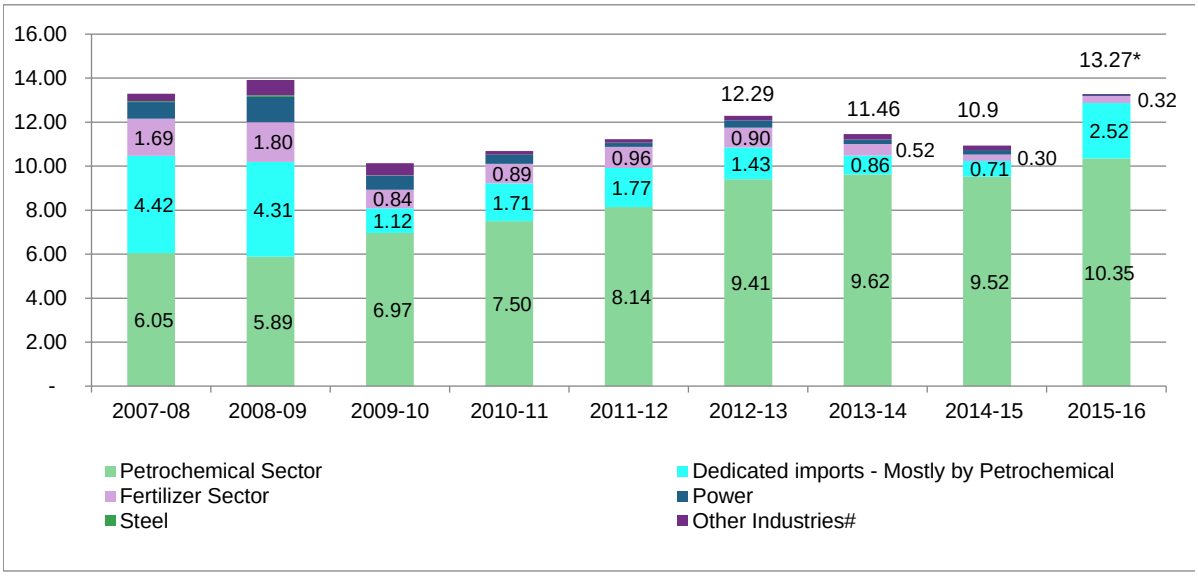
Source: PPAC, MM Analysis

Figure 8 gives distribution of naphtha by consuming industry over past few years. Tabular representation of same can be referred to in Appendix B.

[29] Largely demand driven

[30] Drill down of naphtha production by individual refineries in the past three years can be referred to in Table A.2 in Appendix A.

Figure 8: Trend of Consumption of Naphtha (MMT)



Source: PPAC, PNGSTAT 2015-16

Note: # includes Ceramics, Paints etc

Availability of LNG has replaced LN demand in fertilizers and power sectors

It can be noted that how the availability of LNG has replaced LN demand in fertilizers and power sectors. However, overall demand has been maintained due to increased consumption from petrochemical sector. Consumption in past four years has varied due to varying demand from Haldia Petrochemicals Limited (HPL). Company's down turn in 2013-14 reduced the overall consumption to 10.93 MMT, but consumption grew to around 13.27 MMT in 2015-16 as operations commenced in last quarter of 2014-15.

3.2 D – S by Players

3.2.1 Production

Drill down of crude processing capacity and refinery throughputs in 2015-16 is provided in Table 3. Naphtha production in 2014-15 is indicated against each entity for clarity on its share as a percentage of refining throughput.

Table 4: Naphtha Production - Refiners & Fractionators (MMT)

Company	Refining Capacity	Refining Throughput		Naphtha Production	
	2015-16	2014-15	2015-16	2014-15	2015-16#
Indian Oil Corporation Ltd (IOCL)	69.200	53.586	58.007	3.209	3.886
Reliance Industries Ltd (RIL), Jamnagar (J-1)	27.000	30.867	32.428	5.599	5.972
RIL, Jamnagar SEZ	33.000	37.174	37.133	1.893	1.681
Hindustan Petroleum Corporation Ltd (HPCL)	14.800	16.189	17.236	1.109	0.706

Company	Refining Capacity	Refining Throughput		Naphtha Production	
HPCL- Mittal Energy Limited (HMEL)	9.000	7.34	10.713	0.194	0.263
Bharat Petroleum Corporation Ltd (BPCL)	21.550	23.177	24.081	1.291	1.135
Bharat Oman Refineries Ltd (BORL), Bina	6.000	6.209	6.402	0.035	0.00
Numaligarh Refinery Ltd (NRL)	3.000	2.777	2.520	0.111	0.00
Chennai Petroleum Corporation Ltd (CPCL)	11.500	10.779	9.632	0.705	0.787
Mangalore Refinery & Petrochemicals Ltd (MRPL)	15.000	14.632	15.532	1.315	1.574
Essar Oil Ltd (EOL)	20.000	20.491	19.101	0.749	0.745
Oil & Natural Gas Corporation (ONGC) – NGL[31]	-	-	-	1.146	1.01
ONGC Tatipaka			0.006	0.009	
Gas Authority of India Ltd (GAIL) – NGL				0.100	0.100
Total	**230.000**	**223.213**	**232.854**	**17.465**	**17.861**

Source: PPAC, PNGSTAT 2015-16

15.0 MMT capacity was added in 2015-16 due to commissioning of IOCL's Paradip refinery. However, the refining throughput did not increase proportionally as the unit was commissioned in February 2016.

It can be noted that none of the companies, except RIL and IOCL, manufactured more than 1.32 MMT of naphtha even on consolidated basis as against 3.0 MMT (LN) required for a cracker. At this instance, it is felt that production is also a function of size of the refineries in addition to quality of crude and refinery configuration. As LN forms 7-10% of refining throughput, average 15.0 MMT refinery is desired to hold at least 1.0 MMT LN at its base. However, there are only few refineries in India holding crude refining capacity of more than 15.0 MMT at one location.

Out of stated naphtha production, envisaged bifurcation of HN is as follows –

- 50% of naphtha production by RIL's Jamnagar refinery (J-1)
  - RIL, being a leading player in polyester fabric, requires HN for manufacturing PX in Jamnagar aromatic complex (capacity 1.856 MMT) and Vadodara (0.486 MMT). HN requirement of both units put together goes up to 3.00 MMT
  - RIL's other refinery is not producing HN. Being an export oriented unit[32] , it exports the LN produced
  - As a consequence, RIL's HN demand is being met from J-1
- 100% production by ONGC Hazira fields (NGL)
  - ONGC's production of 1.01 MMT NGL from Hazira works falls into heavy category
- MRPL's HN production is consumed by OMPL, and thus not appearing under above table
- IOCL is producing around 0.45 MMT HN for making PX at Panipat petrochemical (aromatic) complex

[31] Natural gas liquid (NGL) , being a similar product, also falls in naphtha category

[32] Jamanagar SEZ

- Apart from this, part of CPCL's production from Narimanam unit and NGL production by GAIL is HN. However, the quantities have been less than 0.20 MMT

IOCL's Panipat cracker was developed to utilize LN from the Panipat refinery. But as LN from the refinery (around 1.6 MMT) is not sufficient in volumes required for cracking, company pools the additional requirement from its Koyali (Gujarat) and Mathura refineries. Naphtha from RIL's Jamnagar refinery finds downstream application in Hazira cracker, but company is dependent on outside supply for the other cracker.

There is no dedicated feedstock supply to Haldia Petrochemical Limited's (HPL) cracker at Haldia; company thus is largely dependent on imported naphtha for meeting its feedstock requirement. However, as it also uses LN as fuel too, it sources part of its requirements domestically from IOCL and HPCL.

None of the refineries other than those mentioned above have options for downstream consumption of LN. Careful analysis of share of naphtha in their crude throughput for indicates that HN and even C-5 cut LN from these refineries is being routed to MS. Over the last decade naphtha (LN) production at all these refineries has reduced to around 4-5% of their refining throughput. However few have been selling LN in limited volumes to their nearest crackers. It is understood that –

- Around 0.10 MMT of HMEL's production is tied up with the Panipat cracker
- RIL has entered into MoU with BPCL & HPCL for sourcing 0.25 MMT petrochemical grade naphtha from each, being supplied by their Mumbai refineries
- IOCL's Haldia (0.48 MMT) refinery are selling LN to HPL

This LN remaining after catering higher needs of auto fuel markets and limited sale is exported.

3.2.2 Consumption

In 2015, the cost of imported naphtha was nearly 15% cheaper to the domestic naphtha priced at import parity basis compelling fertilizer and power manufacturers to import it

Based on discussion till now, consumers of HN and LN in petrochemical sector are clear. As far as LN demand from fertilizer and power industry is concerned, it is largely being met through imports. Domestically available naphtha is given priority when the prices are comparable with that of imported naphtha. In 2015, the cost of imported naphtha – governed by Platt's Index – was nearly 15% cheaper to the domestic naphtha priced at import parity basis. Price structure of naphtha is discussed in Appendix G.

Table 4 reiterates consumers of naphtha and their sourcing locations with tentative individual consumption in 2015-16.

Table 5: Naphtha Consumers in 2015-16 # (MMT)

Company	Source of Supply	Consumption #
LN		
Petrochemical – Naphtha Cracker		

Company	Source of Supply	Consumption #
IOCL, Panipat	Naphtha from Panipat, Koyali and Mathura refineries + HMEL's Bhatinda Refinery	2.70
RIL, Vadodara	Naphtha from RIL's Jamnagar refinery (J-1) + Mumbai refineries of HPCL, BPCL / import in certain quantities	0.35
RIL, Hazira		2.75
Haldia Petrochemicals Ltd (HPL)	Imported naphtha mostly as feedstock+ supply from IOC's Haldia & North Eastern refineries	2.15*
Fertilizer Plants		
Mangalore Chemicals & Fertilizers Limited , Mangalore	Mostly imported naphtha (UAE)	0.18
Madras Fertilizers Ltd, Chennai	Imported naphtha + CPCL naphtha	0.18
SPIC, Tuticorin		0.30
Naphtha Based Power Plants		
Reliance Infrastructure, Kochi	BPCL Kochi	0.09
NTPC Rajiv Gandhi CCPP		
PPN Power, Chennai	Imported naphtha + CPCL naphtha	
Consumption as Fuel and Solvent	Imported naphtha	**0.34**
Tentative LN Consumption		**9.11**
HN – PX Units		
IOCL, Panipat	Panipat refinery	0.45
RIL, Jamnagar	Jamnagar Refinery (J-1)	2.90
ONGC Mangalore Petrochemicals Ltd	MRPL, Mangalore	0.80@
Total - HN		**~ 4.15**

Source: Annual Reports, Company Websites, MM Primary Survey
- as per available capacity during the year;

@- commissioned in October 2014, The complex was operated at around 70% of the installed 0.90 MMT PX capacity indicating consumption in 2015-16 to be around 0.80 MMT
* - Includes consumption as fuel as well; potential consumption was low due to the issues company has been going through. However, consumption in 2015-16 is believed to have increased to nearly 2.2 MMT

Consumption in 2015-16 is noted to be in exhausting existing potential of 13.45 MMT, except for consumption from power industry, as against 10.94 MMT consumed in 2014-15. Hardly scope remains for additional consumption from existing facilities unless fresh petrochemical capacities are commissioned.

Consumption of HN, estimated by back calculating requirement by RIL, IOCL and OMPL's PX units, is noted around one third of total naphtha demand in 2015-16. It needs to be noted that OMPL's unit although commissioned in October 2014, was operated at 70% of the rated capacity at its committed offtake is scheduled to commence by end of FY 2016-17.

As far as LN consumption is concerned –

- Consumption in 2014-15 remained low mainly as HPL's facility remained out of operations for considerable time due to multiple constraints. Underutilization of the cracker thus also impacted imports of naphtha. However, HPL's LN consumption grew four folds as the unit was consistently operated up to rated capacity

- Apart from HPL, fertilizer units are dependent on imported naphtha as their feedstock. Expected consumption from fertilizers was 83% of their consumption potential (0.78 MMT), whereas that from power was 20-25% of the potential (1.02 MMT)

Though fertilizer and power sectors would not continue to consume naphtha beyond next 2-3 years, their decommissioning might not add much to the existing surplus as they are mostly dependent on imported LN. Inadequate utilization of HPL's cracker too shall not have considerable impact on existing surplus as it has also been dependent on imported LN.

3.3 Trade

7.12 MMT naphtha was exported in 2015-16. Despite growth in domestic consumption, marginal increase in exports along with increase production levels confirms compelled nature of exports.

More than 70% of India's exports are to Japan, South Korea, Taiwan, Thailand and China, all of which utilize same for cracking – refer Annexure E for break-up of exports by exporting port in India and by destination country. Imports of LN are mainly observed from Saudi Arabia, UAE and Pakistan, whereas those of solvent grade naphtha are from Singapore.

Exports were at peak between 2009 and 2012, but supressed soon with increased domestic consumption due to –

- Commissioning of IOCL's naphtha cracker
- Higher diversion of naphtha to MS stream
- Indian exports of MS to neighbouring countries have been surpassing the previous benchmarks every year since 2011-12, thus resulting in higher volumes of naphtha diverted to MS

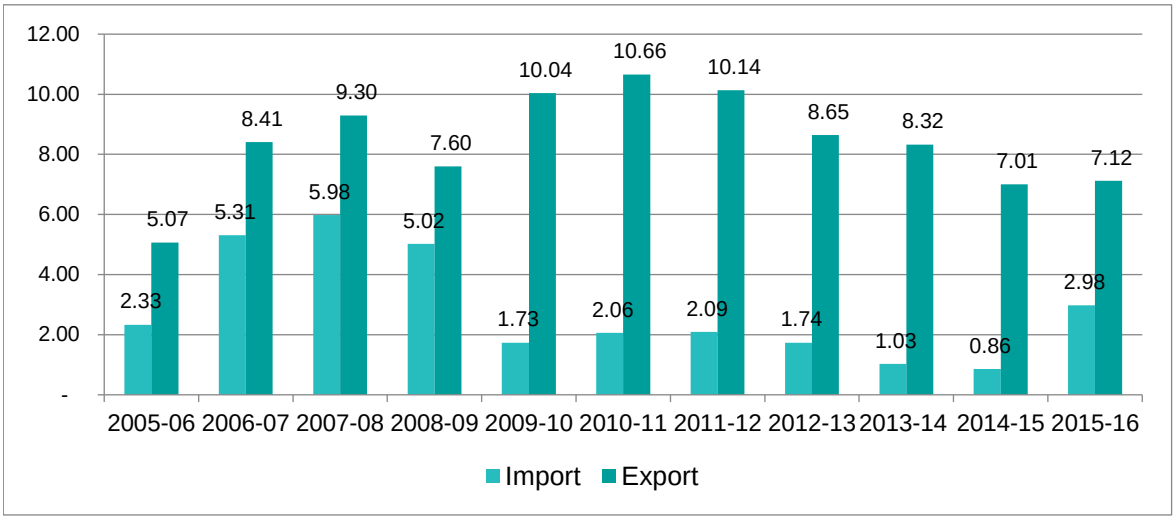
HPL, which does not own a back-end supply of naphtha, has been importing naphtha in absence of availability of bulk volumes in the Eastern region

As discussed earlier, imports are mainly driven by HPL, and then by fertilizer and power units. HPL, which does not own a back-end supply of naphtha, has been importing naphtha in absence of availability of bulk volumes in the Eastern region. Imported naphtha is also preferred due to reasonable prices in comparison with domestic naphtha. Availability and price of large carriers, and material for return haulage was also noted to be a constraint while preferring imports over domestic naphtha.

RIL too had been importing small portion of its requirement, but as noted it has been sourcing it domestically since last 2-3 years.

Figure 9 provides ten-year trend of import and export of naphtha.

Figure 9: Import-Export of Naphtha (MMT)



Source: PPAC, DGCS

Reasons for variations in domestic consumption and import demand over the years have been closely linked with prices of naphtha and the domestic duties

Reasons for fall in domestic consumption and import demand over the years have been closely linked with prices of naphtha and the domestic duties. They have been analysed below –

- High prices of crude oil in the international market during 2009-2013 increased worries of fertilizer industry and HPL
- Withdrawal of zero import duty on naphtha in the budget; the decision of reversal of import duty on naphtha from 0% to 5% affected HPL's operations, and imports. The company has been mainly dependent on imported naphtha for cracking. (it also sources naphtha from IOCL's Haldia refinery to be used as fuel)
  - Customs duty on naphtha was reduced from 5% to 0% in the 2006-07 budget sessions, but the move was withdrawn in 2008-09. Notwithstanding same, duty on imports of polymers was also brought down from 7.5% to 5% eliminating the duty differential. It was a double blow to HPL, and in turn a suffering to the petrochemical industry as the tax exemptions for the fertilizer industry were continued
  - Imports kept reducing as the company couldn't maintain the momentum thereafter[33]; meanwhile RIL and HPL also replaced part of their import demand with domestic naphtha
  - Naphtha based fertilizer plants were out of operation almost for 100 days due to withdrawal of subsidy with effect from 1st January 2015; same was restored with LNG in April 2015

[33] Even after exempting its import duty under Advance Licensing Scheme, HPL continued facing challenges in 2012-13 and 2014-15. The concession was offloaded in 2014-15 as the company has failed to meet export obligations as per the scheme. However, with dip in naphtha prices, and appropriate financial support, the company resumed commercial operations in Feb 2015, and also managed seeking tax relief from Central Government, who has offered HPL more time to meet the export obligations. Eventually, better performance of HPL drove naphtha consumption – largely met through imports – during 2015.

- However, imports increased in 2015-16 as HPL's facility was operated consistently over 95% of the rated capacity. Fertilizer units too enjoyed reduced prices of naphtha in global market to ramp-up their utilization

Though the crude and naphtha prices were relaxed in the past two years, fertilizer and power companies preferred imported naphtha as it was still 15% cheap over domestic naphtha due to tax and profitability implications.

3.4 D – S Forecast

3.4.1 Supply Forecast

As per the ambitious expansion plans, almost 64.00 MMT[34] of refining capacity is expected to be added till 2021-22. Existing and future refining capacities by individual refineries are provided in Appendix B. Major ones under this are –

- IOCL:
  - Expansion of Koyali refinery from 13.7 to 18.0 MMT, Mathura from 8.0 to 9.20 MMT, Panipat from 15.0 to 20.20 MMT and Barauni from 6.0 to 7.0 MMT
- HPCL:
  - 9 MMT Rajasthan Greenfield Refinery
  - Expansion of Vishakhapatnam refinery from 8.3 to 15.0 MMT, and Mumbai refinery from 6.5 to 9.5 MMT
  - 15 MMT grassroot refinery at Vishakhapatnam is not considered under immediate expansion plans as it is still under feasibility stage
- HMEL: Expansion from 9.0 to 11.25 MMT
- BPCL: Expansion of Kochi refinery from 9.5 to 15.5 MMT, and Mumbai refinery from 12.0 to 15.0 MMT
- Nagarjuna Oil Corporation Limited (NOCL) is setting up a 6.0 MMT greenfield refinery at Cuddalore

Country's demand for MS is being comfortably met with the current refining capacity; in fact, we exported 16.82 MMT of MS after fulfilling domestic demand of 19.53 MMT in 2015-16. Over the past ten years, domestic consumption of MS has grown at CAGR of 8.7%, whereas exports have grown almost at CAGR of 20%. Extrapolating the demand to grow at the same rate, domestic demand in 2020 will be around 29 MMT. So it can be noted that present production is ahead of the demand by 5-6 years. Other way, this means the expansions in refining capacity rather is expected to cater the exports market. Under these circumstances, it could be reasonably expected that the new capacities produce LN at an average of 8-10% of the additional refining throughput instead the sacrificed average of less than 5% in the past. Accordingly, supply from the new refining capacities could be expected around 6.21 MMT.

[34] Excludes 9.5 MMT expansion of BORL, 15 MMT Kakinada refinery & petrochemical complex , and HPCL's 15 MMT grassroot refinery at AP PCPIR as the projects are still under evaluation/ feasibility stage

3.4.2 Commitments

Around 7.00 MMT[35] of naphtha was in surplus in 2014-15 as well as 2015-16. Out of this 1.90 to 2.00 MMT, being produced by RIL's refinery in Jamnagar SEZ, can't be considered for domestic consumption. As a result, the effective surplus reduces to 5.00 MMT. Following commitments are scheduled in immediate future from existing surplus:

- ONGC Petro additions Limited (OPaL), a subsidiary of ONCG, is amidst commissioning of 1.1 MMT dual feed cracker at Dahej to utilize the NGL produced from ONGC's Hazira and Uran fields. OPaL will also purchase rich LNG from Petronet LNG Limited.
- Bramhaputra Cracker & Polymer Limited (BCPL), has commissioned a 0.22 MMT dual feed ethylene cracker at Lepetkata in Assam in February 2016, and is expected to offtake 0.16 MMT naphtha from Numaligarh Refinery Ltd (NRL).

Additional offtake of naphtha in accordance with new downstream capacities is tabulated below:

Table 6: Naphtha Commitments in Future (MMT)

Company	Potential	Deductions from Present Suppliers	Supplier	Purpose
OPaL, Dahej	1.50 (HN/LN)	1.04#	ONGC	Dual feed cracker
BCPL	0.16 (LN)	0.16	NRL	Dual feed cracker
Total	1.66*	1.20*		

Source: Industry Reports
- Reduction from present surplus is considered equivalent to ONGC's actual production in 2014-15 i.e. 1.043 MMT
* - commitment considered under OMPL's account earlier is not continued since it has already consumed 75-80% of its potential in 2015-16

Thus, after adjusting the provisions of 1.66 MMT from the existing surplus of 5.00 MMT, present commitments[36] or domestic sales of around 0.30 MMT, around 3.00 MMT of LN is expected to remain in surplus ahead of 2016-17.

After analysing naphtha availability, it becomes important to understand the demand side, i.e. ethylene industry.

35 Surplus has been considered equivalent to exports; as HPL, fertilizer and solvent industry mostly import, they were not considered for calculations.

36 Which were not accounted in 2014-15 – like contract between HPCL and RIL

4 User Industry Analysis

4.1 Petrochemicals

Petrochemicals play a very vital role in functioning of most of the sectors in our economy. Polymers, which is the base, is an enabling sector for many other sectors to grow. Despite same, India's per capital polymer consumption is still around 9-10 Kg/ year as compared to more than 60 Kg in developed countries. This indicates the opportunities available for growth of petrochemical industry.

The self-sufficiency in meeting requirements of the building blocks determines the progress of the industry, and so as the economy. Indian polymer industry, like the global polymer industry, is dominated by polyolefins – polyethylene and polypropylene – representing around 75% of the commodity polymers consumed. Though we are self-sufficient in meeting demand of propylene[37], ethylene is facing severe short supplies due to limited capacity of downstream crackers.

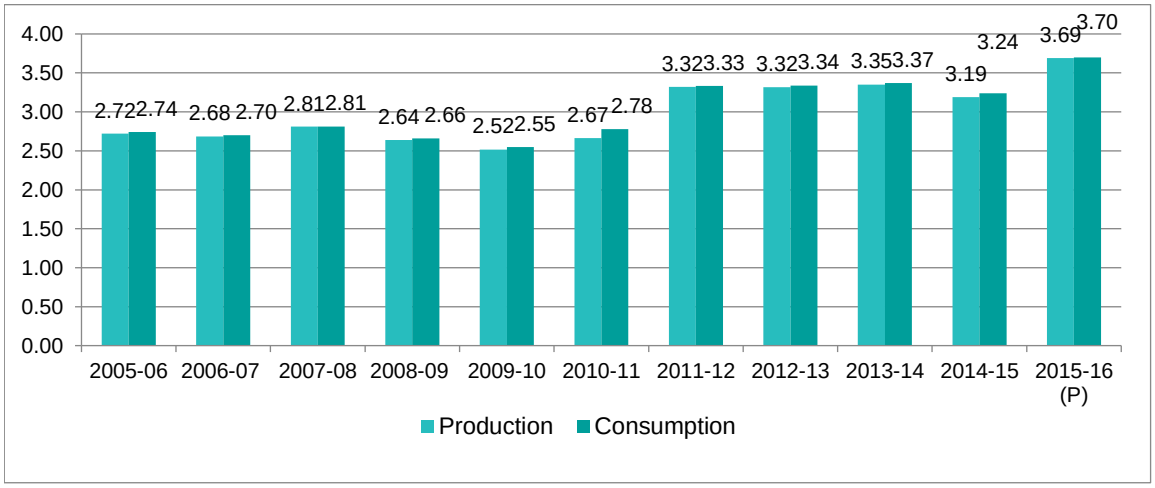
4.2 Ethylene & Derivatives

Apparent demand of ethylene in terms of consumption of its derivatives is growing at CAGR of 8.80% since 2005-06 as against the growth in production only of 3.26%. Ethylene capacities – excluding BCPL – in 2015-16 were already in shortfall of the demand almost by 3.00 MMT.

By virtue of increased import volumes and higher rate of exchange, import bill of key ethylene derivatives has grown nine fold since 2005-06. Even if new capacities to the tune of 3.23 MMT are on the verge of commissioning, additional capacities will have to be planned right now in order to address the demand in 2021-22.

4.2.1 Demand Supply

Figure 10: D-S of ethylene (in MMT)



[37] In India, capacity of propylene is equally distributed in crackers and refineries. In fact, new propylene capacities are concentrated in refineries than in crackers. Selection of feedstock i.e. naphtha or gas, and underutilization of HPL's cracker had an impact on propylene production in crackers. Details of present and upcoming capacities of propylene in crackers as well as in refineries can be referred in Appendix C

Source: Chemicals & Petrochemicals Statistics at a Glance 2015, CPMA

Figure 10 provides production & consumption of ethylene between 2005-06 and 2015-16. It is understood that production as well as consumption in 2014-15 was around 4.5% lower than in 2013-14 due to irregular operations at HPL[38] ; however, it was regained in 2015-16. Over the years, average utilization of the industry is maintained due to higher capacity utilization by RIL and IOCL.

Production and consumption have gone hand-in-hand, indicating captive nature of consumption. Sharp increase in production and consumption (by 0.60-0.70 MMT) in 2011-12 indicates start-up of IOCL's cracker.

Installed capacity of ethylene in India is 4.15 MMT[39]; of this, an average 3.79 MMT capacity was available for production during 2013-2015, and 3.94 MMT in 2015-16. In terms of installed capacity, RIL is the largest player with two each of naphtha and gas crackers, followed by IOCL, HPL and GAIL. Drill-down of installed capacity by type of cracker is given in Table 6.

Table 7: Ethylene Crackers in India (MMT of ethylene*)

Company	Unit	Capacity
Naphtha Based		
IOCL	Panipat, Haryana	0.85
HPL	Haldia, West Bengal	0.70
RIL	Hazira, Gujarat#	0.90
RIL	Vadodara	0.13
Total Naphtha Based		**2.58**
Gas Based		
RIL	Dahej (Gandhar) Gujarat	0.50
RIL	Nagothane, Maharashtra	0.40
GAIL	Auraiya	0.45
Total Gas Based		**1.35**
Dual Feed - BCPL	Lepetkata, Assam	**0.22**
Total Capacity		**4.15***

Source: Industry Reports

Note : # The cracker is modified to dual feed, but predominantly operates on naphtha; * Installed capacity is determined with respect to the capacity of ethylene.

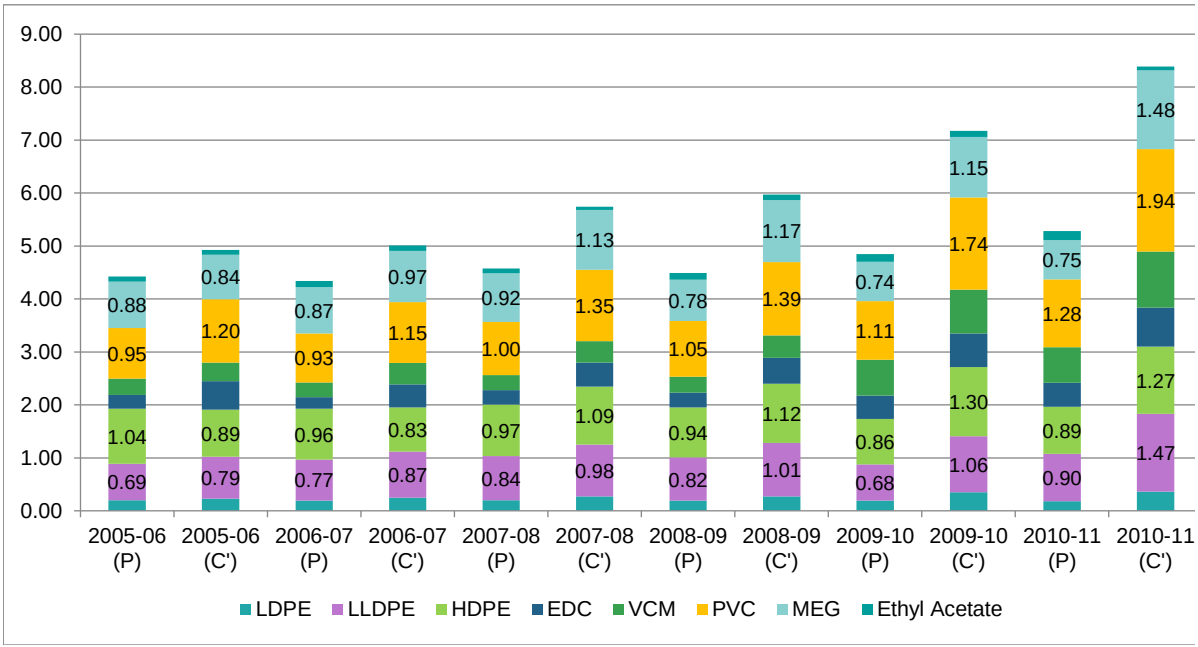
Ethylene, being a gas at normal temperature and pressure, is difficult to transport. Thus is not sold, but captive consumed in manufacturing variants of LDPE, LLDPE, HDPE, and PVC.

Consolidated trend of production and consumption of ethylene derivatives for the past ten years is provided in Figure 11 and 12 respectively. Detailed graphs indicating production, import and export of individual products are provided in Appendix D.

38 Production is expected to resume in second half of 2015-16

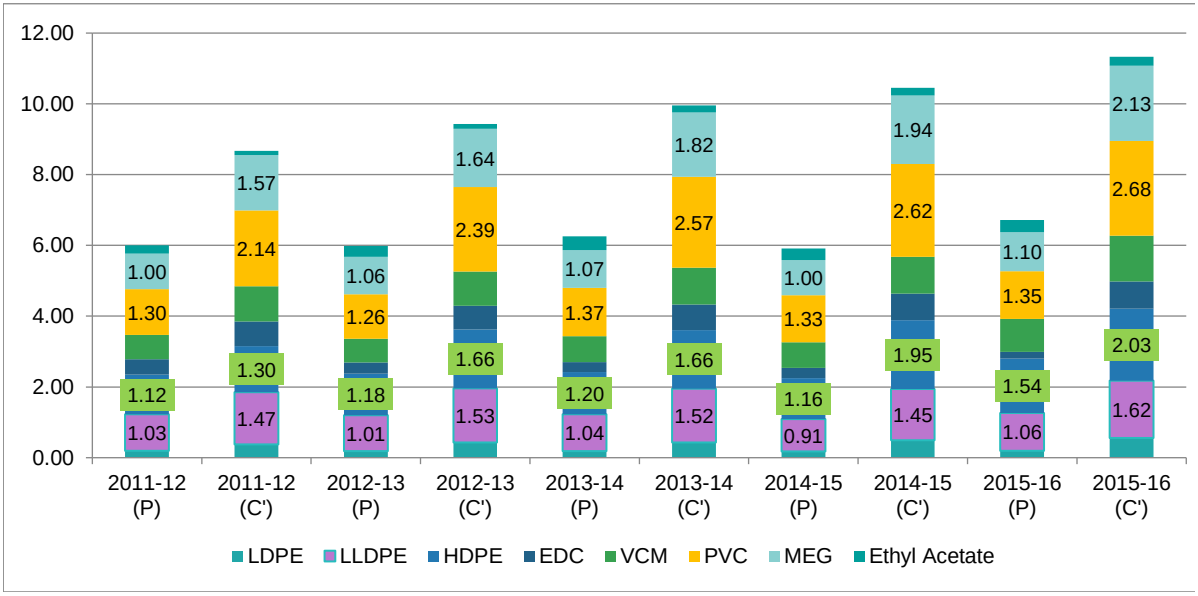
39 Includes 0.22 MMT capacity of BCPL

Figure 11: Trend of Production of Ethylene Derivatives (2005-2010) (MMT)



Source: Chemicals & Petrochemicals Statistics at a Glance 2013-14
(P) denotes production and (C') denotes consumption

Figure 12: Trend of Production & Consumption of Ethylene Derivatives (2011-2015) (MMT)



Source: Chemicals & Petrochemicals Statistics at a Glance 2014-15, APIC 2016 – Country Paper : India by CPMAI
(P) denotes production and (C') denotes consumption

For the past five years India has resorted to imports to address the supply deficit of ethylene and derivatives. Impressive growth in consumption of all derivatives in long (2005-16) as well as short-term (2010-16) can be noted From Table 7.

Table 8: Consumption Growth of Ethylene & Derivatives

Derivatives	CGAR 2005-06 to 2015-16	CGAR 2010-11 to 2015-16
Ethylene	3.05%	5.89%
LDPE	9.25%	9.20%
LLDPE	7.48%	7.40%
HDPE	8.63%	8.90%
Poly Vinyl Chloride (PVC)	8.38%	7.48%
Vinyl Chloride Monomer (VCM)	13.87%	4.12%
Ethylene Dichloride (EDC)	3.73%	0.93%
Ethyl Acetate (EA)	10.61%	26.48%
Mono Ethylene Glycol (MEG)	9.80%	7.56%

Source: Chemicals and Petrochemicals Statistics at a Glance

- As transporting ethylene is expensive in transporting over long distance, import not a viable option for meeting demand, consumption is limited to production or the installed capacity. The ideology does not apply for the derivatives as they can be imported; thus higher growths in LLDPE and PVC consumption can be linked to growing FMGC demand, whereas reduced growth of LDPE and HDPE can be linked to depressed industrial demand. Consumption of VCM and EDC has reduced due to growth in imports of PVC directly.

An overview of installed capacities, production, consumption and shortfall in demand of ethylene derivatives is provided in Table 8. It can be noted that the domestic ethylene capacity in 2015-16 was short of the demand almost by 3.24 MMT. As such, ethylene demand of the country – in terms of its derivatives consumed – was 6.93 MMT, against which supply remained only 3.69 MMT. Demand in 2015-16 grew by 0.49 MMT over last year.

Table 9: Deficit in Capacities of Ethylene Derivatives -2015-16 (MMT)

Product	Installed Capacity	Production	Consumption	Shortfall-Products	Shortfall-Ethylene	Demand-Ethylene
Ethylene	**3.94+0.22**	**3.685**	**3.701**	**0.016**	**0.016**	**0.016**
LDPE	0.205	0.198	0.564	0.384	0.392	0.575
LLDPE	1.795+0.980	1.060	1.625	0.581	0.541	1.512
HDPE		1.543	2.033	0.588	0.600	2.073
PVC	1.402	1.354	2.680	1.326	0.650	0.815
VCM	0.906	0.935	1.294	0.359	0.176	0.306
EDC	By-product	0.190	0.774	0.600	0.180	0.232
EA	0.494	0.350	0.245	0.00#	0.00#	0.093
MEG	0.104	1.095	2.134	1.111	0.689	1.323
Total for Derivatives (Except ethylene)		**6.725**	**11.349**	**4.950**	**3.243**	**6.929**

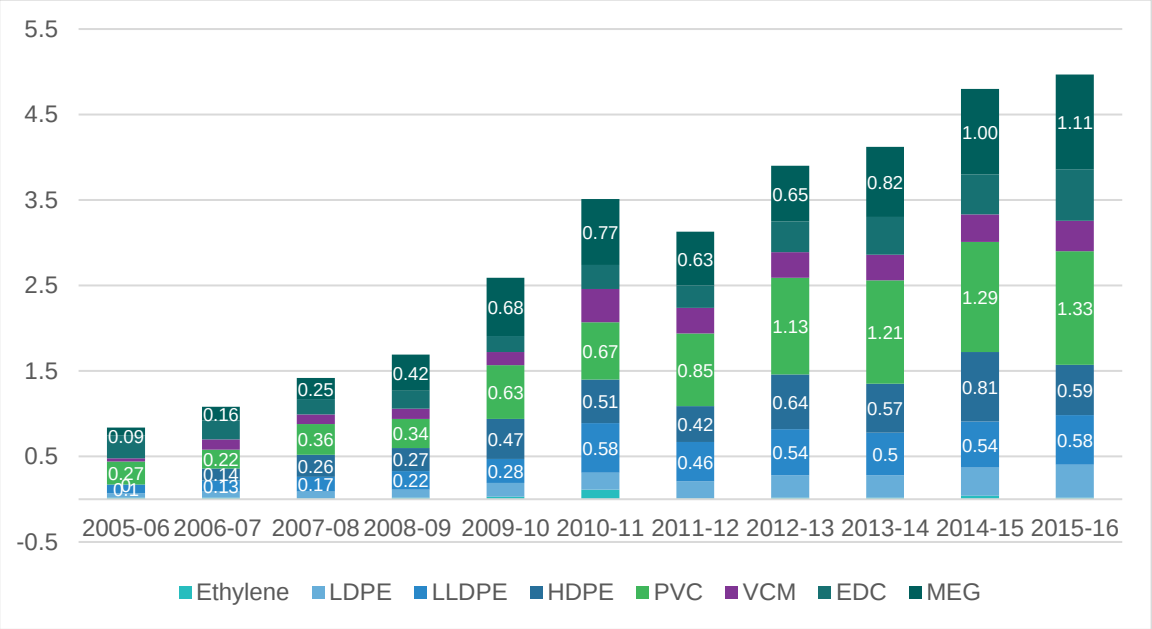
Source: PPAC, CPMA Note: # - Production of EA is in excess of consumption, and hence there is no shortfall

4.2.2 Trade

Consolidated trend of imports of all ethylene derivatives by volume and value is shown in Figure 13 and 14 respectively. Import value has grown from ₹2,944 Crore in 2005-06 to ₹27,731 Crore in 2014-15. Imports of HDPE and LLDPE are largely from Middle East and US, which have dominance of gas based crackers. Imports of products in PVC value chain are from Taiwan,

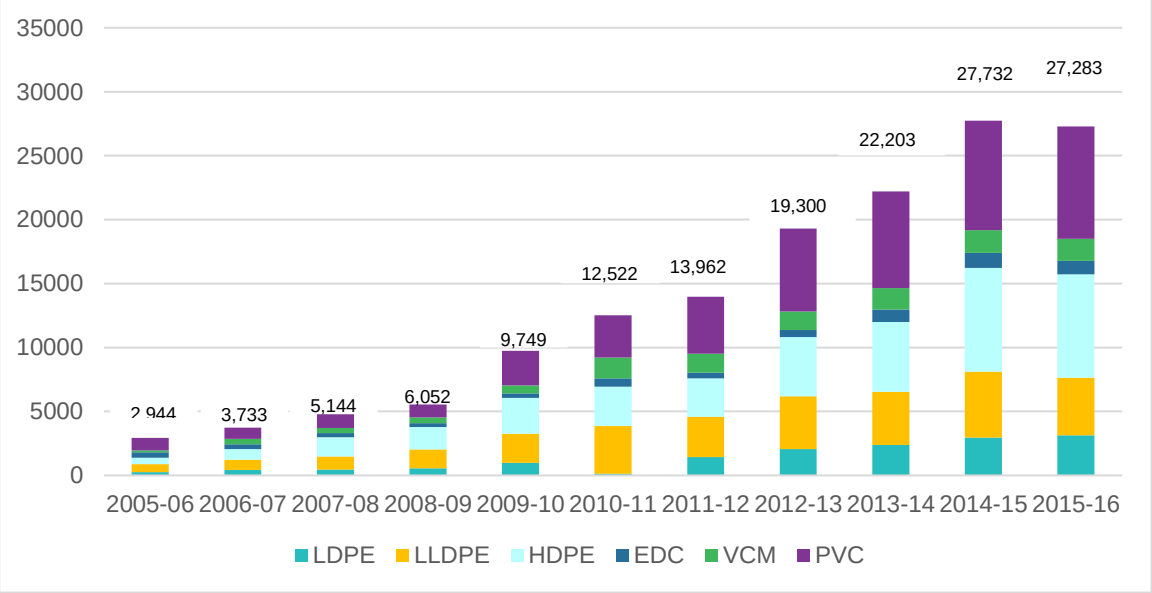
China, Thailand, and Germany, where naphtha based crackers and chlorine based industry is prevalent,

Figure 13: Consolidated Trend of Imports of Ethylene Derivatives (MMT)



Source: DGCIS

Figure 14: Trend of Import Value of Key Ethylene Derivatives (₹ Crore)



Source: DGCIS

In the absence of domestic supply of ethylene, imports of ethylene downstream products are being driven by the PVC industry. Apparent demand from the PVC industry itself is more than 2.00 MMT, two third of which is remains unaddressed. Only RIL, who holds half of the domestic

PVC capacity, has back-end ethylene capacities; but others either have to import the intermediates to process PVC. Demand from PVC industry in Southern India itself adds to 1.00 MMT of ethylene.

4.2.3 Demand Forecast

Even after materializing the ethylene capacities under implementation (3.23 MMT) and those under planning (2.05 MMT), there will be deficit of nearly 3.76 MMT of ethylene in 2025

For 2015-16, consumption of all ethylene derivatives added up to 11.35 MMT as against production of around 6.72 MMT. Extrapolating the past growth trend, but on conservative note, consumption ethylene derivatives is expected to reach 21.00 MMT in 2025-26, whereas corresponding consumption of ethylene as such is expected to reach 13.15 MMT. This translates to an additional requirement of nearly 9.00 MMT of ethylene. So, even after materializing the ethylene capacities under implementation (3.23 MMT) and those under planning (2.05 MMT), there will be deficit of nearly 3.71 MMT of ethylene in 2025-26.

This indicates there shall be enough scope for new ethylene crackers[40] till 2025, excluding the capacities under implementation and planning at present stage. Detailed calculations supporting above estimate and the upcoming ethylene capacities have been provided in Table 9 and 10.

Table 10: Demand Forecast for Ethylene Derivatives (MMT)

Product	Consumption 2014-15	Growth Rate	Consumption 2025-26	Conv. Factor	Ethylene Demand 2025-26
LDPE	0.489	5%	0.874	1.02	0.892
LLDPE	1.450	8%	3.249	0.93	3.022
HDPE	1.947	8%	4.063	1.02	4.144
PVC (as end product)	2.623	8%	5.357	0.49	1.642
VCM (as end product)	1.036	5%	2.007	0.49	0.489
EDC (as end product)	0.750	3%	1.010	0.30	0.303
EA (as end product)	0.213	10%	0.579	0.38	0.220
MEG (as end product)	1.931	7%	3.923	0.62	2.432
Total - Derivatives	**10.441**		**21.063**		**13.143**

Source: CPMA, MM Estimates

Capacities under implementation – with commissioning expected in 2016-17 – and those under planning stage are as follows –

Table 11: Expansions through debottlenecking & New Installations (MMT of ethylene)

Company	Unit	Expansion	Capacity Post Expansion	Feed
Debottlenecking				
RIL	Hazira	0.10	1.00	Feedstock for the capacity under expansion is likely to be ethane
RIL	Nagothane	0.18	0.58	Gas Based

[40] Be naphtha or gas or dual feed

Company	Unit	Expansion	Capacity Post Expansion	Feed
New Greenfield/ Brownfield Installations				
ONGC Petro additions Ltd (OPaL)	Dahej	1.10	1.10	C-2, C-3 and C-4 from Petronet (LNG),1.20 MMT HN from ONGC's Hazira fields and 0.30 MMT LN from ONGC's Uran fields
GAIL	Auraiya	0.45	0.45	Gas from ONGC
RIL	Jamnagar J-3 (Phase I)	1.40	1.40	Off-gases from Jamnagar refinery and imported ethane from United States (US)
RIL	Jamnagar J-3 (Phase II)	2.05*	3.45	
Additional Capacity		**5.28**		
Total Capacity in 2017		**9.43**		
Ethylene Demand 2025-26		**13.14**		
Shortfall in Capacity: 2025-26		**3.71**		

Source: Company Website
Note * - RIL also has commitments for further expansion of the J-3 Petrochemical Complex based on off gases. Phase II, to be undertaken post completing Phase I

Although it appears to be a win-win situation for utilizing surplus naphtha as well as to bridge the D-S gap of ethylene in over ten-year period, capacity under implementation and planning is expected to take care of requirements till 2021-22.

Nonetheless, there are several challenges before the things get materialized – the foremost being cost economics. So, even if demand of ethylene and its derivatives urge requirement of crackers, not necessarily it will create proportional demand of naphtha as the feedstock. Looking at the trend of setting up a dual feed cracker, it is sure that economics will decide the type of the cracker, and so thus its feedstock.

5 Industry Challenges

5.1 Introduction

Apart from the scattered availability and perceived heterogeneity of the available LN, there are several other constraints driving the ethylene industry away from naphtha as the feedstock.

A cracker has always been a capital intensive venture. Given the commodity nature of feedstock and end products, the input prices and sales prices of output show volatility thereby influencing the margins. The operators are left with only option to control cost of operations. Under such situation, sharing utilities or infrastructure makes immense sense, but the option is not being exercised in the country.

Natural gas cracking enjoys lower utility consumption however; its domestic availability for cracking is a question as this does come under priority sector allocation. Imported RLNG does not seem to be an option due to higher cost and capacity constraints.

Applicable duties on naphtha call for review as we export it in huge volumes while HPL and fertilizer industry are importing it. Although tax exemptions are available to these importers, cross-refinery sale is still required to be done at transfer price basis.

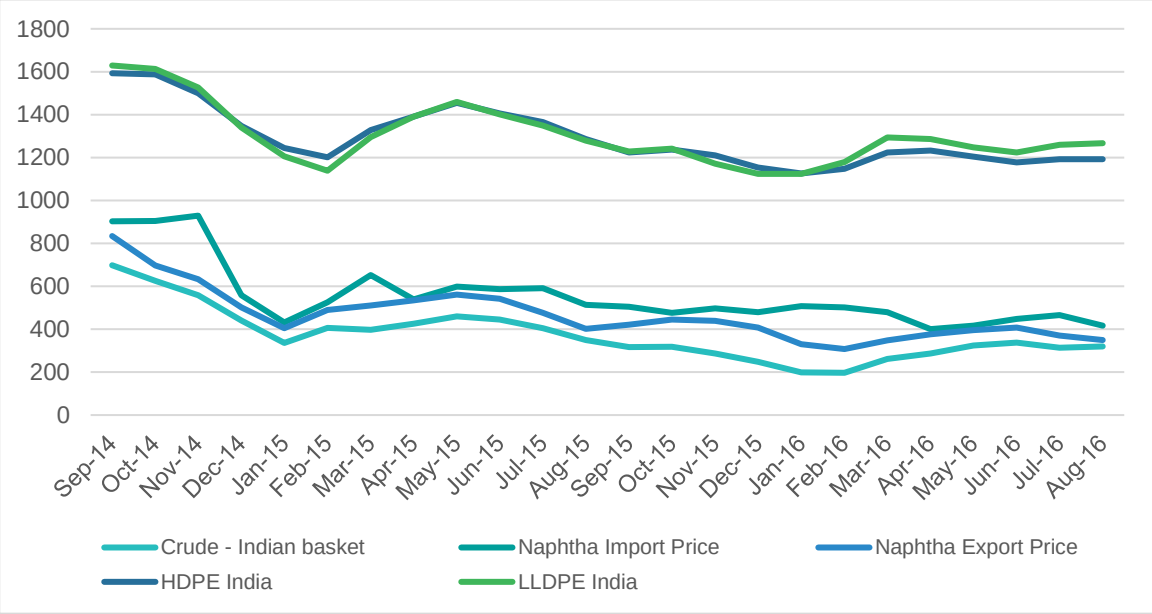
Finally, popularity of dual feed crackers are preferred by the operators to ensure choice of feedstock in accordance of market dynamics.

5.2 Pricing

The foremost constraint naphtha based crackers have been facing during 2012-2014 is the higher cost of the feedstock in comparison with domestically produced gas or even imported LNG. But, this has changed to certain extent with fall in crude prices in 2015.

Figure 15 compares export prices of naphtha and ethylene derivatives in the past couple of years. It can be noticed that prices of LLDPE and HDPE are 2-2.5 times of the price of naphtha; taxes and duties extra for sale in domestic market. So, viability of naphtha crackers is jeopardized as cost of three tons of naphtha at market price is itself more than selling price of LLDPE & HDPE.

Figure 15: Comparison of Price Trend of Naphtha and Ethylene Derivatives (CFR Basis) (US$/MT)



Source: PPAC, Polymerupdate

On the other side, naphtha is being exported (FOB) to Eastern Countries at a stressed price – even lesser than their FOB price – in order to be competitive with Saudi Arabia and UAE. The difference in the corresponding FOB prices add to local taxes on naphtha such as State Sales Tax/VAT.

5.3 Feedstock: Naphtha Vs Gas

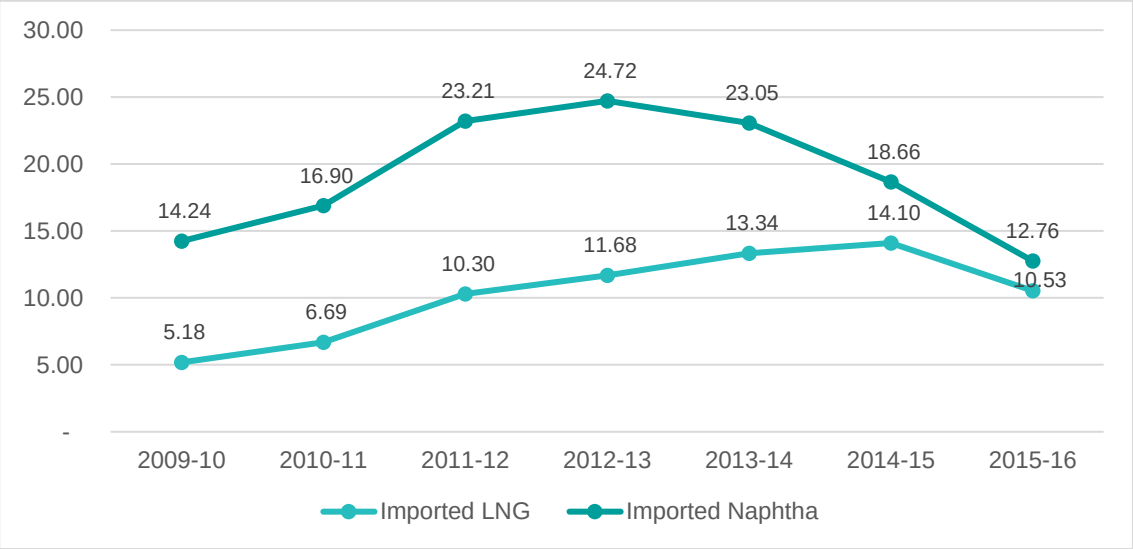
5.3.1 Cost Difference

As compared to naphtha, natural gas prices in India are more regulated on account of limited availability against high demand from wide spectrum of usage. Different pricing mechanisms are practised as per the source of natural gas – same have been discussed in Appendix F – and naphtha.

As compared to the customized pricing mechanism for natural gas, naphtha for domestic sale is priced on Import Parity Price (IPP) Basis

As compared to the customized pricing mechanism for natural gas, naphtha for domestic sale is priced on Import Parity Price (IPP) Basis. The refinery transfer price (RTP) is arrived as the landed cost of naphtha as an imported product at the port nearest to the refinery on CIF basis plus applicable domestic taxes; at the same time exports are priced on FOB basis. The difference between the CIF & FOB prices and the portion of customs duty on this difference contribute to the gap between Import Parity and Export Parity Price (EPP) of naphtha. Comparison of annual average prices of imported naphtha and LNG (Qatar, spot) has been provided below –

Figure 16: Import prices of naphtha and LNG (both CIF) (US$/MMBTU)



Source: PPAC, DGCIS

It can be seen that LNG has been competitive over naphtha for the years. On the other hand, prices of domestically produced gas has ranged between 3.0 and 5.5 US$/MMBTU – present being 3.82 US$/MMBTU (Oct 2015-Mar 2016). With such a considerable difference in the prices, gas based or dual feed crackers are being preferred over naphtha crackers.

5.3.2 Fiscal Disparity

In addition to considerable difference in the prices of the naphtha and natural gas, there is disparity in the taxes and duties being levied on the two as well. Comparison of duty structure on naphtha and LNG is provided in Table 11.

Table 12: Taxes on Naphtha Vs Natural gas (2015-16)

Tax/Duty	Naphtha#	LNG
Customs Duty		
Basic Customs Duty	5%	5%
Additional Customs Duty (CVD)	14%	NIL
Central Excise		
Basic CENVAT	14%	NIL
Special Additional Duty	NIL	NIL

Source: PPAC ; #- for use in Petrochemicals, but duties are exempted for use in Fertilizers

Taxes imposed on naphtha vary depending upon its use – fertilizers or petrochemicals. However, unlike naphtha, there exists uniform tax mechanism for natural gas irrespective of the priorities of usage. Disparity in taxes has also been a reason for preference of gas or dual feed crackers over naphtha crackers.

5.3.3 Technical Issues

Gas rich in ethane and propane fractions have advantages over naphtha :

5.3.3.1 Specific Consumption

Naphtha cracker is characterized by higher specific consumption of the feedstock and energy required to crack it as compared to a gas cracker. On account of inherent composition of naphtha, conversion or the yield of ethylene in naphtha cracking is far lower than the yield achieved in gas cracking. As a result, almost up to three tonne of naphtha is required for making one tonne of ethylene as against only 1.25 tonne of natural gas. Comparison of specific consumption of feedstock, steam and energy requirement for both processes is provided in Table 12. However, it needs to be noted that specific consumption for no two gas or naphtha crackers would be the same. It varies depending upon feed composition and thus configuration of the complex, and hence a range has been provided.

Table 13: Specific Consumptions: Naphtha Vs Gas Cracker

Parameter	Unit	Naphtha Cracker	Gas Cracker
Feedstock	T/T of ethylene	2.66-3.00	1.25-1.35
Steam	T/T of feed	0.56-0.64	0.30-0.50
Energy	Kcal of fuel/kg of feed	5000-6000	3000-3500
Power for 1 MTPA complex	MW	150-165	100-120

Source: MM Estimates - Primary Survey

5.3.3.2 Configuration & Relative Investment

As a reason of higher specific consumption, cost of production of ethylene via naphtha route is comparatively higher than the gas route. Viability of any project depends upon the profit margin that the product portfolio reaps with the installed configuration. Gas based crackers have limited co-products, thus making the configuration and operations straight forward and simpler. On the contrary, a naphtha cracker shall have fairly complex configuration due to its product slate normally covering

- Co-products such as propylene, butadiene, benzene
- Portfolio of value added products – ethylene & propylene derivatives – such as LDPE, LLDPE, HDPE, MEG etc.

Product slates of existing and upcoming naphtha and gas crackers is provided in Appendix C.

In order to maintain accuracy of separated fractions, it is desirable for naphtha crackers to have fractionating columns for separating propylene and butadiene. Therefore naphtha based cracker units have propylene, butadiene and benzene in their product portfolio – decided more by design than by choice. In case of gas cracking, selected feedstock is normally rich in ethane, with little volumes of methane and propane[41], the preceding set-up is not as exhaustive as required for naphtha units.

5.4 Duty Structure

Taxes and duties levied on the petrochemical feedstock, be it naphtha or domestic gas or LNG, are one of the highest among the global petrochemical industry

[41] Yield declines with higher proportion of methane in gas

Fiscal measures adopted by the country have also been noted hurting industry sentiments. Taxes and duties levied on the petrochemical feedstock, be it naphtha or domestic gas or LNG, are one of the highest among the global petrochemical industry.

Duty structure on naphtha and ethylene derivatives is provided below in Table 13.

Table 14: Customs & Excise on Naphtha & Ethylene Derivatives (2015-16)

HS Code	Custom Duty (With Abatement)							Central Excise
	Basic Customs	Edu Cess	Hig Edu Cess	CVD	Addn CVD	Cess on CVD	Total	
Naphtha – HS 2707	2.5%	2%	1%	14%	0%	0%	17.36%	12.5%
Naphtha – HS 2710	10%	2%	1%	14%	0%	0%	26.26%	12.5%
EDC, VCM	5%	2%	1%	12.5%	0%	0%	18.67%	12.5%
MEG, EA, PVC	7.5%	2%	1%	12.5%	4%	0%	26.4%	12.5%
LDPE, LLDPE, HDPE	7.5%	2%	1%	12.5%	4%	0%	26.4%	12.5%

Source: Icegate.gov.in

Since naphtha is not particularly defined in customs' tariff, it is being traded under different harmonic system (HS) codes. Import taxes for different categories have been noted to be different.

As naphtha is priced on import parity basis, aggregate of customs and central excise duties are levied in order to arrive at refinery transfer price. CENVAT (2% in 2015-16) or state VAT[42] – refer Table 15 – are levied further to arrive at retail price. Hence, proposition of cracker remains infeasible if naphtha is traded at market price. On the contrary, export prices are determined based on international market, which are competitive over domestic naphtha as can be referred in Figure 15.

Naphtha downstream projects have also suffered from the duty differential between naphtha and imported finished products; this has underperformed in providing much needed impetus to naphtha crackers. As evident from Table 14, duty differential is one of the lowest in India.

There is need to build duty differential. Increasing export duty on naphtha need not be considered at present as it will further stress refiners' margin.

Table 15: Comparative position of Indian Customs Duty on Naphtha & Derivatives (2015)

Product	India		China/ Taiwan	Japan	South Korea	Saudi Arabia	United States
	Basic #	CVD & Cess					
Naphtha (HS code 2707)	2.50%	14.86%	0%	NA	NA	5%	NA
Naphtha 2 (HS Code 2710)	10.00%	16.26%	2.50%	0.00%	0%	0%	0.20%
EDC	5.00%	13.67%	3.50%	3.90%	5.50%	5.50%	5.50%
VCM	5.00%	13.67%	3.50%	3.90%	5.50%	5.00%	5.50%
MEG	7.50%	18.93%	7.50%	4.60%	5.50%	5.50%	5.50%
PVC	7.50%	18.93%	7.50%	4.10%	5.50%	6.50%	5.50%
LDPE	7.50%	18.93%	7.50%	6.50%	6.50%	6.50%	6.50%
LLDPE	7.50%	18.93%	7.50%	6.50%	6.50%	6.50%	6.50%
HDPE	7.50%	18.93%	7.50%	6.50%	6.50%	6.50%	6.50%
Duty Differential	**(2.50%)**	**2.67%**	**5.00%**	**6.50%**	**6.50%**	**5.00%**	**6.50%**

[42] VAT is applicable for intra-state trade, whereas central sales tax (CST) of 2% is applicable on inter-state trade.

Source: Customs Tariff Departments of Respective Countries
- Basic duties at discounted tariffs;

There is also a strong call for rationalizing VAT/sales tax to have a uniform tax structure across all the Country. Table 15 compares sales tax/ VAT on naphtha for selected states –

Table 16: State Sales Tax on Naphtha and derivatives (2015-16)

State	Naphtha	PE	PVC	PP
Gujarat	16%#	5.0%	5.0%	5.0%
Andhra Pradesh	14.5%	5.0%	5.0%	5.0%
Bihar	13.5%	5.0%	5.0%	5.0%
Haryana	12.5%@	5.0%	5.0%	5.0%
Karnataka	5.5%	5.5%	5.5%	5.5%
Tamil Nadu	5.0%	5.0%	5.0%	5.0%
Maharashtra	12.5%	5.0%	5.0%	5.0%
West Bengal	5.0%	5.0%	5.0%	5.0%

Source: VAT Schedules (Dept of Sales Tax)
Additional 2.50% surcharge on taxable amount
@ - surcharge of 5.00% on tax payable

5.5 Other Important Aspects

Like refineries, crackers too are designed customised with respect to the composition of the feed – naphtha or rich LNG or mix of two – and so their performance varies with the feed mix. Having said so, it is of utmost importance to an operator to ensure reliable availability of the feedstock of the given composition at competitive prices. It would be plausible to set-up a cracker only after a thorough understanding of quality of feedstock and assurance of its long term supply.

Availability of single large parcel of land (~500 acre), its acquisition, fiscal incentives, fuel for power as well as cracker furnace, reliable supply of water, proximity to port, and the infrastructure for domestic distribution are among the other constraints limiting new capacities.

5.5.1 Minimum Economic Size

Configuration becomes an essential function for arriving at utility requirements and thus determines capital as well as operating cost. As the concept of sharing utilities[43] is not yet practised for mega scale projects in our Country, substantial investment also has to be considered for setting-up infrastructure for utilities like water, steam and power. Estimated cost for such a large complex could anywhere around ₹18,800 Crore[44], which apparently is a concern in terms of the size of investment.

Maintaining dedicated utilities have higher contribution to operational expenses, which effectively reduce operating margin especially when raw material cost is beyond owner's control. Higher tax incidence adds to woes by further reducing profit margin.

As a result of higher investment and depleted delta (profit margins), minimum economic size of external supply based naphtha cracker for domestic investment is nearly 0.90-1.00 MMT. Review

43 A model on the similar principles of Jurong Iceland in Singapore housing large scale Petrochemical complexes based on naphtha

44 Hard cost of around ₹ 16,000 Crore.

Project Cost of OPaL's 1.1 MMT ethylene cracker in latest is estimated around `27,000 Crore, whereas that of BCPL's 0.22 MMT cracker is around `9,833 Crore. Cost of IOCL's 0.9 MMT cracker was around 14,440 Crore in 2009-10

of ethylene capacities under implementation in China released by Platts International in September 2014 too supported the estimate.

Further, high level review of small capacity crackers operating globally[45] indicated –

- All were commissioned between 1970-2000, and hence revamped, expanded or decommissioned by now
- All the crackers are backed-up by captive supply of naphtha, hence reducing fiscal obligations
- Product slate mostly contains commodity polymers – PE, PP, PVC – and in few instances other downstream products such as superior plastics, surfactants, synthetic rubber, and chemicals [46] in addition to commodity polymers.
  - However, it needs to be noted that the ethylene and propylene being the cracks of primary importance, shall have to be utilized on priority

List of under implementation projects and small capacity crackers is presented in Appendix I.

5.5.2 Location & Logistics

None of refineries, except RIL, possess more than 1.0-1.2 MMT of naphtha at their disposal. Under such situation, there could multiple constraints related to sourcing of naphtha, its transport from different locations and the cost involved in it. Nonetheless, location of the cracker shall have to be ascertained from the point of view of –

- Adequate availability of land, considering future expansions as well
- Ease of acquisition of land – if required to
- Proximity to port infrastructure for importing naphtha and exporting petrochemicals
- Availability of cross-country pipelines from refinery to either port or to the envisaged location of the petrochemical complex, and
- the nature of transactions between the entities
- Nearby downstream industries

In the wake of above constraints, plans of setting up naphtha based petrochemical complexes did not materialize so far.

5.5.3 Common Infrastructure

Petroleum, Chemicals and Petrochemicals Investment Regions (PCPIRs) were introduced with motive of inviting investments that would have benefited from co-siting, networking and greater efficiencies resulting from sharing of common infrastructure and support services.

Owing to the high costs of developing utility infrastructure like common effluent treatment system, water intake system, power plant, and transportation system, locating crackers within PCPIRs makes sense so that synergistic relationships may be forged. Other than sharing of utility costs locating cracker within PCPIR will also facilitate transportation cost and lead time to downstream industries, saving their costs as well. However, unfortunately, no PCPIR, except Dahej, has been able to progress as expected.

45 International Survery of Ethylene Steam Crackers - 2015

46 **Superior plastics**: poly styrene and acrylonitrile butadiene styrene (ABS); **surfactants**: ethylene oxide, ethylene glycol; **synthetic rubber**: poly butadiene rubber, styrene butadiene rubber etc; Chemicals: Methyl tertiary butyl ether (MBTE), ethylene diamine tetra acetic acid (EDTA)

5.5.4 Concessions & Facilitation

By virtue of the products, a petrochemical complex will always be a mega scale project. Investments in such mega scale projects shall require equity participation, which could either be through equity funding agencies or investment partner, and hence bring related intricacies. Mobilizing huge investment required in a cracker may not be convenient at the applicable factor costs.

Given the inherent advantages of cheap availability of gas and naphtha to Middle East, and competitive (local) technologies with shared infrastructure to Eastern Countries, domestic industry shall not be able to compete with global industry. High cost of capital in India is a major challenge among the global ethylene industry.

Table 16 compares cost of industrial investment in domestic and global industry.

Table 17: Comparative Analysis of Factor Cost in India

Country	Location	Land Rate(US$/m^2)	Power (US$/KW)	Water (US$/m^3)	Interest Rate (%)
India	Mangalore/ Vishakhapatnam	40-90	0.14	0.53	12.0%
Singapore	Jurong	~300	0.20	0.90	5.4%
Malaysia	Penang	30-70	0.11	0.43	4.6%
Thailand	Amata Nakorn	144	011	0.37	6.8%
Japan	Around Tokyo	800	0.24	1.85	0.1%
China	Around Beijing	~160	0.11	0.82	5.5%
Saudi Arabia	Jubail/Yanbu	1.30*	0.04	6.0	5.0%
Oman	Sohar/Rusayl	1.30*	0.06	2.06	5.0%

Source: Compiled from World Bank and Industrial Devpt Authorities of Respective Countries
purchase ; * lease rental

5.6 Changing Priorities: Business Plan

Oil refineries are considered as the best suited investors in cracker business. But, owing to widespread business options available to them, it is obvious that the option with less implementation & operational intricacies and with better profit margins will be chosen. Different business interests or change in priorities has also shifted the capital investments against the favour of crackers.

5.6.1 Petrochemicals Vs Auto Fuels

As per Auto Fuel Policy – Vision 2025 published by the (MoP&NG), all the refineries shall have to comply BS IV standards by 1st April 2017 and BS V/VI by 1st April 2019. This shall require further improving octane number of MS, calling for isomerisation of still higher portions of LN to maintain the throughput of MS[47].

As a matter of maintaining the yields, all the refineries have already begun verifying feasibility for revamping the handling capacities of the reformers and setting-up new isomerisation units. As MS is any day is better placed against naphtha cracker – capital cost, demand drivers, hurdles in implementation and profitability – refiners have clearly given priority to MS.

[47] Failing which level of back-blending of MS with LN would go down, thus reducing the throughput

5.6.2 Other Petrochemical Derivatives

Propylene derivatives and para-xylene value chain (polyester fabric) are the other two prominent sub-categories in the petrochemicals family, which could be considered as a business option over ethylene value chain. Oversupply of propylene and polypropylene has made the refiners to consider value-added propositions for utilizing propylene produced in their refineries. Few years back, BPCL had intentions of setting up naphtha cracker, but the plan now has changed to propylene based petrochemical complex – which is underway in Kochi – keeping the naphtha plans aside. IOCL is also setting up a 100,000 TPA acrylic acid and derivative complex in Gujarat to utilise the propylene produced in other refineries. MRPL has recently commissioned the 0.45 MMT polypropylene unit, and whereas OMPL has commissioned the 0.90 MMT para-xylene unit.

5.7 Availability of Natural Gas

Given the constraints of naphtha as a feedstock, availability of natural gas was analysed to explore possibilities of setting-up a dual feed cracker.

Domestic natural gas is in short-supply, primarily due to shortfall in production. The natural gas market had got impetus with commencement of production in Krishna-Godavari (KG) fields in 2009-10. However from 2012-13 onwards, the production from the KG has not been up to the targets due to geotechnical issues. Though the other onshore and offshore fields have been under regular production, increasing production at these may not be possible due to ageing constraints. As it is, the sector has barely met one-third of demand; the deficit is expected to widen further with increase in demand in the coming years. On the contrary, consumption which is a function of production; reduced from 51.08 billion cubic meter (bcm) in 2010-11 to around 47 BCM in 2014-15 due to decline in production levels.

Apart from this, domestic gas is allocated to consumers as per the sectoral priorities under Natural Gas Allocation and Pricing Scheme 2013; whereas, marketers are free to import and re-sale LNG. As per the policy, petrochemical sector falls at 5th priority trailing (1) gas based fertilizer plants (2) LPG plants (3) power plants supplying to the National Grid and (4) city gas distribution systems. As a result, present share of petrochemicals in total consumption of natural gas is only 6%. In the given circumstances, easy access to competitively priced domestic gas for any of the upcoming gas based petrochemical projects too is in jeopardy.

6 Pooling Aspects & Cost Economics

6.1 Introduction

Even after multiple challenges, economic viability still remains an option to be validated to conclude the instant study. However, as pooling continues to be an integral part of the economics, contributing to the landing price of the feedstock, economics aspects of pooling were reviewed. This demanded analysing

- Existing and future surplus at refineries
- Pooling options and costs at locations of major availability and
- Preferred pooling locations

Accordingly, a framework analysis has been carried out ahead to conclude the findings.

6.2 Equating Surplus & Commitment

Even though the existing LN surplus appears enough for one million tonne ethylene cracker, availability is scattered. Also, as the expansions will be taking place in different regions, it is pertinent that availability of naphtha should be verified by regions and locations.

However, as a matter of increasing demand for isomerisation, and considering perceived heterogeneity, not all of the produced naphtha might be available for pooling. Apart from same, some import-export will also have to be considered in future for balancing prices.

A framework analysis on availability within existing surplus and that from additional production resulting from capacity expansion is provided below in Table 17. The table provides estimated break-up of production, downstream consumption, sale and exports of naphtha in 2014-15. As the situation on exportable surplus has almost remained same in 2015-16, the framework is believed applicable for the year as well[48]. Appropriate comments have been incorporated below the table analysing the situation in 2015-16.

The estimates have been updated against likely production of naphtha after expansion in refining capacity, commitments and subsequent downstream consumption – if any. Reduced availability due to isomerisation, domestic sale or exports against the additional production has been factored suitably in Table 18 at the time of considering availability by locations.

It needs to be noted that the estimates have typically been based on analysis of trends in production, captive consumption, sale and exports since 2011-12; hence the figures should be considered only for reasoning purpose, and not in absolute terms. Future availability has been based on IOCL's predictions.

[48] Data for developing similar framework for 2015-16 is not published till Sep 2016. However, having reviewed annual reports of Oil Corporations, the framework mostly remains applicable for 2015-16 as well

Table 18: Equating Present Surplus and Commitments by Individual Refineries 2014-15 (MMT)

Refinery	Naphtha Production	% of Refining Throughput	Downstream Use/Commitment	Open Sale Surplus	Export Surplus	Capacity Addition	Addn Naphtha Production#	Commitment/ Isomerisation	Further Surplus	Total Surplus	Region
IOCL-KOYALI, GUJARAT	0.542	4-6%	0.27[1]	-	0.27[2]	4.30	0.43	0.15[2]	0.28	0.58	West
IOCL-MATHURA, UP	0.436	5-7%	0.42[1]	-	0.06[2]	1.20	0.30	0.30[2]	0.00	0.00	-
IOCL-PANIPAT, HARYANA	1.554	10-11%	1.55[1]	-	-	5.20	0.52	0.52	0.00	0.00	-
IOCL-HALDIA, WEST BENGAL	0.391	5-7%	0.36[3]	-	0.05	0.50	0.05	0.00	0.05	0.10	East@
IOCL-BARAUNI, BIHAR	0.102	2-4%	-	0.050	0.05	1.00	0.10	0.10	0.00	0.10	East
IOCL-GUWAHATI, ASSAM	0.027	2.5-3.0%	-	0.013	0.013	-	-	0.027	0.00	0.00	-
IOCL-BONGAIGAON, ASSAM	0.155	5-7%	-	0.07	0.085	0.35	0.004	0.200	0.00	0.00	-
IOCL – PARADIP	-	-	-	-	-	15.00	1.50	1.50	0.00	0.00	-
IOCL TOTAL (w/o Digboi)#	**3.209**		**2.60**	**0.133**	**0.53**	**27.55**	**2.90**	**2.80**	**0.33**	**0.80**	
HPCL-MUMBAI, MAHARASHTRA	0.499	5-7%	0.25[4]	-	0.25	3.00	0.30	0.55	0.00	0.00	-
HPCL-VISAKH, ANDHRA PRADESH	0.610	4-6%	0.25[5]	0.17	0.18	6.70	0.70	-	0.70	0.90	East
HMEL-GGSR, BATHINDA, PUNJAB	0.194	3-5%	-	0.10[1]	0.09	2.25	0.20	0.20[2]	0.00	0.00	West$
HPCL, Rajasthan	-	-	-	-	-	9.00	1.00	1.00	0.00	0.00	-
HPCL-TOTAL	**1.303**		**0.50**	**0.27**	**0.52**	**20.95**	**2.20**	**1.75**	**0.70**	**0.90**	
BPCL-MUMBAI, MAHARASHTRA	0.799	6-10%	0.25[6]	-	0.55	3.00	0.30	0.65	0.00	0.20	West
BPCL-KOCHI, KERALA	0.492[7]	5-7%	-	0.10	0.40	6.00	0.70	1.10	0.00	0.10	South
BPCL-TOTAL (w/o BORL)#	**1.326**		**0.25**	**0.10**	**0.95**	**9.00**	**1.00**	**1.75**	**0.00**	**0.30**	
NRL, Numaligarh, Assam	**0.111**	**4-6%**	**-**	**0.01**	**0.10**	**-**	**-**	**0.16[8]**	**0.00**	**0.00**	**-**
CPCL-MANALI, TAMILNADU	0.568	5-6%	0.26	-	0.30	0.50	0.05	-	0.05	0.40	South
CPCL-NARIMANAM, TAMILNADU	0.137	25-40%	-	0.13	0.007	-	-	-	-		-
CPCL-TOTAL	**0.705**		**0.26**	**0.13**	**0.307**	**0.50**	**0.05**	**-**	**0.05**	**0.40**	**-**
NOCL, Cuddalore	**-**	**-**	**-**	**-**	**-**	**6.00**	**0.60**	**-**	**0.60**	**0.40**	**South**
MRPL-MANGALORE #	**1.315**	**9-10%**	**0.30[9]**	**-**	**1.00**	**-**	**-**	**0.20**	**0.00**	**0.80[9]**	**South**
RIL, JAMNAGAR, GUJARAT	5.555	17-18%	5.55	-	-	-	-	-	-	0.00	-
RIL-(SEZ), JAMNAGAR, GUJARAT	1.893	5%	-	-	1.893	-	-	-	-	0.00	-
RIL TOTAL	**7.492**		**5.55**	**-**	**1.89**	**-**	**-**	**-**	**-**	**0.00**	**-**
ESSAR OIL VADINAR, GUJARAT	**0.749**	**4%**	**-**	**-**	**0.75**	**-**	**-**	**-**	**-**	**0.40**	**West**
TOTAL – Refineries	**16.21**		**9.21**	**1.09**	**6.05**	**64.0**	**6.75**	**6.11**	**1.68**	**4.00**	
ONGC – Fractionator#	**1.142**	**-**	**-**	**-**	**1.14**	**-**	**-**	**1.50[10]**	**-**		**-**

Source: PPAC, IOCL, MM Estimates

Table Notes:

- Entire naphtha from Digboi is consumed by the refinery itself. Being minor in nature, BORL, GAIL & ONGC Tatipaka's production not considered
@ Can be transported to Haldia/Paradeep Port;

$ Can be transported to Mundra/JNPT Port

Detailed Notes

IOCL

1) Around 2.25-2.40 MMT of combined LN production by Panipat, Mathura and Koyali refinery is consumed by Panipat cracker. This leaves the cracker short of around 0.45 MMT feed, which is presently being arranged from HMEL and Barauni refinery. The cracker has estimated to have consumed around 2.70-2.90 MMT of LN in 2015-16
2) Around 0.05 MMT LN from Mathura and another 0.3 MMT from Koyali is exported by IOC from West coast.
3) Haldia refinery supplies entire LN to HPL. The unit has not been exporting LN at all. But, after expansion, around 0.10 MMT LN is expected to remain available for pooling

- High yields of MS in Barauni, Bongaigao and Guwahati does not leave considerable surplus LN with the refineries
- But, 0.15 MMT surplus LN at Bongaingaon is believed to be consumed in-house in new CCR unit to be installed to improve yield of MS; hence, no LN might be available for pooling in future
- 0.10 MT surplus LN at Barauni refinery is likely to remain available for pooling
- Digboi is not generating any excess naphtha at all

Summing up, IOCL has captive consumption of 2.25 MT LN, and sells 0.36 MMT LN under commitment and 0.58 MMT under open market sale; another 0.53 MMT is exported. Out of the present surplus – open market sale and exports – quantities from Koyali and Barauni refineries are informed to be available for pooling. Considering part of future surplus at Koyali dedicated to Panipat cracker, around 0.60 MMT LN is likely to remain available for pooling.

However, despite capacity additions, no LN is likely to be available from Paradip, Mathura, and Bongaingaon refineries as there are plans for maximising MS yield by revamping, or setting new CCRs and isomerisation units. As the Panipat cracker keeps provision for expansion to 1.40 MMT by retrofitting and debottlenecking, additional LN from Panipat and Mathura could be associated with the cracker in future.

Excess LN from Koyali will be available at west coast, and that from Barauni and Haldia will be available at east coast. IOCL operates product pipelines between Koyali and Dahej, and Barauni and Haldia.

HPCL

HPCL's naphtha yield declined from 7% in 2014-15 to average 4% of the refinery throughput in 2015-16 as the company carried out modifications in existing CCR units; contracted sales to RIL and HPL during 2014-15 might also not have continued to the next year. In 2014-15

4) Mumbai unit, with throughput of 0.50 MMT LN in 2014-15, had contracted 0.25 MMT supply LN to RIL; rest was exported
5) Vishakhapatnam produced 0.518 MMT LN as compared to 0.30 MMT in previous year to cater HPL's demand[49]

After 3.0 MMT expansion at Mumbai, and 6.7 MMT at Vishakhapatnam, around 1.0 MMT of naphtha (present surplus + additional production) will be available at Vishakhapatnam. Of this, around 0.87-0.90 MMT is expected to remain available for cracking, and rest exported for trade balance. Despite capacity expansion, hardly any LN is likely to be available in Mumbai on account of refinery's plans for maximising yield of MS.

New 9.0 MMT new grass route refinery at Rajasthan and Vishakhapatnam are expected to produce 1.0 MMT and 1.5 MMT of naphtha respectively. However, corresponding quantities have not been considered right now as the refineries have plans for setting-up downstream naphtha crackers in future.

HMEL

In 2014-15, HMEL produced 0.194 MMT LN, most of which was sold to IOCL's Panipat cracker. Around 0.22 MMT of naphtha is expected to be available in addition to this post expansion of refinery to 12.0 MMT. 50-60% of this could ether be routed to Panipat cracker in future against its expansion or can be expected to be available for pooling near West coast (from where LN is being exported right now).

The company owns a 1017 Km crude pipeline from Mundra to Bhatinda, and is connected with Panipat by IOCL's product pipeline as well.

BPCL

6) Naphtha yield declined from 12% till 2013-14 to 6% (0.8 MMT) in 2014-15 as the new CCR unit was commissioned. Yield further declined to 4.7% in 2015-16. Out of 0.799 MMT naphtha produced by Mumbai refinery, around 0.25 MMT naphtha was sold to RIL and rest exported
7) Production in Kochi too declined from 0.67 MMT in 2013-14 to 0.50 MMT in 2014-15, with proportional increase in the throughput of MS

Out of 1.135 MMT naphtha generated from both units, only 0.104 MMT was domestically sold, while rest was exported. Company's annual report 2015-16 boasts of highest ever naphtha absorption in MS and HSD leading to reduction in naphtha production. Even then, as per data compiled by IOCL, only 0.30 MMT approx. is likely to remain available for pooling after 3.0 MMT expansion in Mumbai and 9.0 MMT expansion in Kochi refinery on account of plans for further maximising MS yield.

NRL

8) NRL's naphtha throughput is expected to increase from 0.111 MMT in 2014-15 to at least 0.160 MMT on account of commitment to BCPL. However, this shall not result in any surplus as the increased volume shall be absorbed by BCPL

[49] It is understood that sale to RIL and HPL is on annual basis, i.e. no long term commitment

CPCL & NOCL

- CPCL
  - CPCL's Chennai unit produced around 0.57 MMT and Narimanam unit produced 0.14 MMT naphtha in 2014-15
  - Roughly one third of the throughput is expected to have been sold to fertilizer and power plants in the vicinity and rest exported
  - Production from Narimanam unit appears to be committed, and hence no naphtha may be available in future
  - However, around 0.40 MMT LN is expected to be available from Chennai unit

0.40 MMT of around 0.60 MMT LN produced by NOCL could be available for pooling. Hence, around 0.80 MMT of naphtha is expected to be available on combined basis from CPCL and NOCL upon commissioning NOCL's Cuddalore refinery.

MRPL

9) In 2014-15, OMPL has expected to have consumed 0.12 MMT of HN and 0.28 MMT LN (isomerised to aromatic stream); remaining was exported. In 2015-16, company produced 1.574 MMT naphtha, of which around 0.93 MMT was exportable surplus

Out of refinery's LN throughput in future, at least 0.80-0.90 MMT LN can be expected to be available for pooling

ONGC Hazira

10) ONGC's NGL production will be dedicated towards ONGC Petro additions Ltd (OPaL), Dahej, which is expected to be commissioned by end of second quarter of 2016-17.

NGL production in 2015-16 declined to 1.03 MMT from 1.1.5 MMT in 2014-15.

RIL & EOL

- No domestic surplus is or will be available with RIL
- EOL is exporting its entire production of 0.75 MMT. Roughly half of this can be expected to be available for pooling and rest for export

Around 4.00 MMT can reasonably be expected available for pooling in 2021-22, after necessary discounting for isomerisation and exports

So, it is expected that around 4.00 MMT can reasonably be expected available for pooling in 2021-22, after necessary discounting for isomerisation and exports. In near terms, following could be the distribution of existing surplus and additional availability –

Table 19: Probable Distribution of LN Available for Pooling

Refinery	Existing Available Surplus (A)	Additional Supply (B)	Total Available Supply (C')	Region
IOCL Barauni	0.05	0.10	0.10	East@
IOCL, Haldia	0.05	0.05	0.10	East
IOCL, Koyali	0.27	0.43	0.60	West
BPCL, Mumbai	0.35	0.30	0.20	West
BPCL, Kochi	0.30	0.90	0.10	South
HPCL Vishakhapatnam	0.25	0.70	0.90	East
HMEL Bhatinda	0.05	0.22	0.20	West#
CPCL, Chennai	0.35	0.05	0.40	South
NOCL Cuddalore	NIL	0.60	0.40	South
MRPL	1.0	NIL	0.80	West
Essar Oil	0.40	NIL	0.40	West
Total	**3.07**	**3.35**	**4.20**	

Source: MM Research
@ Can be transported to Haldia/Paradeep Port,
# Can be transported to Mundra/JNPT Port
^ Net of 2.22 MMT which will get used in isomerisation or committed sale or exports

The surplus looks sufficient to install at least one 0.90-1.00 MMT naphtha cracker.

6.3 Pooling Cost

Cost of transportation shall certainly be an important factor in comparing the location, but it was not noted to be a deciding factor as it formed 3%-4% of the landing price.

6.3.1 Pooling Cost - New Pipeline Infrastructure

As pipelines would be the most sustainable mean of transportation, need for developing dedicated pipelines was explored. It was estimated that around 2,600 running Km pipeline required for pooling of 3.0 MMT of naphtha. This would entail a capital cost of around ₹3,400 Crore. In addition, operating and maintenance cost were being estimated to be around ₹285-300/ Tonne**.** Refer Appendix I for details.

However, the proposal was not considered as the piping network becomes a subject of techno-commercial feasibility in itself. Also, the expenditure and timelines required for developing same could be a discouraging element for the proposal at this stage.

6.3.2 Pooling Cost – Coastal Shipping & Existing Pipelines

As nine of these are coastal refineries, four located on each of East and West coast, shipping can be done along the coastal lines. Both the landlocked refineries, HMEL and IOCL's Barauni refinery, are connected with Mundra and Haldia port respectively, from where the naphtha can be conveniently shipped.

Accordingly, Plotting the nautical miles (Nm) and approximate cost per MT-Nm for shipping distances from the naphtha sources indicated in Table Ex.1, the weighted average cost per MT for pooling of entire surplus naphtha at each of the locations worked out to be[50]

50 The figures are indicative, and to be used for comparison between the two locations. Case specific cost has been discussed under planning section in the Executive Summary

- Kochin – ₹785/T
- Mangalore - ₹922/T
- Chennai - ₹926/T
- Mumbai – ₹928/T
- Dahej (Koyali) - ₹1,240/T
- Vishakhapatnam - ₹1,283/T and
- Paradip/ Haldia - ₹1,333/T

Refer Appendix I for details

Evaluation based on cost suggests Kochi to be the most preferred pooling location followed by Mangalore, Chennai, and Mumbai. However, as can be noted pooling costs are comparable and form insignificant portion of naphtha landing cost worked out in Appendix G. Hence, following factors were given priority over pooling cost in shortlisting the location.

6.4 Shortlisting Locations

Region

Considering the location of the existing crackers and the unaddressed demand from PVC industry in southern part, necessity was felt for establishing new cracker(s) in southern region. Checking availability by region, it is noted that –

- 1.4 MMTPA LN is located in west zone: HMEL, IOCL-Koyali, BPCL-Mumbai and EOL-Vadinar
- 1.1 MMTPA in east zone: IOCL-Barauni, Haldia and HPCL-Vishakhapatnam and
- 1.7 MMTPA in southern zone: MRPL, CPCL, NOCL, and BPCL-Kochi

Although one third of the total surplus LN is located in west, the region was not considered to be to be the probable ones for having cracker on account of oversupply of downstream industries in the region.

Integration with Refinery Operations

Refinery streams being the input for petrochemical complexes, integrating operations of both hold immense techno-commercial importance. It does not only allow systemizing production, but also reap benefits of utility sharing. However, it is recommended that at least one third of LN requirement for a cracker should come from the associated (integrated) refinery. For that to happen, the minimum capacity of the associated refinery should be 15 MMTPA.

All the three shortlisted refineries: IOCL-Koyali, MRPL- Mangalore and HPCL-Vishakhapatnam will have installed capacity of 15 MMTPA or more in 2020-21. However, as per IOCL's plans, LN from Koyali refinery may partly be diverted to Panipat cracker upon its expansion resulting in fall in surplus LN. Hence, Koyali is not continued as a preferred location. Western coast was also not preferred due to existing presence of RIL and OPaL.

As none of the Mangalore or Vishakhapatnam refineries have plans for recovery of propylene or maximising MS yield, they fit into the criteria of acting as the base refineries.

Clearances

Mangalore SEZ (MSEZ) has received environmental clearance for setting-up 2.168 MMT naphtha cracker on 8 April 2008. HPCL's proposed complex is under feasibility stage.

Port Infrastructure

Around 0.30-0.40 MMT naphtha or rich LNG will have to be imported under following situations –

- should participation from private refiners is not confirmed or if refineries with smaller surplus continue exporting LN resulting either in shortfall of feedstock
- cost economics of imported naphtha over domestic, not only in terms of market price, but transportation from particular location(s) as well
- discontinuity in operations of refiners with smaller volumes of surplus LN against the inventory period of the cracker

Costs would be optimized should LN is pooled only between the refineries with larger surplus i.e Koyali (IOCL), Mangalore (MRPL), Chennai (CPCL) and Vizag (HPCL). In that case, part of LN imports could be replaced with imports of rich LNG.

Hence, the port infrastructure will play vital role in facilitating long term operations. Both Mangalore and Vishakhapatnam ports are presently handling POL products.

LNG Terminal

Connectivity to LNG terminal will be required to source gas feedstock whenever cost economics of LN go against the petrochemical market.

- Vishakhapatnam: LNG terminal has been planned at Gangavaram port by Petronet LNG
- Mangalore:
  - LNG piping is being established between Kochi and Mangalore
- Recently, MRPL is also examining feasibility of setting up an LNG terminal in Mangalore

Proximity to End Users

Nearly 0.8 MMTPA PVC resin industry is located in southern (Tamil Nadu) and south-west (Ratnagiri, Maharashtra) part of our country. Tuticorin is the single most destinations importing vinyl chloride monomer (VCM), and Kochi is one of the three top destinations importing ethylene dichloride (EDC) in our country.

Considering geographical distances, Mangalore is the most convenient location for supplying VCM/EDC to the leading PVC manufacturers in southern India – refer Appendix D.

Pooling Cost

Distances for transporting naphtha from each refinery to the shortlisted pooling locations have been set out below in Table 19.

- It is envisaged that naphtha from land locked Barauni refinery will have to be transported to Paradip by POL pipelines, and that from HMEL will be transported by pipeline to Mundra. Cost of such transportation is envisaged around ₹250-300 /MT.
- Considering average shipping charges of ₹1.0[51] / MT-NM (nautical mile) for a 35,000 MT cargo, cost of pooling entire surplus to Vishakhapatnam and Mangalore works out to be ₹424 Crore/annum and ₹313 Crore/annum respectively. In per tonne of naphtha basis, transportation cost is estimated at around ₹1283

[51] Unit charges have been considered on indicative basis. Actual charges may vary 20% depending upon the distance, nature of contract (frequency), exchange rate variations and shipping load (tonnage) of transport. Also, it is assumed that adequate infrastructure will be available or created on ports for handling the product

for Vishakhapatnam and ₹922 for Mangalore. The remain in the same range even if quantities from Essar Oil & NOCL – being private companies – are deferred.

Table 20: Approximate Pooling Distances & Cost of Transportation (in nautical miles)

Refinery	Available Supply (D)	Distance to Vizag	Distance to Mangalore	Pooling Charge Vizg (₹ Cr)	Pooling Charge Mangalore (₹Cr)
IOCL Barauni	0.10	406*	1518*	6.56	17.68
IOCL, Haldia	0.10	406*	1518*	4.06	15.18
IOCL Koyali	0.60	1886	670	113.16	40.20
BPCL, Mumbai	0.20	1625	409	32.5	8.18
BPCL, Kochi	0.10	1035	202	10.35	2.02
CPCL, Chennai	0.40	420	797	16.8	31.88
HMEL, Bhatinda	0.20	2052*	1039*	41.04	25.78
HPCL Vishakhapatnam	0.90	00	1216	00	109.44
MRPL, Mangalore	0.80	1216	00	97.28	00
NOCL Cuddalore	0.40	490	742	19.60	29.68
Essar Oil, Vadinar	0.40	2052	836	82.08	33.44
Total	**4.20**			**423.43**	**313.48**

Source: Ports.com, MM Analysis
* - from Paradip Port and Mundra Port

As naphtha as well as LNG is dominantly imported from Saudi Arabia, UAE and Oman, imports at Mangalore (@₹1600/Ton for 2000 nautical miles) will enjoy benefit of lower transportation cost over Vishakhapatnam (@₹2600 /Ton for 3250 nautical miles).

Land & Local Infrastructure

Both Mangalore and Vishakhapatnam are benefited with investment for crude oil refining and petrochemical projects. Key features of Mangalore SEZ and AP PCPIR are stated in Table 20.

Table 21: Key Features of MSEZ & APPCPIR

Parameter	Mangalore SEZ	AP PCPIR
Land Area (Sq Km)	~ 8.0 Sq Km in first phase; being expanded to more are in phases	603 Sq Km to be developed in three phases
Land Availability	Should be available	Should be available
Port & Capacities	Mangalore Port – a congestion free port; Port capacity – 77 MMTPA Utilization in 2015 – 50% POL Handling – 7 MMTPA	Includes three ports: Vishakhapatnam, Kakinada and Gangavaram Vishakhapatnam port has handling capacity of 120 MMTPA with capacity utilization ranging between 60-65%
Water	Sanction to draw 15 million gallon per day (MGD) water from Netravathi and Gurpur rivers	Dedicated 26 MGD water supply scheme to PCPIR
Power	190 MVA sanctioned at present	Dedicated 220/132 KV substation for the PCPIR. Status of power availability & associated distribution network will have to be explored
Common Waste Management	Effluent collection & (secondary) treatment system is available (capacity not known).	ETPs available for different clusters. 4x40 million litre per day (MLD) ETPs available in Vishakhapatnam cluster (Present load not known)

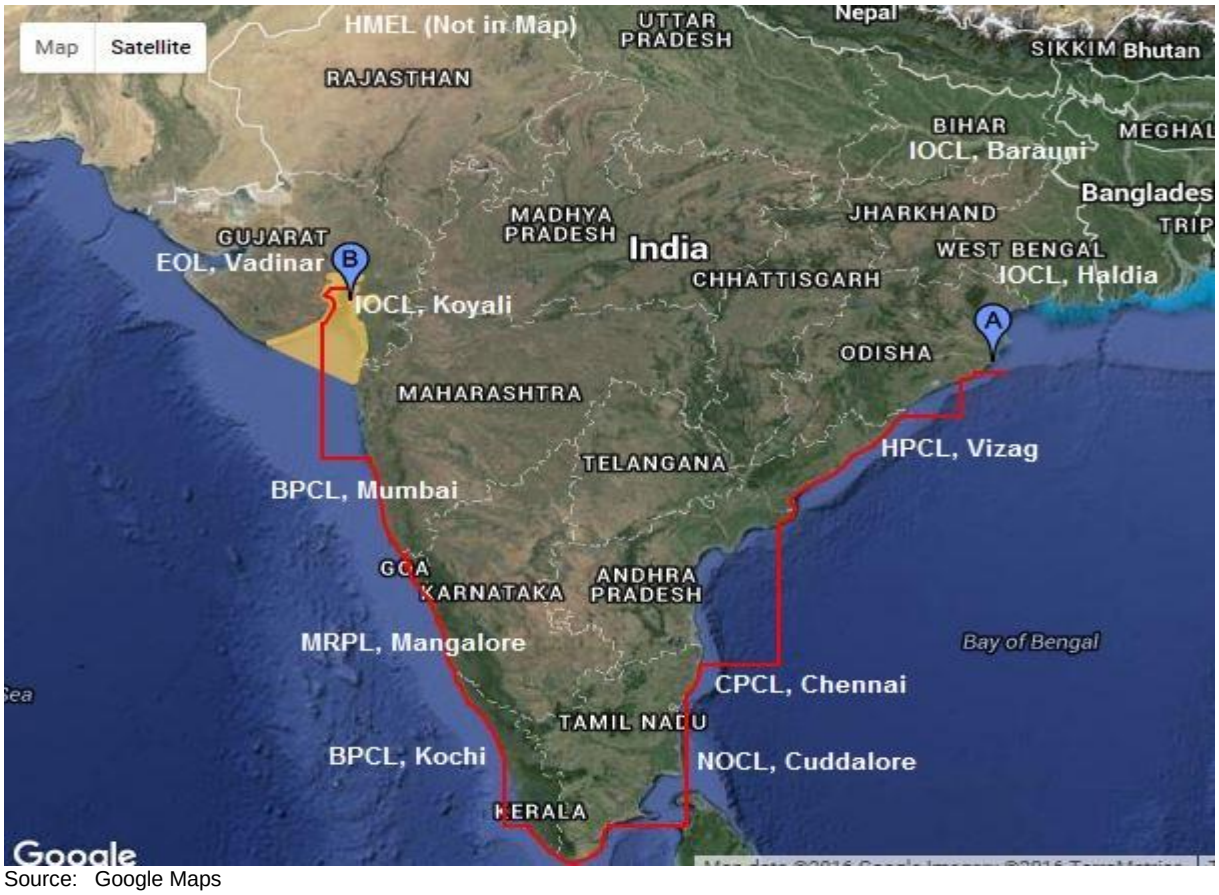
Parameter	Mangalore SEZ	AP PCPIR
	12 Km long pipeline laid to pump treated effluent into ocean	
Road Infrastructure	50 & 30 m wide roads with utility pipelines passing along the road corridor	Well connected by National & State Highways
Connectivity	Well connected on road & rail route	Well connected on road & rail route
Anchor Tenant/Projects	• MRPL (15 MMTPA refinery) & OMPL (PX Unit) • Both units are operating	• HPCL – 1 MMTPA Olefin & Aromatic complex (Naphtha cracker) • Kakinada Refinery & Petrochemicals Ltd – 15 MMTPA refinery • Projects are yet to kick-start

Source: Websites of MSEZ & APPCPIR

Cracker has already been proposed for Vishakhapatnam/ Andhra Pradesh PCPIR. However, there have been roadblocks in capital investment; HCPL has already been in search for an investor in the proposed complex.

Cracker can become a part of Mangalore SEZ, but the decision might contradict benefit of domestic industry as export obligations will have to be kept in mind. A pictorial view of the pooling plan has been provided below:

Figure 17: Pooling Plan



Source: Google Maps

Broad comparison between the two locations is made in Table 21 –

Table 22: Comparison between Mangalore & Vizag as Pooling Locations

Parameter	Mangalore	Vishakhapatnam
LN Availability at base location	0.8 MMTPA	0.9 MMTPA
Capacity of base refinery in 2021-22	15 MMTPA[52]	15 MMTPA[53]
Port & Capacities	Mangalore port capacity – 77 MMTPA Utilization in 2015 – 50% POL Handling – 7 MMTPA	Vishakhapatnam port has handling capacity of 120 MMTPA with capacity utilization ranging between 60-65%
LNG Connectivity	Yes, should be available in near future as MCFL awaits same	Under planning stage
Land Availability for cracker	Should be available	Should be available
Water & Power	Available & Should be sufficient	Available, but sufficiency of power not known
Common Effluent Network	Available, but sufficiency not known	Available, but sufficiency not known
Connectivity	Well connected on road & rail route	Well connected on road & rail route
Indicative transportation cost of pooling LN	~ ₹922/Ton	~ ₹1383/Ton
Indicative transportation cost of importing LN	~ ₹1600/Ton	~ ₹2600/Ton
Proximity to PVC Industry	Nearer to Ratnagiri, Salem and Sahupuram (Tuticorin) where the leading PVC players operate	Farther to the locations as compared to Mangalore. However, it should only be a secondary measure for comparison
Primary Stakeholder	MRPL	HPCL
Clearances	MSEZ has received environmental clearance for setting up 2.168 MMT naphtha cracker (naphtha capacity)	HPCL's proposal itself is under feasibility stage

Source: MM Analysis

SEZ restriction for accessing domestic market may tilt the decision in favour of Vishakhapatnam

Based on limited evaluation, Mangalore seems to possess advantage over Vishakhapatnam. However, the SEZ restriction for accessing domestic market may tilt the decision in favour of Vishakhapatnam.

6.5 Pooling Mechanism

No pooling operator has been envisaged unlike in natural gas pooling in Fertilizer Industry

No pooling operator has been envisaged unlike in natural gas pooling in Fertilizer Industry. The mechanism of natural gas pooling may not hold applicable for naphtha as:

- the earlier is driven by demand (one supplier-multiple purchasers) whereas the latter is driven by surplus supply (one purchaser-multiple suppliers)
- surplus supply as well as willingness to participate in pooling may differ for suppliers, the mechanism including prices to be governed by market forces rather the Administered Price Mechanism (APM)

52 The CDUs have been designed with higher capacity, but there seem to be limitations with heavy treatment unit

53 Does not include HPCL's 15 MMT Greenfield refinery at AP PCPIR as the project is under evaluation/ feasibility stage

- an independent pooling operator could be applicable for O&M of cross-country piping, which has not been considered s due to cost and other practical implications related to criteria for selection, mode of operation and willingness of the shortlisted parties

Eventually, there could be a long term supply agreement between the purchasing and supplying entities. The agreement may govern obligations of minimum supply and benchmark the pricing criteria.

6.6 Cost Economics

As a standalone cracker will not be technically viable due to challenges in product storage and handling[54] , a downstream complex housing polymer units is necessary.

After benchmarking cost and configuration of IOCL's Panipat cracker, present day cost of a 0.90 MMT cracker – expandable to 1.10 MMT – cum downstream complex was estimated at around ₹18,800 Crore. The prevailing cost (2015-16) includes 30% inflation built-up over IOCL's as-built cost of ₹14,440 Crore in 2009-10.

Table 23: Configuration of Cracker & Downstream Complex

Facilities	Installed Capacity (MMT)	Market Price 2015 (₹ /T)	Remarks
Dual Feed Cracker	2.70		
Ethylene Recovery	0.90	-	Conversion to LLDPE, HDPE
Propylene Recovery	0.65	-	Conversion to PP
Butadiene Recovery	0.14	-	
C6 & Higher raffinate Recovery	0.40	-	Conversion to Benzene & Other Products
Methane/Off gas Recovery	0.40	-	Captive Consumption
Chemical Recovery Units			
Benzene	0.13	66,545	
Butadiene	0.13	68,752	
Pygas & Other raffinates	0.35	45,000	
Polymerization Units			
Polypropylene (PP)	0.65	90,510	
Dedicated HDPE	0.30	98,900	
LLDPE & HDPE Swing#	0.55	98,490	

Source: MM Analysis
- MEG is not considered as a part of configuration in absence of PX unit. Corresponding tonnage has been incorporated LLDPE & HDPE Swing Unit

Macro level analysis of the financials indicators based on average prices of the feedstock and finished products in 2015-16, and upon benchmarking operating costs is provided Table 22. Price of naphtha was averaged out from direct imports, as well as it was built-up as per the pricing model used by Oil Corporations for developing refinery transfer and retail price – refer Appendix F.

Economics have been worked out considering Vishakhapatnam as the probable location. It is assumed that:

- 2.2 T of naphtha and 0.60 T imported LNG will be consumed on average per tonne of ethylene
- Out of 2.0 MMT requirement of naphtha, 0.90 MMT will be available with HPCL's Vishakhapatnam refinery and rest 1.10 MMT will be pooled from Mangalore (MRPL) and Tamil Nadu (CPCL)
- The complex will operate at 95% capacity utilization, and thus the expected output will be 95% of the capacities indicated under chemical recovery units and polymerization units under Table 23

[54] Both ethylene and propylene are gases at normal room & temperature. Ethylene needs to be transported at -60oC

- Methane off gas will be captive consumed for generating waste heat recovery (WHR) steam and subsequently for firing boilers
- Additionally pyrolysis oil too will be used as fuel for firing steam boilers for generating electricity. Additional fuel will be purchased from back-end refinery
- Hydrogen will too be captive consumed for hydrogenation of incoming naphtha – if required – or of C6, C7-C8 streams
- Entire ethylene will be converted to HDPE and LLDPE, whereas entire propylene to polypropylene – both consumed in 1:1 ratio
- Residual pygas and raffinates will also be sold at prevalent market price
- Operating costs will fall in line with industry standards
- Debt to equity ratio – 75:25
- Construction Period – 4 years
- Repayment tenure – 11 years after 6-month moratorium from the date of commercial operations
- Door-to-door tenure – 15 years
- Selling price of products as stipulated under Table 22
- Cost of naphtha as worked out under Appendix G (₹40,187/T on retail price basis)

Economics of the project were thus evaluated by plotting simple profit and loss statement. However, the outcome does not appear favourable. Pooling cost, on conservative side, was considered flat at ₹1500[55] per tonne of naphtha.

Table 24: Prototype Profit & Loss Statement (Amount in ₹Crore)

Description	Basis/ Assumption	Amount	% of Net Sales
Gross Revenue	Sale of LLDPE, HDPE, PP, Butadiene, Benzene & Pygas/ Raffinates at 95% of installed capacity, and at 2015-16 prices	16720.91	
Less Excise		2090.11	
Net Sales		**14630.80**	
Cost Stream			
Raw Material: 2.2 T Naphtha, 0.6 T LNG & 0.1 T Butene per T of Ethylene		10087.85	69.0%
Consumables	Catalysts, Spares etc.	351.14	~2.5%
Power, Fuel & Utility Cost	Captive Power Generation from Off gases. Fuel cost considered for process steam	673.02	4.6%
Repair, Maintenance & Insurance		146.31	1.0%
Packing, Distribution & Freight		146.31	1.0%
Admin & Selling Expenses		365.77	2.5%
Manpower & Employee Benefits		438.92	3.0%
Miscellaneous Expenses	Finance cost, Provision for bad debts,	365.77	2.5%
Total Cost of Production		**12575.08**	**86%**
Earnings Before Interest Tax Depreciation & Amortisation (EBITDA)		**2055.72**	**14%**
Add Depreciation	Life – 20 years; salvage value 5%	877.85	

[55] Refer section 6.2 for averaged out cost of pooling to Vishakhapatnam. Reasonable margin has been considered for financial analysis

Description	Basis/ Assumption	Amount	% of Net Sales
Less Interest on WC & Term Loan	Working Capital Interest 12.5%; Term Loan 11.5%		5% of Gross Fixed Assets
Profit Before Tax (PBT)		**1177.87**	**8%**
Less Corporate Tax	33% of PBT	388.70	
Profit After Tax (PAT)		**789.17**	**5%**
Repayment of Term Loan	**11 year tenure**	**1,282.0**	

Source: MM Analysis, Annual reports (2014-15) of IOCL and Haldia Petrochemical Ltd

It can be noted that free cash flow for the scenario considering average of 2015 prices is negative. An updated analysis carried out as of January 2017 confirms negative results persisting due to escalation in crude oil and thus naphtha prices.

As the scenario is not conducive for investment under the present circumstances, there is a need to explore the options for improving the base case scenario in discussion with the Industry. Industry's opinion on materialising opportunities, and expectations in the form of fiscal, regulatory, and infrastructure facilitations could be invited.

Thus, the situation finally demands concessions to live up to the requirements under the 'Make-in-India' policy, but there also has to be a socio-economic rationale supporting it.

7 Conclusions & Recommendations

7.1 Need for Cracker

There is need for augmenting domestic ethylene capacity as the supply would fall short of demand in long term. Considering inherent advantages of natural gas cracker over a naphtha cracker, preference is higher for a gas cracker.

A naphtha cracker would certainly enable consuming export-bound naphtha indigenously for making value added downstream polymers. While it would also result in economic benefits in terms of direct and indirect employment and higher economic activity resulting in additional contribution to the exchequer, preliminary response from the industry compiled during course of this study called for constructive measures enabling the industry to consider this capital intensive venture. However, more clarity is desired from Oil Corporations on improvement measures.

7.1.1 Ethylene Demand Supply

In 2015-16, demand of ethylene, in terms of consumption of equivalent quantity of downstream products, stood around 6.93 MMT. The demand exceeded supply by 3.00 MMT; with growth at the rate of 0.62 MMT every year, it is expected to reach 13.14 MMT by 2025-26.

So, even after the 3.45 MMT capacity under implementation at present and 2.05 MMT under planning stage being materialized, there will be a shortfall of around 3.71 MMT ethylene in 2025-26.

7.1.2 'Make in India' Policy

Despite 7.0 MMT surplus naphtha and imports of polyethylene to meet the demand, the value addition of naphtha is being carried out outside. This is not in line with the principles of the 'Make in India' policy. If India aspires becoming self-reliant in 85% of polymer needs, we have to set up new cracker(s). However, around 10-15% of demand could be met through imports in case of change in specifications, demand fluctuations and price instability.

7.1.3 Comparative Competitive Position

It makes sense in integrating operations of cracker with refinery to optimise costs. However, domestic crackers, even at its best integration with refinery operations, operate with costs 6-7% higher than global average[56] ; reasons are higher cost of feedstock and capital, thereby increasing operating costs.

It is well known that Middle East crackers (Saudi Arabia and UAE) possess competitive advantage of being gas based crackers, whereas South East & Asia (South Korea, Thailand, Japan and China) possess advantage of zero import duty on naphtha and shared utility services infrastructure.

The options for optimising costs of feedstock need to be explored through fiscal concessions.

[56] As can be referred in section D.2 in Appendix D

7.2 Key Challenges

7.2.1 Higher Cost Factor

Higher rate of interest and capital costs in the country are likely to adversely affect the viability of the project. Huge capital cost would be required for setting up crackers, and thus inviting investments will certainly require constant facilitation and support from the policy point of view.

Although a perfect comparison with developed economies like Japan and USA might not be a correct approach, a comparative analysis of factor costs (land, energy, capital) to economic indicators calls for Governmental support for competitive land rental and interest subvention on term loan.

7.2.2 High Tax Incidence

Cumulative 26.3% tax incidence on naphtha in India is very high compared to Middle East (ME) and South East Asia (SEA).

Refinery transfer price of naphtha – from refineries to the cracker – is an important aspect determining competitiveness of the cracker. As it is priced on import parity rather cost plus basis, customs duty is being inbuilt into price in addition to central excise and VAT/central sales tax. A higher import duty increases the price of feedstock beyond break-even price, making the project commercially unviable.

Notwithstanding this, marginal or nil duty differential in the country is favouring imports of ethylene based polymers instead encouraging indigenous processing of naphtha. All leading naphtha processing countries have built at least 5% duty differential between naphtha and derivative products.

7.2.3 Implementation Support

In absence of implementation support (in terms of co-ordination during land acquisition and timely processing of statutory clearances) there could be ricks adding to project delays, and capital outlay.

7.3 Conclusions

Irrespective of whether naphtha is pooled or made available at back-end refinery, the scenario considering naphtha priced on retail basis was not found economically viable with only 5% PAT margin and negative cash flow. Hence, the proposal is not conducive for investment under the present circumstances due to following reasons:

- Natural gas – rich LNG – possesses inherent advantages over naphtha as feedstock to cracker. Simpler configuration of a gas based cracker saves capital as well as operating expenses. Competitive pricing of natural gas or rich LNG over the years has resulted in cost effective production of polymers vis-à-vis naphtha.
- Further, naphtha is a derivative of crude oil distillation, it entails a processing cost in addition to import price, which normally gets reflected in profit margins under refinery transfer price (RTP) putting it at disadvantage as compared to natural gas which can readily be cracked after conditioning at the very source of its origin
- Even if a dual feed cracker is being conceived with naphtha as major feedstock, only refiners would be in best position to utilize the available surplus naphtha as a forward integration into petrochemicals
- However, out of the prominent refiners, only Indian Oil Corporation Limited (IOCL) and Reliance Industries Limited (RIL) are operating crackers by managing naphtha from their refineries
- Both have developed operating synergies by integrating cracker with back-end refineries. However, this was possible as both possessed required volumes of naphtha available at a location, or in the vicinity

- Despite at its best integration with refinery operations, and even after treating naphtha on transfer price, domestic crackers operate with costs 6-7% higher than global average as it is well known that Saudi Arabia and UAE possess competitive advantage of gas based crackers
- None of the refiners possess deemed advantage of holding adequate naphtha volumes, even IOCL's Eastern refineries, they either are isomerising maximum portion of naphtha to motor spirit, or exporting it to South Korea, Japan and China, which levy zero import duty on naphtha in order to make it economically viable for cracking
- Isomerising naphtha to motor spirit has always been convenient and profitable as compared its exports or cracking. Share of MS in India's refining product slate increased from 8% in 2005-06 to 15.37% in 2015-16, whereas that of naphtha declined from 13% to 7.64%
- In order to meet Government's mandate for adhering to BS V/VI norms, higher volumes of LN will be isomerised in future to maintain yield of motor spirit; this is expected to deplete surplus naphtha. Refiners are already in the process of revamping existing or installing higher capacity isomerisation units
- Given the widespread distribution of available surplus, it is not economically viable to pool it by setting up new pipelines. Coastal shipping seems possible, but shall add cost to landing price – as calculated in Appendix G
- Following facts add to Industry's challenges:
  - Cost of capital and the duties in India are among the highest in surrounding nations in the ME and SEA
  - High capital cost of setting up crackers – around ₹18,800 Crore – need investment partners, which shall require forming joint ventures, and hence shall bring in related intricacies
  - Higher import duty on naphtha increases its price as feedstock for making commodity products, and thus adversely impact the commercial viability of cracker
  - Scope for improvement remains in enabling infrastructure and implementation support without which projects could get delayed adding to the capital costs; absence of common utilities tend to increase the operations cost
- High level review of small capacity crackers operating globally revealed that the scales are no more viable, thus confirming minimum economic capacity of 1 MMT of ethylene
- Eventually, it is noted that there is a need to explore the options for improving the operating margins in due discussion with the refiners. The opinion of refiners on materialising opportunities, and expectations in the form of fiscal, regulatory, and infrastructure facilitations could be invited

The situation finally demands concessions to live up to the requirements under the 'Make-in-India' policy, but there also has to be a socio-economic rationale supporting it.

Eventually, preliminary response from the refiners was not in support of setting up a new cracker under the present circumstances. The analogy got further supported when economic analysis was carried out.

7.4 Recommendations – Way forward

There is a need to explore the options for improving the base case scenario in discussion with the Industry. Industry's opinion on materialising opportunities, and expectations in the form of fiscal, regulatory, and infrastructure facilitations can be invited.

Collective efforts shall eventually support the 'Make in India' policy.

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A. Crude Oil – Occurrence & Processing

A.1 Crude Oil

Petroleum or crude oil is a naturally occurring mixture of hydrocarbons, generally in liquid state, which may also include compounds of sulphur, nitrogen, oxygen, water and other elements (ASTM D-4175). It contains 84%-87% carbon and 11%-14% hydrogen, 0%-3% sulphur and nearly 0.5% traces of other elements. The hydrocarbon components in crude oil are tabulated below:

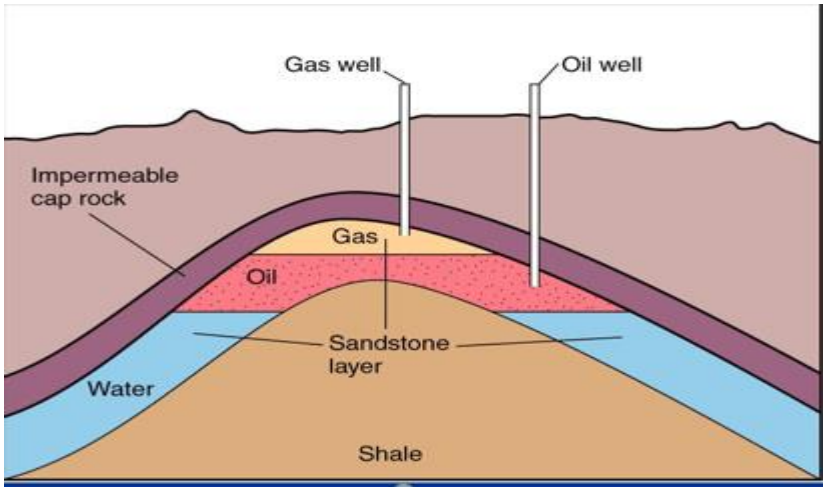
Table 25: Components of Crude Oil

Type of Hydrocarbons	Characteristic	Chemical Formula	Remarks
Alkanes / Paraffins	Straight chain hydrocarbons, all single bonds	C_nH_{2n+2}	Methane (CH_4), Ethane (C_2H_6), Propane (C_3H_8), Butane (C_4H_{10}) etc
Iso Paraffins	Branched chain hydrocarbons	C_nH_{2n+2}	Iso-butane, Iso-pentane
Alkenes / Olefins	Straight chain hydrocarbons with one double bond	C_nH_{2n}	Ethylene (C_2H_4), Propylene (C_3H_6), Butene (C_4H_8)
Naphthenes	Cyclic hydrocarbons with 5 or 6 carbon atoms, all single bonds	$C_nH_{2n+2-2R_n}$	Includes cyclopentane, cyclohexane etc Rn is number of napthenic rings
Aromatic	6 hydrocarbons, with double bonds	-	Benzene (C_6H_6), Toluene (C_7H_9), Xylene etc

Source: Compiled from NPTEL Courses coordinated by IITs

Petroleum was formed by fossilization of organisms buried under soil and rocks for millions of years, which got converted to fatty liquids and solids. It occurs as a separable mixture of natural gas, oil and water trapped between sandstone i.e. permeable rock and impermeable rock acting as cap. Water being heavier than oil, accumulates at the bottom of the deposit, whereas gas – being lightest – remains on top. Depth of the deposit varies from 3500 feet to 40,500 feet below ground level. Figure 18 shows cross section of geological strata containing petroleum fractions.

Figure 18: Geological Strata – Oil Well



Source: Compiled from NPTEL Courses coordinated by IITs

Crude oil is classified as light, medium and heavy by its specific gravity and as sweet, medium sour and sour based on its sulphur content. Table 25 shows the classification matrix for crude oil. The specific gravities are classified based on the scale stipulated by American Petroleum Institute (API)

Table 26: Crude Oil Classification Matrix

Type	Specific Gravity(g/cm^3)	API	Sulphur %
Light Sweet	< 0.85	30-40	< 0.5%
Light Sour	0.85 – 0.89	30-40	0.5 – 1.5%
Heavy Sour	0.89 – 1.0	15-30	1.5 – 3%
Extra Heavy	>1.0	< 15	> 3%

Source: Compiled from NPTEL Courses coordinated by IITs

Crude oil is processed in atmospheric and then in vacuum distillation columns to separate various fractions as per their boiling points. Physical & chemical properties of various fractions are tabulated below:

Table 27: Properties of Petroleum Fractions

Distillate/ Fraction	No of C atoms	IBP (°C)	FBP (°C)	Pour Point(°C)	Freezing Point(°C)	Specific Gravity @15°C (Kg/m^3)	Flash Point (°C)
Light Fractions							
LPG#	3 to 4	-45	-22	-	-	0.543	-
Light Naphtha	5 to 12	32	180	-70	-75	700-770	-21
Motor Spirit/Heavy Naphtha	6 to 12	82	180	-70	-90	720-775	-38 to -42
Benzene	6	80	-	6-8	-	876	-12
Toluene	7	110	-	-	-95	867-875	4
Medium Fractions							
superior kerosene oil (SKO), Aviation turbine fuel (ATF)	13-18	193	271	6-12	-47	790-820	35
High speed diesel (HSD) & light diesel oil (LDO)	13-20	215	321	12-18	-	820-845	32
Heavy Fractions							
Furnace oil (FO)	>20	321	427	<3	-	~900	66
Bitumen	>30	343	620	-	-	1800-2500	175
Raw or crude petroleum coke	>60	>600	-	-	-	1200-1500	-
Paraffin wax	17-20						

Source: Product Specification Catalogues of Oil Corporations

LPG, mixture of propane and butane, is stored in Horton spheres under liquefied condition. It is distributed through for household use through domestic cylinders with pressure less than its vapour pressure at storage temperature – 9 Kg/Sq.cm at 38°C.

Simplified process flow diagram of the atmospheric and vacuum distillation units is shown in Figure 2 in Chapter 2.

A.2 Specification of Naphtha

Table 28: Specifications of Naphtha by its type

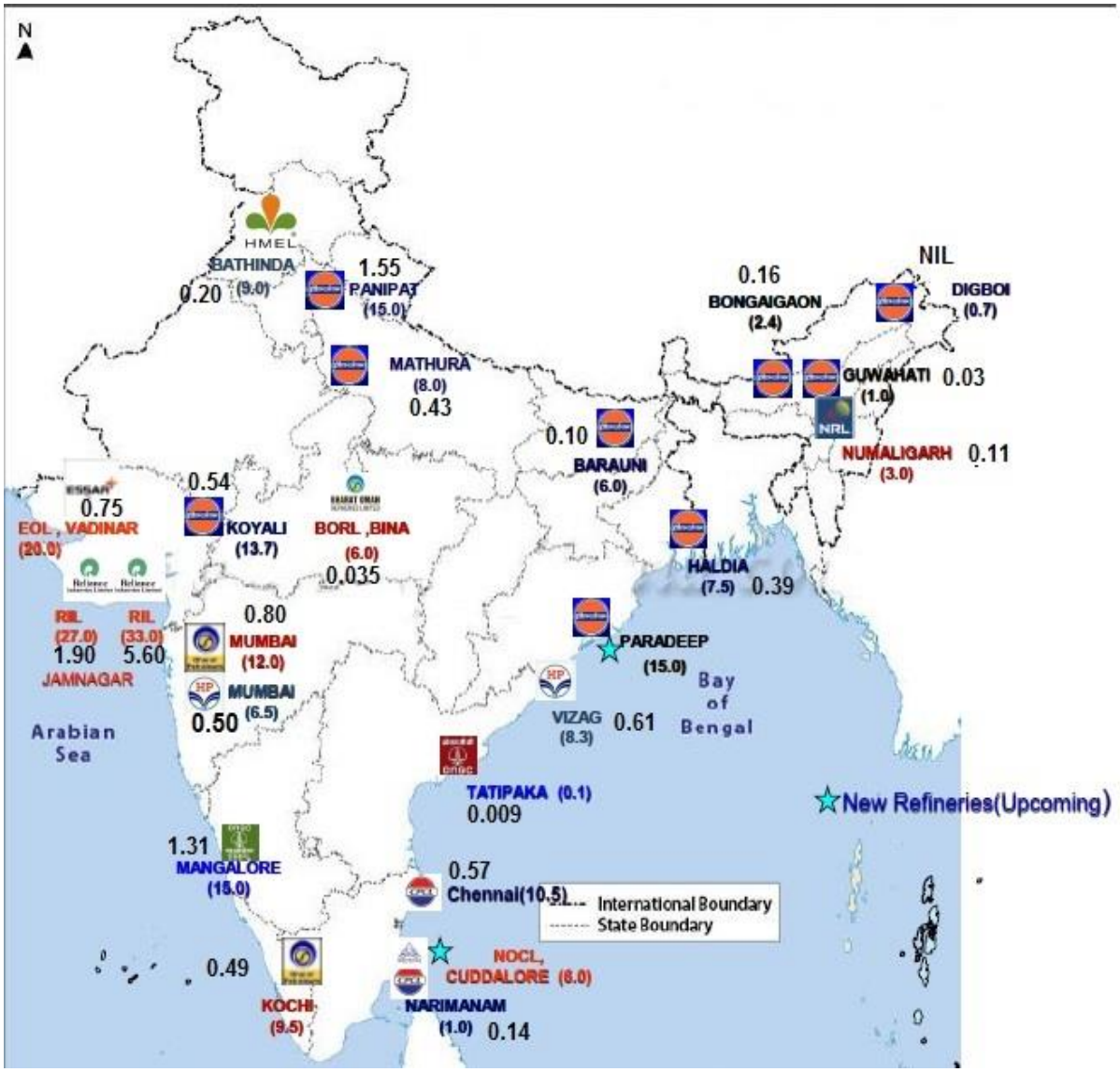
Parameter	Unit	LN – Petrochemicals	LN – Normal	HN
IBP	^{o}C	Min 30	Min 34	Min 35
FBP	^{o}C	Max 180	Max 160	Max 180
Vapour Pressure at 38oC	Psi	Max 10	Max 10	Max 0.7
Aromatics	% Vol	NIL	Max 10	Min 12
Aromatics+ Naphthenes	% Vol	Not reported	Not reported	Min 34
Olefins	% Vol	Max 1	Max 1	Max 1
Paraffins	% Vol	Min 65	Not reported	Max 65
Sulphur Content	PPM	Max 0.05	Max 0.05	Max 0.05

Source: Product Specification Catalogues of Oil Corporations

B. Naphtha

B.1 Production by Location

Figure 19: Location of Refineries and production of Naphtha



Source: Compiled by MM

B.2 Refining Capacity & Expansion Plan

Table 29: Refinery Installed Capacities and Expansion Plans (MMT)

Company & Refinery	Existing Capacity	Capacity After Expansion
IOCL-KOYALI, GUJARAT	13.70	18.00
IOCL-MATHURA, UTTAR PRADESH	8.00	9.20
IOCL-PANIPAT, HARYANA	15.00	20.20
IOCL-HALDIA, WEST BENGAL	7.50	8.00
IOCL-BARAUNI,BIHAR	6.00	7.00
IOCL-GUWAHATI,ASSAM	1.00	1.00
IOCL-DIGBOI,ASSAM	0.65	0.65
IOCL-BONGAIGAON,ASSAM	2.35	2.70
IOCL- Paradip	15.00	15.00
IOCL TOTAL	69.20	81.75
HPCL & Affiliates		
HPCL-MUMBAI,MAHARASHTRA	6.50	9.50
HPCL-VIZAG,ANDHRA PRADESH	8.30	15.00
HMEL-GGSR, BATHINDA, PUNJAB	9.00	11.25
HPCL Badmer, Rajasthan	-	9.00
HPCL-TOTAL	23.80	44.75
BPCL & Affiliates		
BPCL-MUMBAI, MAHARASHTRA	12.00	15.00
BPCL-KOCHI,KERALA	9.50	15.50
BPCL- BORL-BINA	6.00	15.50
BPCL-TOTAL	27.50	46.00
Numaligarh Refinery td.(NRL)- Assam	3.00	3.00
CPCL		
CPCL-MANALI, TAMILNADU	10.50	11.00
CPCL-NARIMANAM,TAMILNADU	1.00	1.00
CPCL-TOTAL	11.50	12.00
ONGC		
ONGC-TATIPAKA,ANDHRA PRADESH	0.066	0.066
MRPL-MANGALORE,KARNATAKA	15.00	15.00
ONGC TOTAL	15.066	15.066
RIL		
RIL,JAMNAGAR,GUJARAT	33.00	33.00
RIL-(SEZ), JAMNAGAR,GUJARAT	27.00	27.00
RIL TOTAL*	60.00	60.00
ESSAR OIL LTD.,VADINAR,GUJARAT	20.00	20.00
NOCL, Cuddalore	-	6.00
TOTAL – Refineries #	230.066	288.566

Source: IOCL, EIA Reports, Environmental Clearances to Companies Notes: * - RIL in June 2013 had prepared EC-TOR for installing 5th train of crude distillation unit with capacity of 20 MMTPA. # - New capacity does not include 15 MMT Kakinada Refinery and HPCL's 15 MMT Greenfield refinery at AP PCPIR as the projects are still under evaluation/ feasibility stage

B.3 Naphtha Production by Refineries

Table 30: Production of Naphtha by Refineries (1000' MT)

	Refining Throughput			Naphtha Production		
Refinery	2012-13	2013-14	2014-15	2012-13	2013-14	2014-15
Indian Oil Corporation Ltd.(IOCL)						
IOCL-KOYALI, GUJARAT	13155	12960	13285	785	721	542.3
IOCL-MATHURA, UTTAR PRADESH	8561	6641	8515	636	503	436.6
IOCL-PANIPAT, HARYANA	15126	15098	14191	1196	1351	1554.2
IOCL-HALDIA, WEST BENGAL	7490	7952	7650	545	578	391.1
IOCL-BARAUNI,BIHAR	6345	6478	5944	237	125	102
IOCL-GUWAHATI,ASSAM	956	1019	1006	27	31	27.5
IOCL-DIGBOI,ASSAM	660	651	591	0	0	0
IOCL-BONGAIGAON,ASSAM	2356	2328	2403	124	134	155.8
IOCL TOTAL	54650	53126	53586	3550	3443	3209.5
Hindustan Petroleum Corporation Ltd						
HPCL-MUMBAI,MAHARASHTRA	7748	7737	7412	409	433	499.4
HPCL-VIZAG,,ANDHRA PRADESH	8011	7776	8767	251	331	609.8
HMEL-GGSR, BATHINDA, PUNJAB	4904	9272	7344	323	425	194.3
HPCL-TOTAL	20663	24784	23522	983	1189	1303.5
Bharat Petroleum Corporation Ltd						
BPCL-MUMBAI, MAHARASHTRA	12736	12684	12821	1586	1511	798.9
BPCL-KOCHI,KERALA	10105	10285	10356	675	666	491.9
BPCL- BORL-BINA	5732	5450	6209	94	99	35.4
BPCL-TOTAL	28573	28419	29385	2355	2276	1326.2
Numaligarh Refinery Ltd.(NRL)-Numaligarh, Assam	2478	2613	2777	108	161	111.4
Chennai Petroleum Corporation Ltd						
CPCL-MANALI, TAMILNADU	9098	10068	10247	483	640	568.2
CPCL-NARIMANAM,TAMILNADU	640	559	531	261	213	136.8
CPCL-TOTAL	9738	10627	10779	744	853	705
Oil & Natural Gas Corporation Ltd						
ONGC-TATIPAKA,ANDHRA PRADESH	57	65	51	7	10	9.3
MRPL-MANGALORE,KARNATAKA	14415	14589	14632	1482	1350	1315.1
ONGC TOTAL	14471	14654	14683	1489	1360	1324.4
Reliance Industries Ltd. (RIL)						
RIL,JAMNAGAR,GUJARAT	32613	30305	30867	5662	5112	5599.3
RIL-(SEZ), JAMNAGAR,GUJARAT	35891	37722	37174	1631	1898	1892.9
RIL TOTAL	68505	68027	68041	7293	7010	7492
ESSAR OIL LTD.,VADINAR,GUJARAT	19769	20202	20491	837	798	748.9
TOTAL – Refineries	218847	222453	223263	17359	17090	16221

Source: PPAC

Naphtha Production by fractionators is set is below –

Table 31: Naphtha Production by Fractionators (1000 MT)

Company	2012-13	2013-14	2014-15	2015-16
GAIL, Araiya	137	120	98	100
ONGC, Hazira & Uran	1527	1348	1146	1010
Total	**1664**	**1468**	**1244**	**1110**

Source: PPAC

B.4 Naphtha Consumption

Table 32: Trend of Consumption of Naphtha (MMT)

	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Petrochemical Sector	6.05	5.89	6.97	7.50	8.14	9.41	9.62	9.52	10.35
Dedicated imports*	4.42	4.31	1.12	1.71	1.77	1.43	0.86	0.71	2.51
Fertilizer Sector	1.69	1.80	0.84	0.89	0.96	0.90	0.52	0.30	0.32
Power	0.75	1.15	0.64	0.42	0.19	0.34	0.22	0.20	0.05
Steel	0.05	0.07	0.00	0.01	0.01	-	-	-	-
Other Industries#	0.33	0.69	0.56	0.15	0.16	0.20	0.24	0.20	0.03
Total	13.29	13.91	10.13	10.68	11.23	12.28	11.46	10.93	13.27

Source: PPAC
* Mostly by Petrochemicals sector # includes Ceramics, Paints etc.
P: Projected Values

C. Product Slate-Cracker & Aromatic Complex

C.1 Product Slate of Existing Petrochemical Complex

Table 33: Product Slate of Existing Petrochemical Complexes (MMT)

	Naphtha Based				Gas Based			
Product	**IOC, Panipat**	**RIL Hazira**	**RIL Vadodara**	**HPL, Haldia**	**GAIL, Auraiya**	**RIL Dahej (Gandhar)**	**RIL Nagothane**	**Total**
Olefins								
Ethylene	0.857	0.900	0.130	0.700	0.450	0.500	0.400	3.937
Propylene	0.650	0.438	0.100	0.320	0.035	0.160	0.90	1.793
Butadiene	0.130	0.140	0.037	0.101			0.015	0.423
Butene		0.035						0.035
Benzene	0.130	0.282	0.023	0.132				0.567
Toluene		0.236						0.236
Xylene/Mixed Xylene		0.198						0.198
Ethylene Derivatives								
LDPE							0.205	0.205
HDPE - Dedicated	0.300							0.300
HDPE/ LLDPE Swing	0.350	0.500	0.080	0.700		0.220	0.300	2.600
Ethylene Oxide		0.055	0.020			0.015	0.060	0.165
EDC						0.500		0.500
VCM						0.315		0.915
PVC		0.350	0.055			0.315		1.390
MEG	0.300	0.600				0.309	0.070	1.279
Propylene Derivatives								
Polypropylene	0.650	0.500	0.055	0.320	0.450	0.150	0.060	1.735

	Naphtha Based				Gas Based			
Olefins								
Ethylene	0.100	0.180	1.100	0.220	0.450	1.400	3.450	7.387
Propylene	0.062	0.040	0.400	0.060	0.035	0.759	1.356	3.149
Butadiene	0.070		0.115				0.185	0.648
Butene	0.045						0.045	0.080
Benzene			0.150				0.150	0.720
Toluene								0.236
Xylene/Mixed Xylene								0.198
Ethylene Derivatives								
LDPE						0.190	0.190	0.395
HDPE - Dedicated			0.340				0.340	0.640
HDPE/ LLDPE Swing	0.050	0.050	0.720	0.220	0.450	0.624	2.114	4.714
Ethylene Oxide	0.065	0.010					0.075	0.240
EDC								0.500
VCM								0.915
PVC	0.050						0.050	1.440
MEG	0.120	0.055				0.720	0.895	2.174
Propylene Derivatives								
Polypropylene			0.340	0.060			0.400	2.135

Source: Compiled from Company's Websites, Annual Reports, Environment Clearances and Environment Impact Assessment Reports
Note # - RIL also has commitments for further expansion of the J-3 Petrochemical Complex based on off gases. Phase II, to be undertaken post completing Phase I, will comprise of 2.050 MMT ethylene, 0.913 MMT propylene, 1.466 MMT MEG, 0.590 MMT LDPE, and 1.478 MMT swing capacity for LLDPE/HDPE

C.2 Capacity Expansion in Crackers

Table 34: Capacity Expansions in Crackers – Both Debottlenecking & New Projects (MMT)

	RIL Hazira (Converting to Dual Feed)	RIL Nagothane (Gas based)	OPAL, Dahej (2016-17)	BCPL, Assam** (2016-17)	GAIL, Auraiya (2016-17)	RIL Jamnagar (J-3) Refinery off gas Phase I (2016-17)	Total	Capacity After Expansion
Olefins								
Ethylene	0.100	0.180	1.100	0.220	0.450	1.400	**3.450**	**7.387**
Propylene	0.062	0.040	0.400	0.060	0.035	0.759	**1.356**	**3.149**
Butadiene	0.070		0.115				**0.185**	**0.648**
Butene	0.045						**0.045**	**0.080**
Benzene			0.150				**0.150**	**0.720**
Toluene								**0.236**
Xylene/Mixed Xylene								**0.198**
Ethylene Derivatives								
LDPE						0.190	**0.190**	**0.395**
HDPE - Dedicated			0.340				**0.340**	**0.640**
HDPE/ LLDPE Swing	0.050	0.050	0.720	0.220	0.450	0.624	**2.114**	**4.714**
Ethylene Oxide	0.065	0.010					**0.075**	**0.240**
EDC								**0.500**
VCM								**0.915**
PVC	0.050						**0.050**	**1.440**
MEG	0.120	0.055				0.720	**0.895**	**2.174**
Propylene Derivatives								
Polypropylene			0.340	0.060			**0.400**	**2.135**

Source: Compiled from Company's Websites, Annual Reports, Environment Clearances and Environment Impact Assessment Reports
- RIL also has commitments for further expansion of the J-3 Petrochemical Complex based on off gases. Phase II, to be undertaken post completing Phase I, will comprise of 2.050 MMT ethylene, 0.913 MMT propylene, 1.466 MMT MEG, 0.590 MMT LDPE, and 1.478 MMT swing capacity for LLDPE/HDPE
** - commissioned in February 2016

D. Petrochemicals

D.1.1 Olefins

Propylene and butadiene are the other two building blocks in the olefins' family.

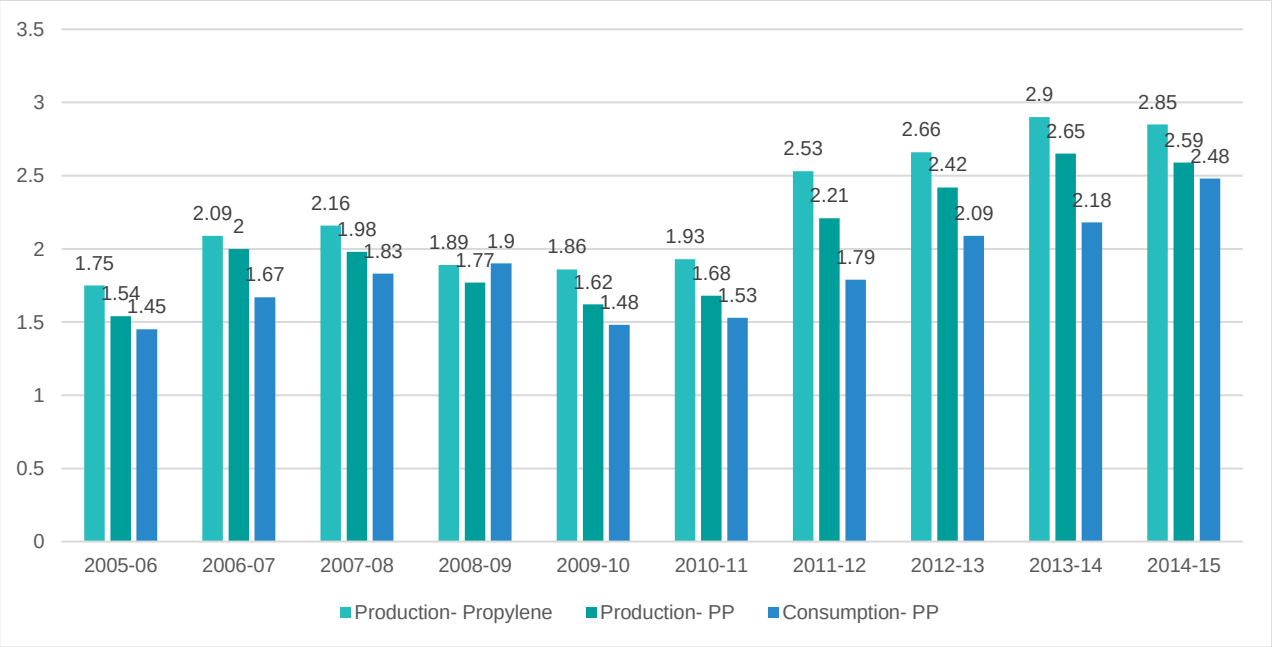
Propylene

Like ethylene, propylene's value chain too entails diverse usage into polymers (polypropylene) and numerous chemicals including acrylic acid, butyl acrylate, epichlorohydrin (goes in making epoxy resin), propylene glycol, isopropyl alcohol, propylene oxide, phenol and more. The chemicals are used for making paints, adhesives speciality fibres and speciality plastics.

The chemical is produced in refineries as well as in crackers. However, in the absence of sufficient capacities in the domestic market for making few prominent derivatives, potential of the versatile chemical is not being tapped. Domestic demand of these chemicals is being met through imports. Almost 95% of the propylene produced in the Country is converted to polypropylene, which is now oversupplied.

Nevertheless, as discussed earlier, IOC and BPCL have plans of setting up petrochemical complexes based on propylene, and so the chemical is expected to have better future. D-S propylene and polypropylene is provided below.

Figure 20: Production of Propylene & Polypropylene (MMT)



Source: Chemicals & Petrochemicals Statistics at a Glance 2015

In 2015-16, propylene production stood at 2.85 MMT, while that of PP was 2.59 MMT.

Trade of polypropylene is provided in Figure 21, India is a net exporter of polypropylene. Propylene, being a gas, is not traded to considerable extent.

Figure 21: Trade of Polypropylene (MMT)



Source: DGCIS

Apart from the capacities shown under crackers, following refineries too produce, or have plans to produce propylene.

Table 35: Propylene Capacities in Refineries (MMT)

Refinery	Existing Capacity	Expansion Plan
RIL, Jamnagar	1.940	
IOC Mathura	0.024	
IOC Panipat	0.024	
HPCL, Vishakhapatnam	0.065	
HMEL, Bhatinda	0.450	
MRPL	0.450	
BORL, Bina	0.130	
CPCPL (Chennai)	0.030	
BPCL, Mumbai		0.255
BPCL, Kochi	-	0.500
IOC Paradip	-	0.690
Total	3.113	1.355

Source: Company Websites

Almost all the existing capacities have associated polypropylene units.

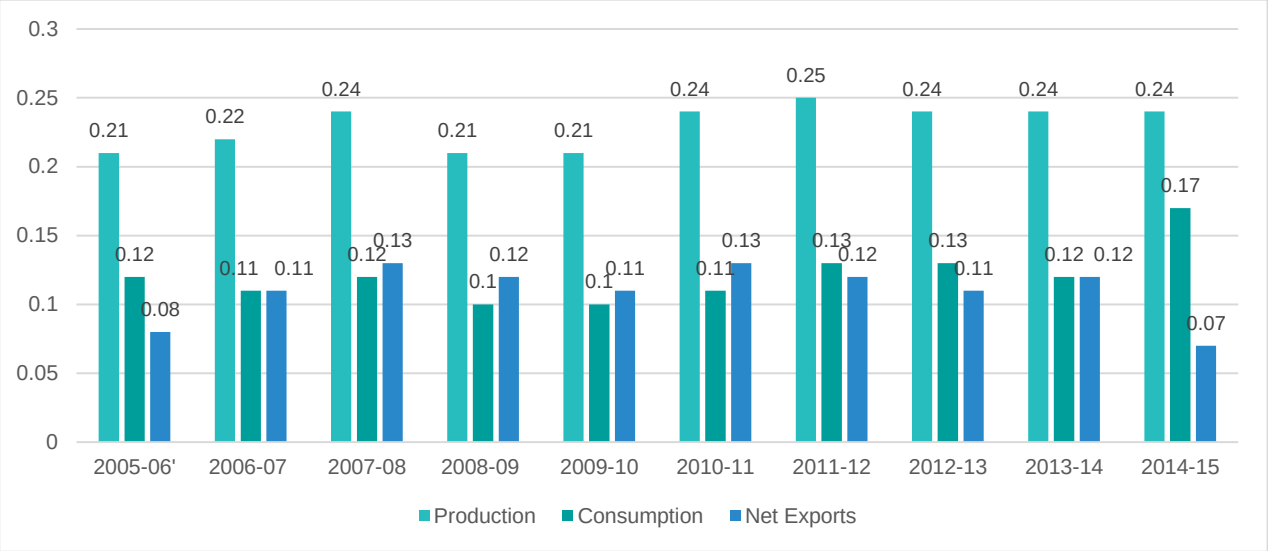
Butadiene

Butadiene, also a gas, is produced in naphtha crackers, by fractionating C-4 fractions in the cracked naphtha. It is largely used in making synthetic rubber – poly-butadiene, styrene-butadiene and nitrile-butadiene.

Present and the upcoming capacities of butadiene have been provided under Appendix C, Table 32 and 33.

Production, imports, exports and consumption of butadiene is shown below. India is a net exporter of butadiene. Butadiene, though a gas, has higher stability than ethylene and propylene.

Figure 22: Production & Consumption of Butadiene (MMT)



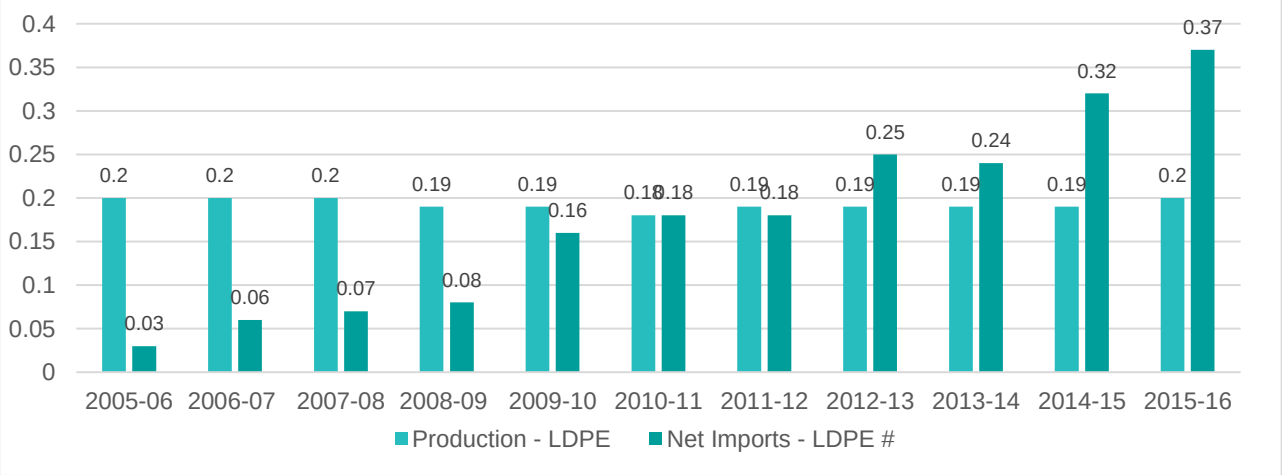
Source: Chemicals & Petrochemicals Statistics at a Glance 2015

D.1.2 Ethylene Based Polymers

LDPE and LLDPE are the commodity polyethylene based plastics used in making packaging and laminating films and lining material. HDPE, a high density polyethylene is used in making pipes, heavy duty liners, and components of hard plastic. The products are essentially produced in a petrochemical complex associated with cracker. Present installed capacity and expansion plans for LDPE, LLDPE and HDPE is discussed in Appendix C, under Table 32 and 33. Details of production, import, export and consumption of same is set out below –

LDPE

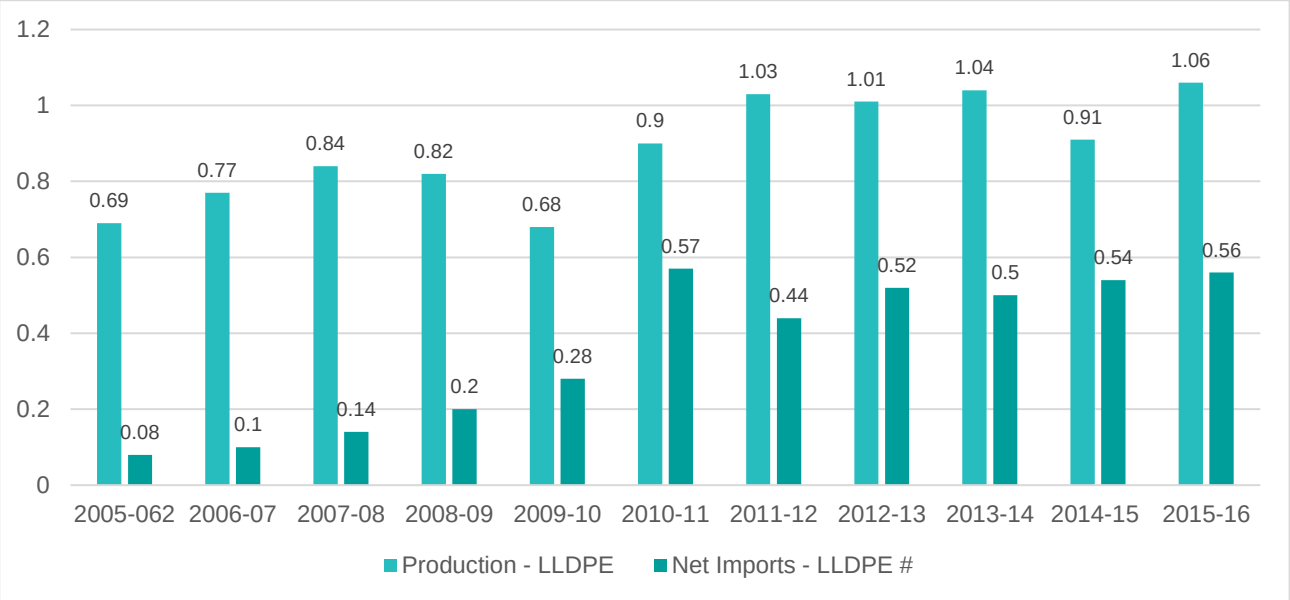
Figure 23: Production and Net Imports of LDPE (MMT)



Source: Chemicals & Petrochemicals Statistics at a Glance 2014-15, DGCIS;
Note # - Exports of LDPE are less than 5% of imports

LLDPE

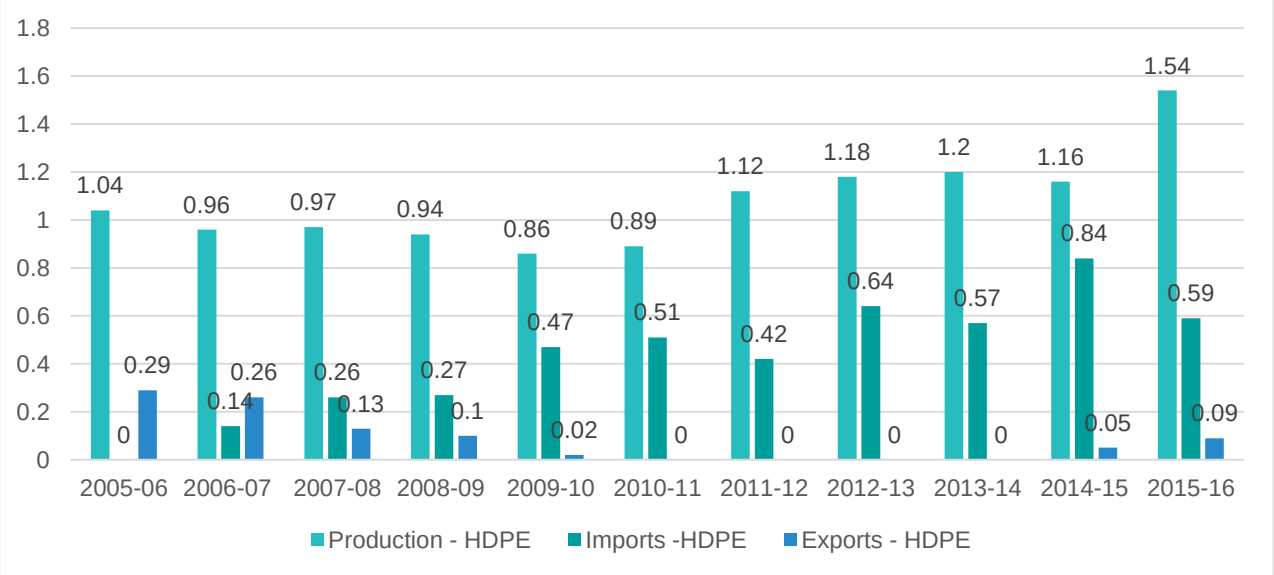
Figure 24: Production and Net Imports of LLDPE (MMT)



Source: Chemicals & Petrochemicals Statistics at a Glance 2015
- Exports of LLDPE are less than 5% of imports (in fact were NIL in the past two years)

HDPE

Figure 25: Production, Import & Export of HDPE



Source: Chemicals & Petrochemicals Statistics at a Glance 2015

It could be noted that exports of HDPE have declined, whereas imports have increased with increase in domestic demand

PVC

PVC is another commodity plastic produced from ethylene. It is the third most widely consumed plastic after polyethylene and polypropylene. It is made by polymerising vinyl chloride monomer (VCM); VCM is made by dehydration of ethylene dichloride[58] , which in turn is made by direct or indirect chlorination of ethylene.

Following are the major players into production of PVC in the Country

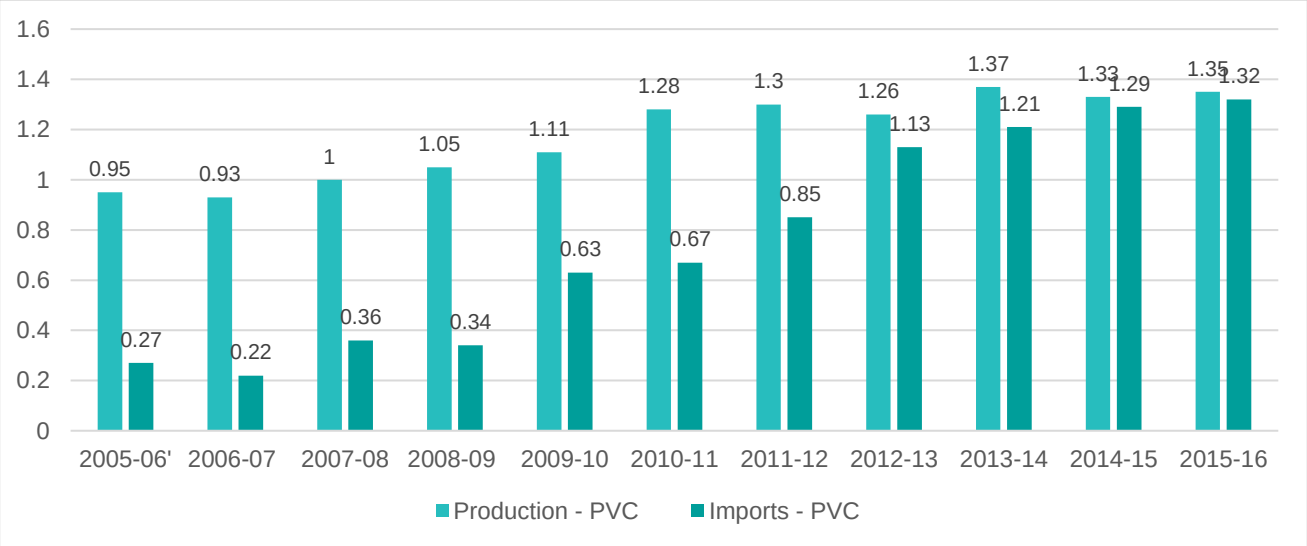
Table 36: PVC and Intermediate Production Capacity (MMT)

Company	Existing Capacity	Expansion
RIL, Hazira	0.500	0.050
RIL Vadodara	0.055	
RIL Dahej	0.315	
Finolex	0.260	
Sanmar, Chennai	0.250	
DCW	0.090	0.060*
Shriram Axiall (Compounding)	0.070	
Total	1.540	0.110

Source: CPMAI
* Company had plans of expanding the capacity to 0.15 MMT

Details of production and imports of PVC, VCM and EDC are set out below. Exports are not sufficient to be considered –

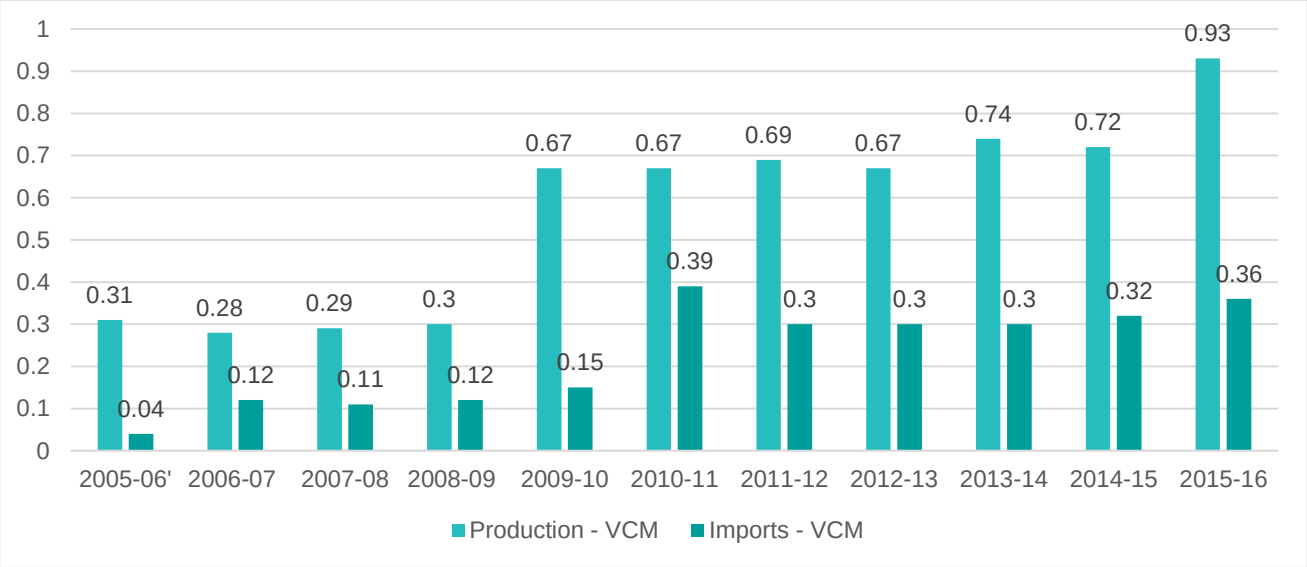
Figure 26: Production & Imports of PVC (MMT)



Source: Chemicals & Petrochemicals Statistics at a Glance 2015

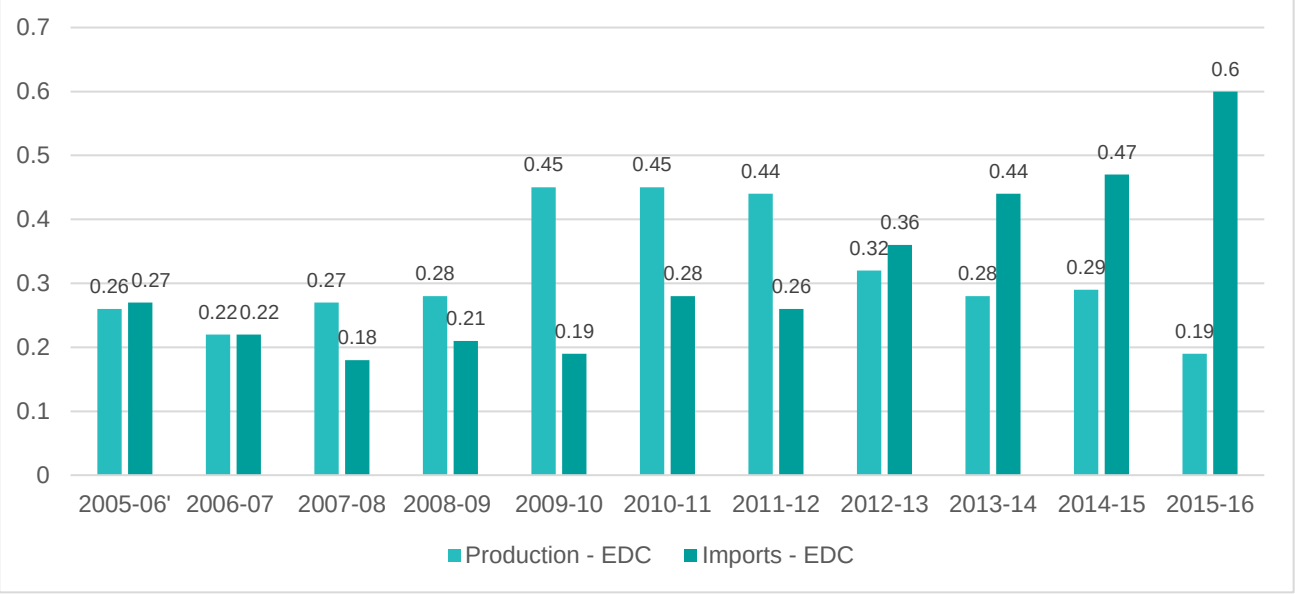
[58] VCM can also be prepared by chlorination of acetylene gas

Figure 27: Production & Imports of VCM (MMT)



Source: Chemicals & Petrochemicals Statistics at a Glance 2015

Figure 28: Production & Imports of EDC (MMT)



Source: Chemicals & Petrochemicals Statistics at a Glance 2015

As the Country doesn't export any of the products, consumptions is understood to be summation of production and imports. Going backwards from PVC, it is noted that –

- PVC supply is short of demand by 1.42 MMT. Thus to restore supply, we need equivalent amount of VCM, and 0.71 MMT of ethylene

- There is short supply of around 0.3 MMT VCM and 0.44 MMT EDC, which shall require 0.15 MMT ethylene each
- Thus, the Country at present is short of 1.0 MMT ethylene required in PVC value chain

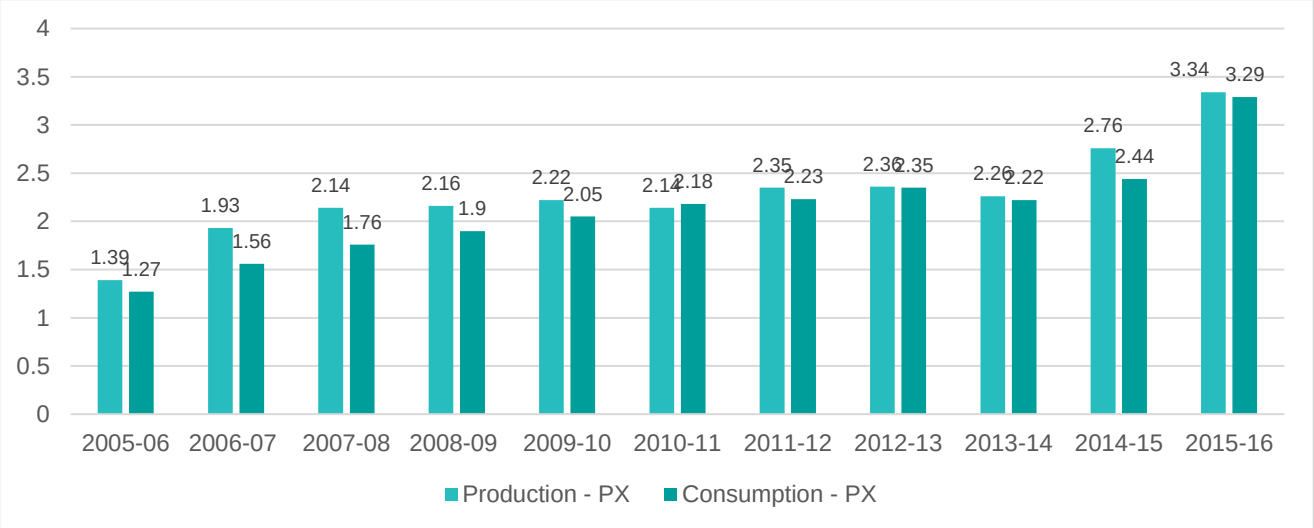
D.1.3 Aromatics

Para Xylene

Para xylene is produced by reforming heavy naphtha, when it is not routed to auto fuel pool. The product is a key component in manufacturing purified terephthalic acid (PTA), which is used in manufacturing polyester chips, and subsequently polyester yarn.

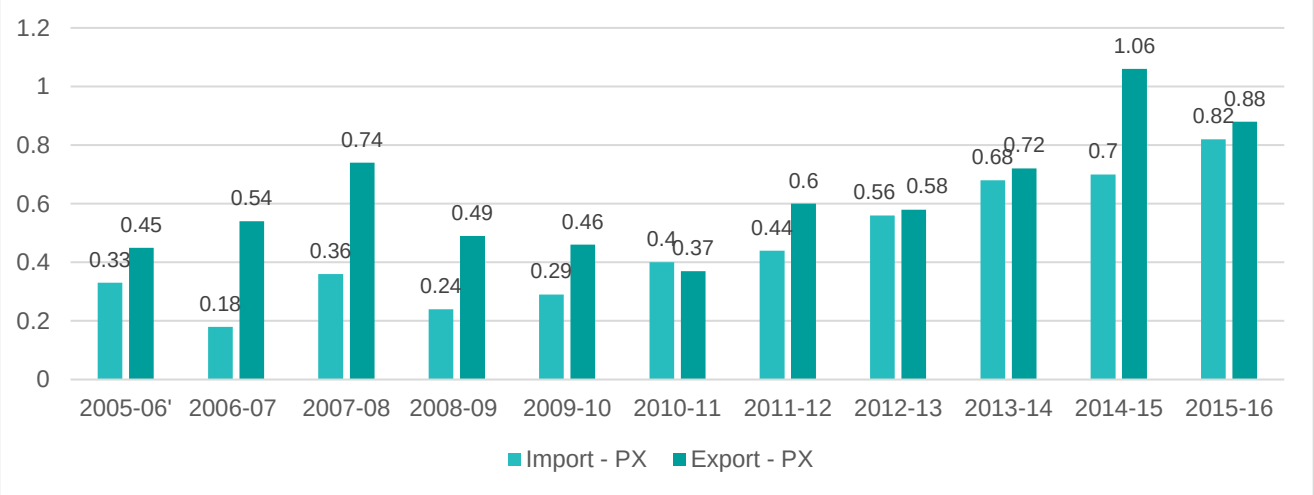
Trend of production, import, export and consumption of PX is set out below

Figure 29: Production & Consumption of Para-Xylene



Source: Chemicals & Petrochemicals Statistics at a Glance 2015

Figure 30: Import & Export of Para-Xylene



Source: Chemicals & Petrochemicals Statistics at a Glance 2015

Capacities of aromatic complexes, and expansion plans are given below –

Table 37: Aromatic Complexes: PX Capacity India (MMT)

Company	Existing PX	Expansion Plans
IOC, Panipat	0.360	-
RIL, Jamnagar	1.856	1.856
RIL Vadodara	0.486	-
OMPL, Mangalore	0.900	-
Total	3.602	1.856

Source: Company Websites

E. Prices

E.1 Naphtha

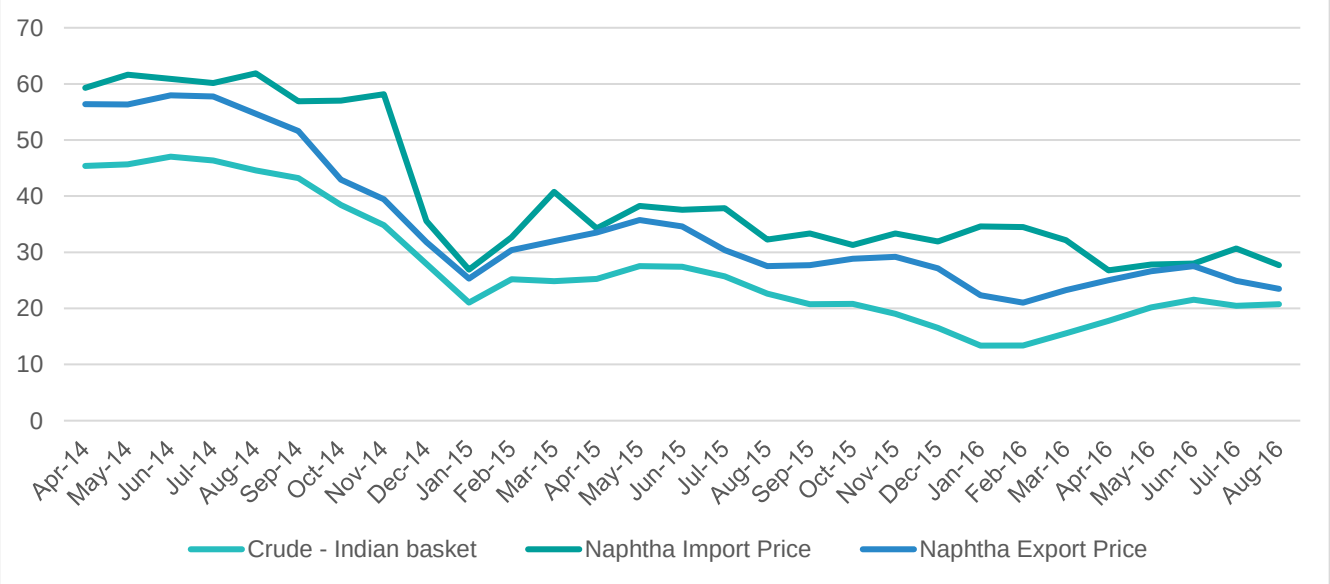
Crude oil prices play very important role in our economy as more than 70% of our requirements are dependent on imports. Any negative change directly impacts GDP and Index of Industrial Production (IIP) as the prices of not only refinery main stream products, but of naphtha and all its petrochemical derivations follow the trend.

Trend of import prices of crude oil, and that of import and export prices of naphtha since April 2014 is shown in Figure 31. It can be observed that –

- Naphtha prices have followed the trend of crude prices
- Export prices have always been lower than the import prices for our country

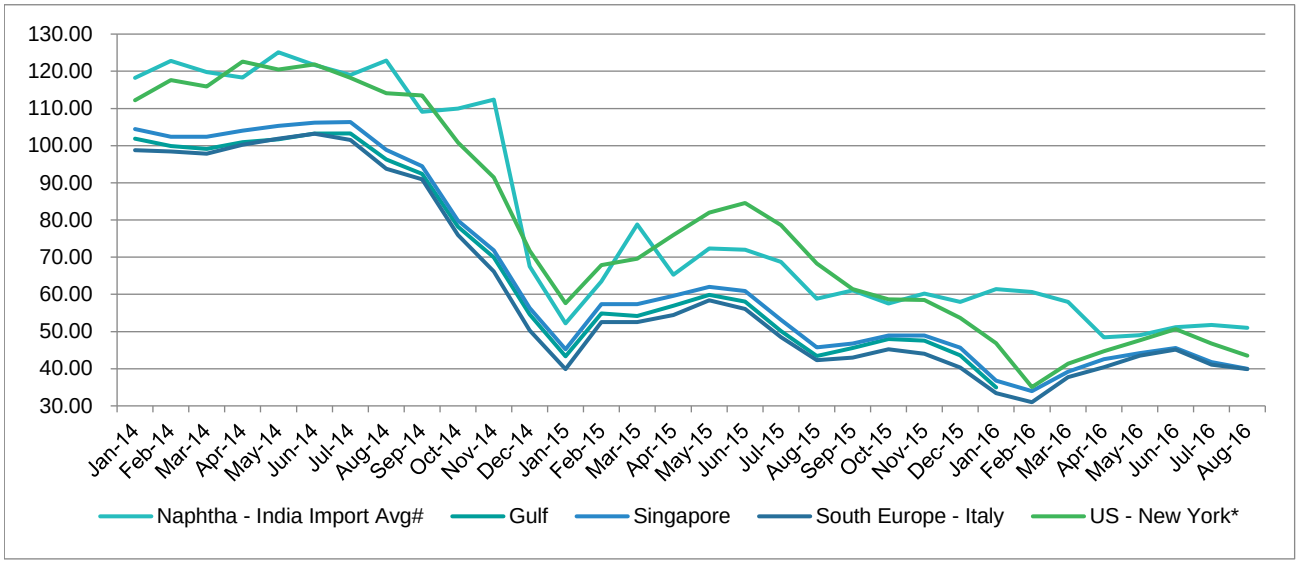
A comparison of naphtha prices across several regions from over the same period is provided in Figure 32. It appears that Indian prices have marginally deviated from the global price trend.

Figure 31: Price trend - Crude and Naphtha (₹/Kg)



Source: PPAC – Derived from Import/Export volumes and values

Figure 32: Comparison of FOB Naphtha Prices Across the Global market (USD/BBL)



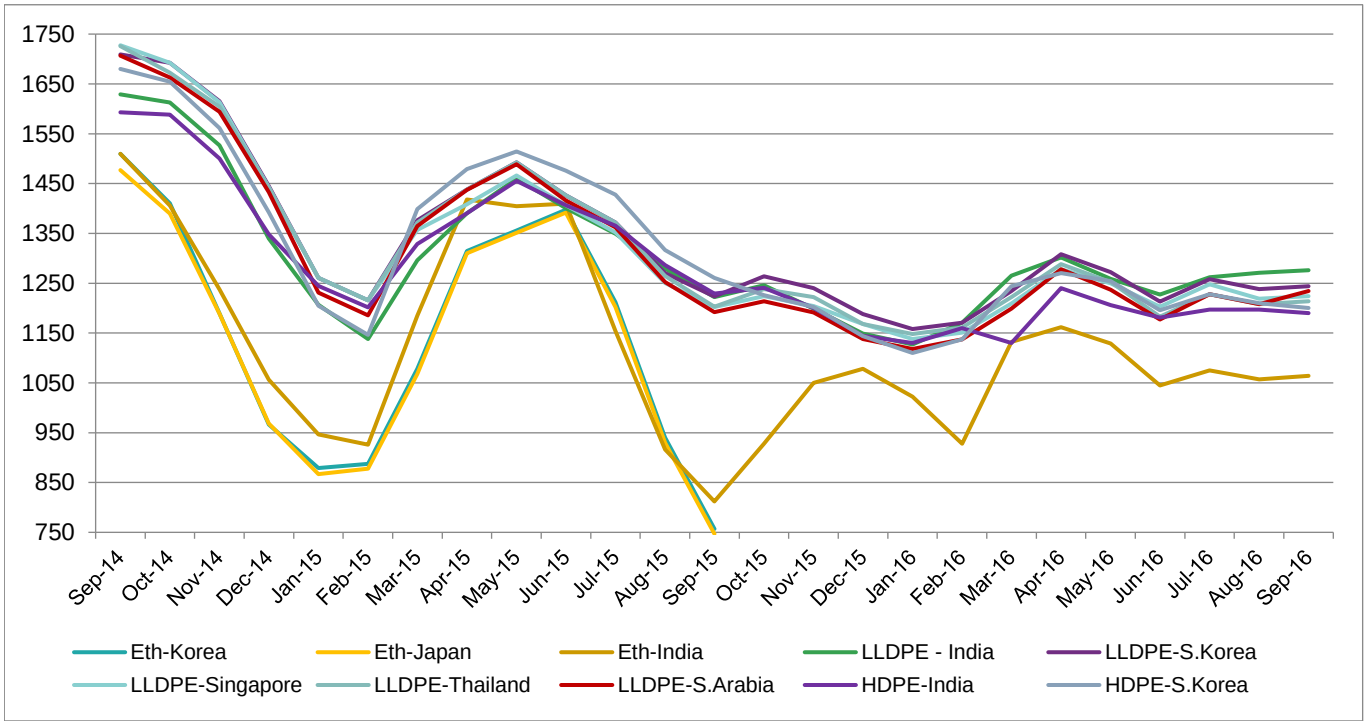
Source: Platts, OPEC Bulletins Notes ; # - India prices are CIF, but excluding custom duty; * - US prices include duties too

E.2 Petrochemical

Trend of global prices of ethylene and key derivatives is shown in Figure 33.

It is observed that prices of ethylene imported from Japan & South Korea have moved together, without making much of difference except for freight. Price of Indian LLDPE, even on CIF basis, is in the range of global prices. On the contrary, price of HDPE has been dearer that price of imported HDPE. Though fall in crude oil prices though has reflected on price of ethylene, it is yet to reflect in price of LLDPE.

Figure 33: Price Trend of Ethylene & LLDPE Export Prices (FOB for India, CFR for Global#) (US$/MT)



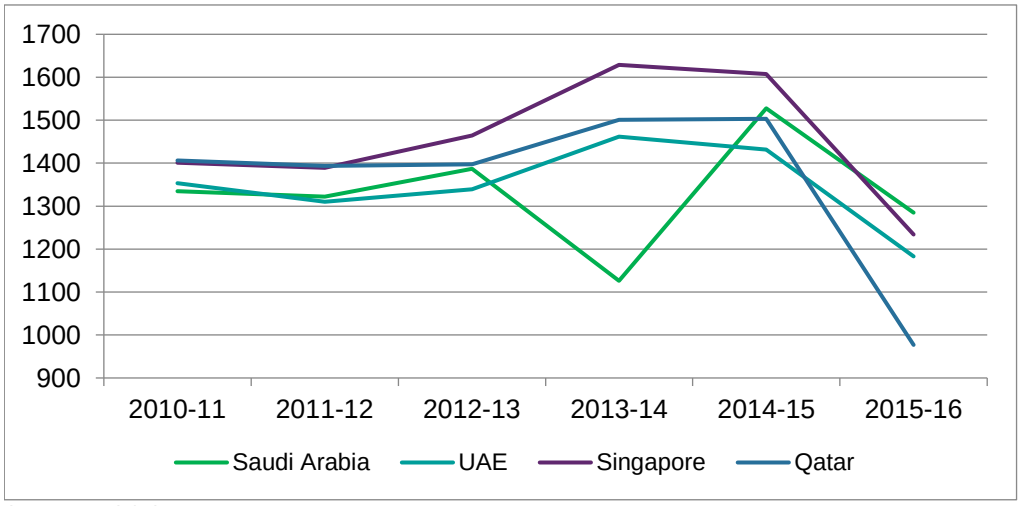
Source: Polymerupdates
As ethylene is not sold or exported by the domestic industry, domestic price is not available

The global prices, as per the source, are indicated as CIF import price at Nhava Sheva i.e. they include cost, insurance and freight till JNPT, Mumbai; whereas India's export price is on FOB basis. This indicates competitive position of other manufacturing countries over us.

E.3 Import Price of Polymers by Country of Origin

Figure 34 and 35 compares import prices of LLDPE and PVC by countries of origin.

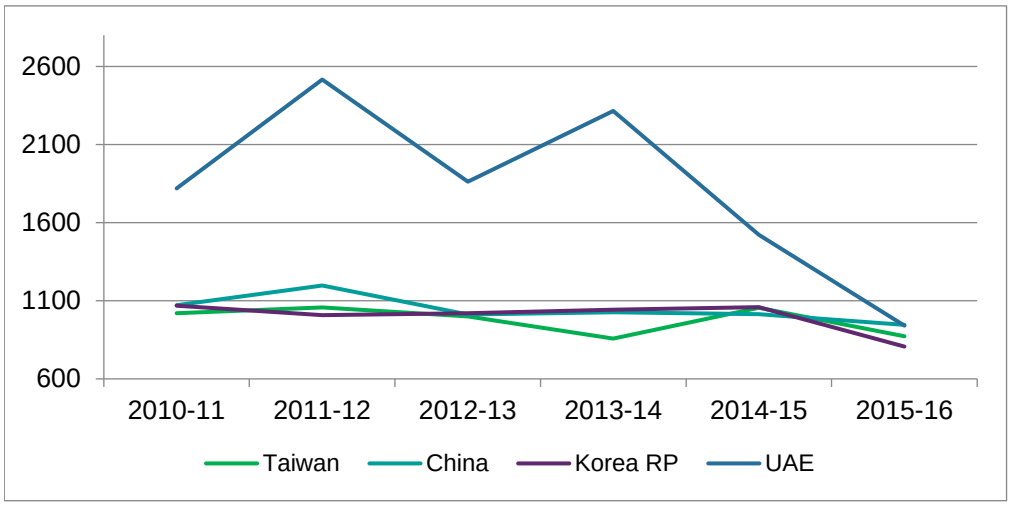
Figure 34: Annual Avg. Import Price of LLDPE by Countries of Origin (US$/MT)



Source: DGCIS

It can be noted that LLDPE imported from Middle East is economic than LLDPE imported from Singapore. This signifies lower cost of production of LDPE/LLDPE from gas as compared to naphtha. On the contrary, price of PVC imported from Middle East, is higher than that imported from Asian countries.

Figure 35: Annual Avg. Import Price of PVC by Countries of Origin (US$/MT)



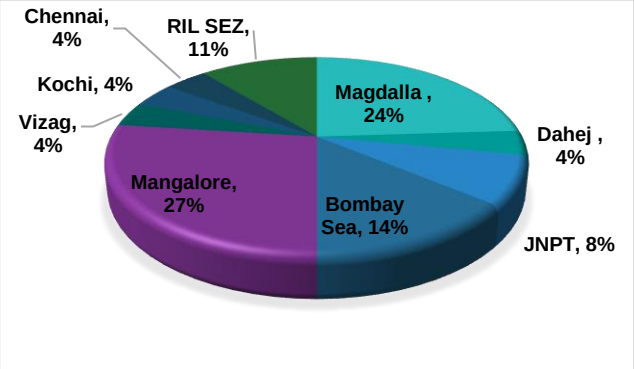
Source: DGCIS

F. Trade

F.1 Naphtha

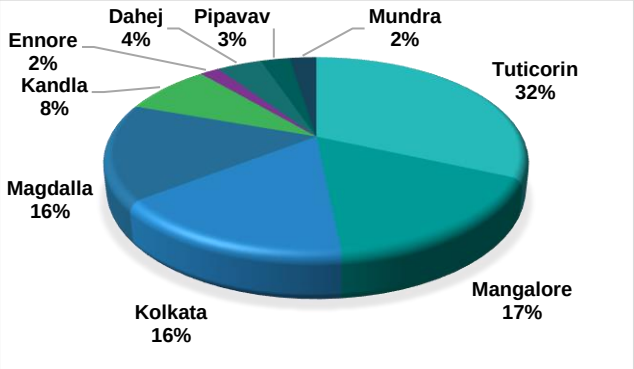
Figure 36 and 37 provide tentative break-up of the imports and exports of naphtha by ports in India.

Figure 36: Naphtha Exports by Port (2014-15)



Source: M/S SEAIR

Figure 37: : Naphtha Imports by Port (2014-15)



Source: M/S SEAIR

It is noted that –

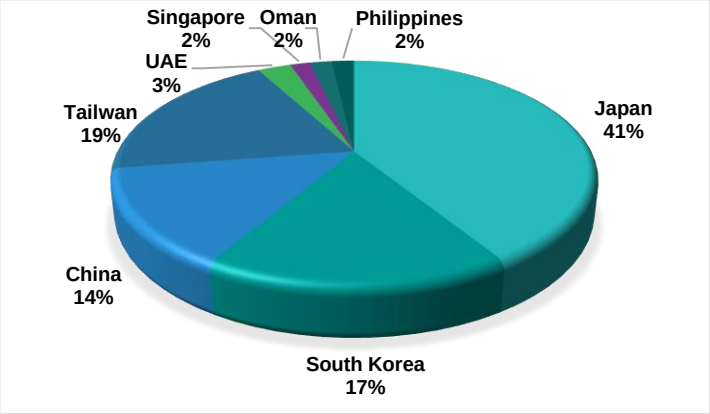
- ONGC, Hazira is exporting its production from Magdalla port. The export will be discontinued onwards of 2016-17 due to commissioning of downstream cracking capacity being developed by its subsidiary ONGC Petro additions Limited (OPaL) – a dual feed cracker in Dahej
- IOCL is exporting naphtha left with Koyali and Mathura refineries from Dahej
- BPCL, HPCL, and ONGC Uran field are exporting naphtha from Mumbai – Bombay Sea and JNPT
- Remaining exports are expected from
- Kochi – BPCL, Kochi
- Vishakhapatnam – HPCL
- Mangalore – MRPL
- Chennai – CPCL, and
- RIL SEZ, Sikka

Imports-

- RIL is importing from Magdalla (~100 KT) and Dahej (~30 KT), for its crackers
- HPL imports from Kolkata; however the imports have only been around 130 KT in 2014-15
- Imports from Mangalore and Tuticorin are by MCFL and SPIC respectively, who are importing most of their requirements
- Imports from Kandla and Mundra pertain to naphtha based special high boiling solvents not applicable for cracking or even any other requirements discussed in this paper

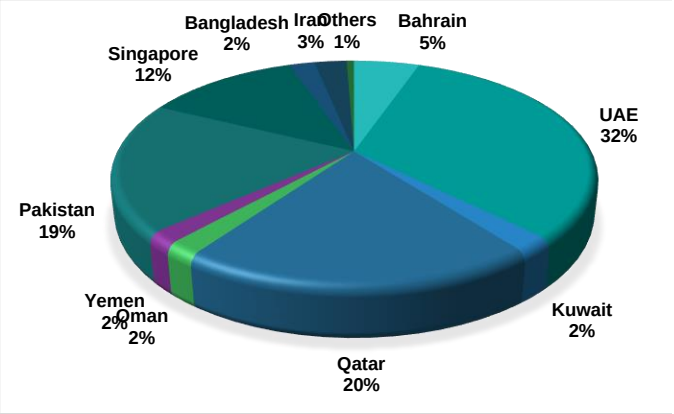
Scenario of exports has typically remained similar in 2015-16, but that of imports has drastically changed due to substantial imports of naphtha by HPL during the year. Out of 2.67 MMT naphtha imported during Apr 2015-Feb 2016, nearly 1.70-1.80 MMT has been imported at Kolkata sea by HPL. Out of rest, around 0.25 MMT has imported at Tuticorin and 0.10 MMT at Mangalore- both fertilizer use. Remaining has been imported through Mundra, Kandla, and other ports in Gujarat – except Dahej. Contrary to 2014-15, there have not been any imports through Dahej port this year.

Figure 38: Naphtha Export (%Vol) (2014-15)



Source: M/S SEAIR

Figure 39: Naphtha Import (%Vol) (2014-15)



Source: M/S SEAIR

Figure 38 and 39 provide break-up of imports and exports by foreign countries. It is noted that –

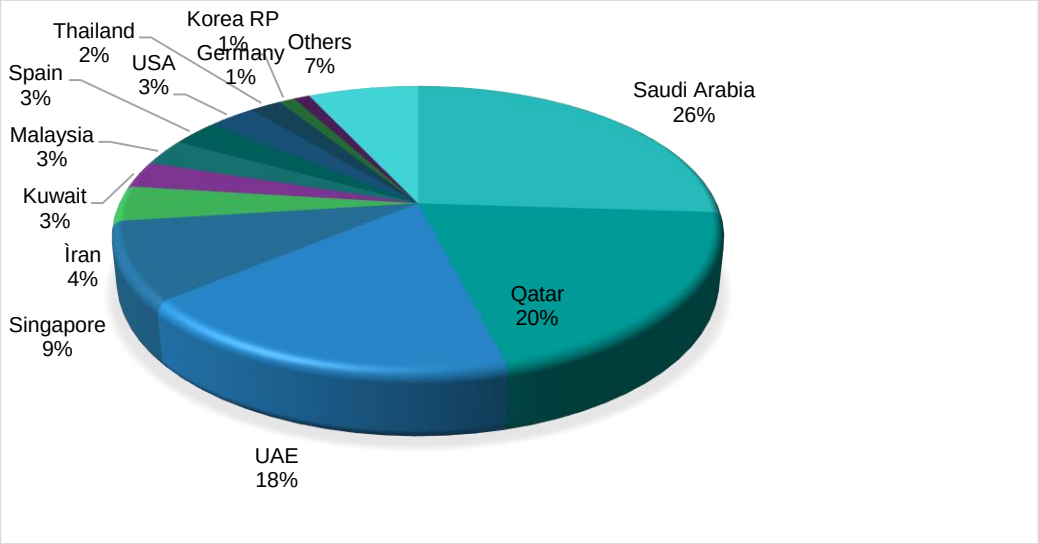
- 95% of country's exports are to crackers in Eastern Asian countries – especially to Japan, Taiwan and South Korea
- Imports of naphtha are mostly from Middle East and Pakistan, whereas those of special boiling solvents are from Asian continent

It is noted that Japan (6.65 MMT), Taiwan (4.54 MMT), South Korea (5.63 MMT), Thailand (3.53 MMT) and Singapore (3.98 MMT) together constitute 17% of the global installed ethylene capacity; all predominantly naphtha based, except Thailand. However, no new refining capacities have established in these countries almost for past one decade. As a result, respective cracking capacities are dependent on imported naphtha to large extent.

F.2 Petrochemicals

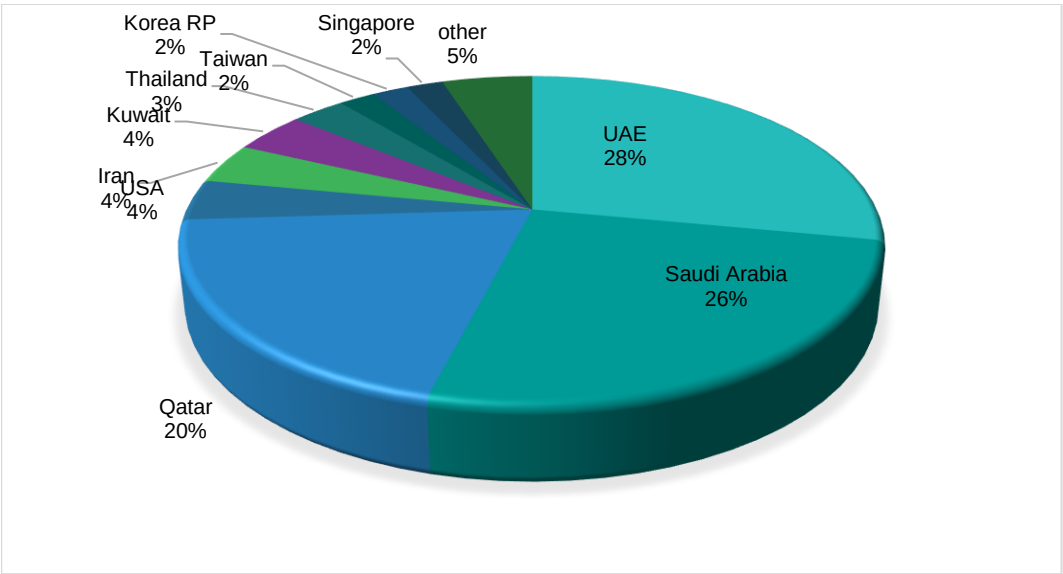
Share of imports of LLDPE, HDPE and PVC by exporting countries (% weight) have been shown below –

Figure 40: Indian Import of LLDPE (2015-16)



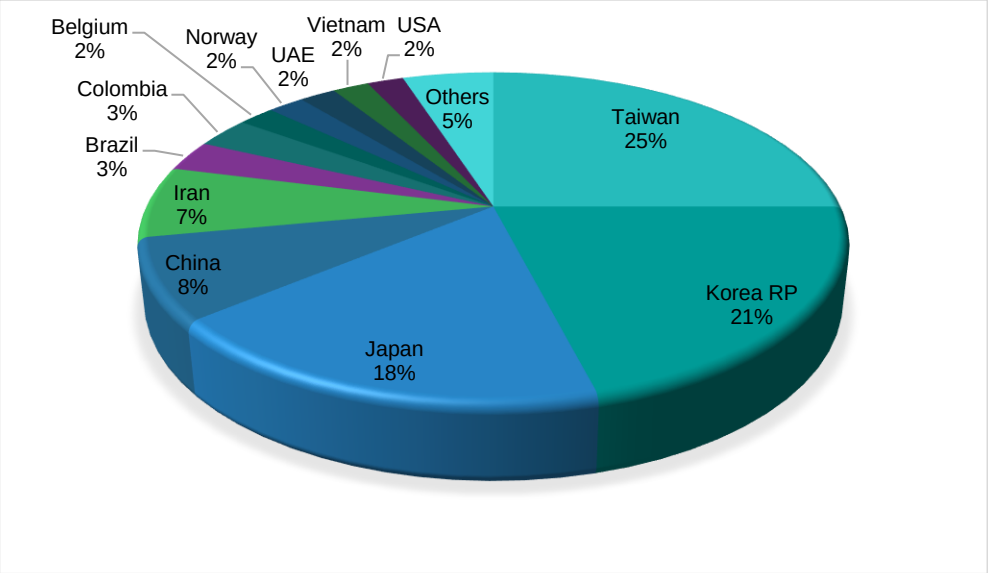
Source: DGCIS

Figure 41: Indian Import of HDPE (2015-16)



Source: DGCIS

Figure 42: Indian Import of PVC by (2014-15)



Source: DGCIS

It can be noted that LDPE, HDPE and LLDPE are largely imported from Middle East (Saudi Arabia, Qatar, UAE) and USA, where gas based crackers dominate the ethylene capacity. Imports of PVC range products are largely from Asian Countries including South Korea, Taiwan, China, Thailand, and Germany, where naphtha based crackers and chlorine based industry is prevalent. This, to an extent signifies lower cost of production of LDPE/LLDPE from gas as compared to naphtha.

G. Pricing of Natural Gas & Naphtha

G.1 Natural Gas

- Administered Price Mechanism (APM)
  - Gas sourced from the existing fields of the Public Sector Undertaking (PSU) companies follows cost plus basis for supplies less than 50 thousand standard cubic meters per day to the fertilizer units and power plants supplying to the National grid
  - In 2014, based on the recommendations of the Rangarajan Committee, Ministry of Petroleum & Natural Gas (MoP&NG) issued new pricing guidelines for natural gas produced in India. As per the guidelines, the prices are determined by a formula which pegs the price of natural gas based on the average annual consumption and average annual monthly prices of natural gas in the global trading hubs including USA, Mexico, Canada, European Union, Former Soviet Union, Henry Hub, Alberta Hub and Russian Federation. These price are determined half yearly basis, and remain constant for the period
- Non-APM gas is divided into –
  - LNG imported from Qatar, whose long term prices have been linked to Japanese Custom Cleared (JCC) CIF prices
  - Domestically produced gas from New Exploration Licensing Policy (NELP), which is priced on arm's length (market price) basis keeping in view the terms and conditions in the production sharing contract (PSC) and on Government's approval, and
  - Gas from the pre-NELP fields, which is priced based on the formula specified in the PSC

G.2 Naphtha

Pricing mechanism for naphtha, in line with the pricing mechanism for petroleum products, is discussed below

Table 38: Pricing Mechanism of Naphtha

Description	Basis	Amount (₹/Kg)
Import Price of Crude as on 1 April 16	US$ 46.26/Barrel	21.47
Ocean Freight	US$ 2.0/Barrel	0.93
Landed Price		22.40
Add: Customs (Import) Duty	26.26%	5.88
Add: Import charges, Insurance, Port Handling	₹0.3/Lit	0.35
Import parity price		28.63
Refinery Marketing Cost	₹1.5/Kg	1.50
Refinery Margin	10%	2.86
Distribution Cost#	₹1.5/Kg	1.50
Price Before Taxes		34.49
Add Central Excise	12.50%	4.31
Add VAT/ CENVAT	Depending upon State, 5% minimum, 16% max	1.38
Retail Price		40.19

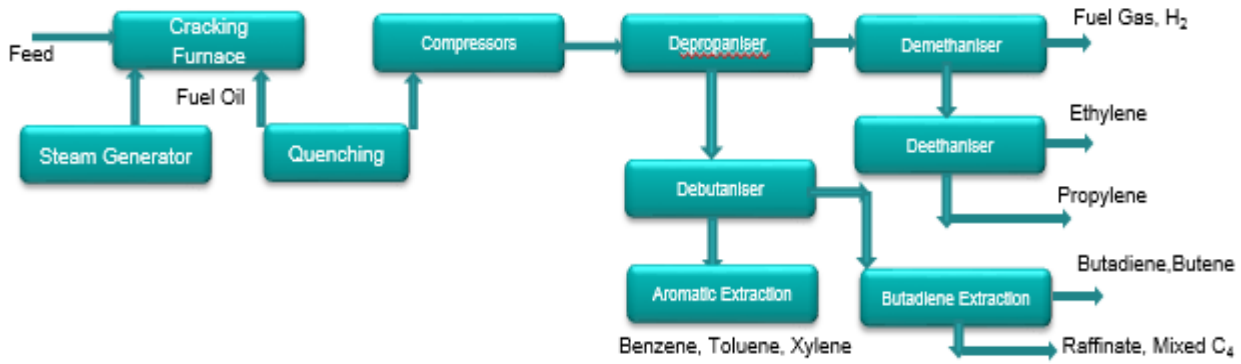
Source: IOCL, BPCL, HPCL Note: # Distribution cost can be replaced by pooling cost.

H. Technical Aspects of Cracking

H.1 Basics

Steam cracker is the mother plant in a petrochemical complex producing ethylene, propylene, butadiene, pyrolysis gases etc. Cracking involves dissociation of parffinic hydrocarbons in the feedstock to olefins with the aid of steam. The basis process involves compression, cracking and separation of the cracked fractions under low temperature.

Figure 43: Process Flow Diagram of Naphtha Cracker



Source: Compiled by MM

H.2 Yield

Lighter hydrocarbons require less steam as compared to heavier hydrocarbons. Thermal stability of the hydrocarbons increase in following order: paraffins, naphthenes and aromatics. Thus, naphtha with higher naphthenes and aromatics tend to consume higher energy to dissociate. In other terms, at least 65% paraffin content is desired in naphtha for better cracking yield. Yield declines as the feedstock gets heavier. Normally C-5 cut naphtha[59] is segregated in refinery as the feedstock for petrochemicals. In case of gas, thermal stability increases, whereas yield of ethylene declines, with increase in length of the carbon chain (ethane – C2, propane - C3 and butane - C4). Invariably, yield of 37-40% for naphtha crackers and 80% for gas cracker is acceptable.

The basics of steam cracking though remains same in both cases, high temperature is required for naphtha cracking than required in gas cracking. It could else be interpreted as lighter hydrocarbons in gas require less steam or energy as compared to comparatively heavier hydrocarbons in naphtha.

H.3 Configuration of Cracker

Crackers are designed with respect to the quality of feedstock i.e. with respect to the paraffin content in the feedstock. Light naphtha being a mixture of hydrocarbons with 4 to 6 carbon items, also produces propylene, butene and benzene on cracking. Thus, series of fractionation columns are designed for accurate separation of each fraction, and so to obtain better yield of ethylene. The off-gases from the cracker containing ethane,

[59] Which otherwise is isomerized to higher-octane stream for MS pool

propane and butane fractions are recycled back to the cracking furnace for converting them to ethylene, propylene and butane respectively. Naphtha crackers possess advantage of production of valuable co-products such propylene (0.35-0.40 T/T of ethylene) and butadiene (0.20-0.25 tonne of ethylene) as against a gas cracker which produces propylene if only the gas is rich in propane.

Ethylene needs to be transported under refrigerated conditions (- 40oC) requiring special arrangements for shipping, involving high costs. So, a cracker necessarily has to be extended with units processing ethylene to derivatives. So, downstream units for processing ethylene and propylene add to the configuration.

Utility requirements, depending upon level of downstream integration, too add complexity to configuration.

As a reason of number of processing units and set of utilities, capital cost and operating cost of cracker remains high.

H.4 Physical Properties of Building Blocks

Ethylene, propylene styrene and butadiene are the building blocks for downstream petrochemicals. Physical properties of naphtha cracks are discussed below:

Table 39: Physical Properties of Naphtha cracks

Chemical	Formula	Density(g/cm^3)	Appearance	Odor	Melting Point(^{o}C)	Boiling Point(^{o}C)
Ethylene	C_2H_4	0.0011	Colourless gas	Sweet aromatic	-169.2 ^{0}C	-103.7 ^{0}C
Propylene	C_3H_6	0.855 (amorphous) 0.946 (crystalline)	Colourless gas	Aromatic	-185.2 ^{0}C	-47.6 ^{0}C
1,3- Butadiene	C_4H_6	0.6149 (25^{0}C)	Colourless gas or refrigerated liquid	Mildly aromatic, like Gasoline	-108.9 ^{0}C	-4.4 ^{0}C
1-Butene	C_4H_8	0.62	Colourless gas	Slightly aromatic	-185.3 ^{0}C	-6.47 ^{0}C

Source: Compiled

As all vital naphtha cracks are gases at ambient conditions, these must be liquefied for long distance transportation, which normally occur under refrigerated conditions involving specialised equipment and cost.

I. Global Crackers

Table 40: List of upcoming crackers in China

Project Name	Location	Capacity (KTPA)	Expected Commissioning
Fujian ethylene project Ligure	Zhanzhou	1.20	2018
Sinochem Ouanzhou Petrochemical Co., Ltd	Ouanzhou	1.00	2017
CNOOC Huizhou ethylene project	Huizhou	1.00	2016
Sinopec Kuwait Petroleum Zhanjiang Branch of joint integration projects	Zhanjiang	1.00	2020
Sinopec Hainan Refining & Chemical (HRCC)	Hainan	1.00	2019
Sinopec	Lianyungang	2.00	2018
Dalian Shide Group Ethylene Phase 1	Dalian	1.30	2019
Sinopec Oingdao Refining & Chemical Co., Ltd	Quiangdao	1.00	2020
Shanghai Gaoqiao ethylene relocation project to Caojing	Shanghai	1.00	2017
PetroChina Sichuan Petrochemical Co., Ltd	Chengdu	0.80	2014
PetroChina-Rosneft Orient Tianjin Refinery & Petrochemicals	Nangan	1.20	2020
PetroChina oil refinery project in Yunnan	Kunming	1.00	2019
PetroChina Lanzhou Ethylene	Lanzhou	1.00	2019
Sinopec Yangzi ethylene Ill transformation	Nanjing	0.80	2017
Formosa Plastics Ningbo Ethylene Cracker	Ningbo	1.20	2018
CNPC Taizhou Refinery & Petrochemical Complex	Taizhou	1.20	2020

Source: Platts Special Report on Petrochemicals, September 2014

Table 41: List of small capacity crackers

Name of Company	Location	Capacity (MMT)	Start Year	Present Status	Product Slate	Backend Refinery
Lukoil Neftochim Bourgas JSC, Bourgas	Bulgaria	0.25	1980	Decommissioned	NIL	Bourgas Refinery
Lukoil Neftochim Bourgas JSC, Bourgas	Bulgaria	0.15	1966	Decommissioned	NIL	Bourgas Refinery
Sinopec, Guangzhou, Guangdong	China	0.14	1996	Operational, expended to 0.8 MMT	HDPE, PP	Guangzhou Refinery
Sinopec, Puyang	China	0.18	1996	Operational; expended to 0.24 MMT	0.160 KT PE and 60 KT PP	Puyong Refinery
Sinopec, Tianjin	China	0.20	1995	Operational; also have a 1.0 MMT cracker	LDPE, HDPE, PP	Tianjin Refinery
Innovyn, Feyzin,	France	0.25	1995	Operational	HDPE, LLDPE, PP	Yes; Feyzin Refinery
Indian Petrochemicals Corp. Ltd, Vadodara	India	0.13	1970	Operational	Produces 130 KT ethylene, 100 KT propylene, 37 KT Butadiene, 23 KT Benzene and 20 KT Ethylene Oxide	Yes; Jamnagar Refinery
Arak Petrochemical, Arak	Iran	0.247	1995	Operational	HDPE, LLDPE, PP, PBR, Ethylene Glycol	Yes; National Petroleum Company arranges naphtha
Tabriz Petrochemical Co, Tabruz	Iran	0.136	1995	Operational	Ethylene, Propylene, Butene-1, HD/LLDPE, Benzene, Ethylbenzene, Styrene, Toluene, Polystyrenes, Butadiene, C4 Raffinate and ABS	Yes; National Petroleum Company arranges naphtha
Carmel Olefins Ltd, Haifia	Israel	0.200	1964	Operational	165 KT LDPE, 135 KTPA Poly propylene,	Yes; Haifia Refinery
Titan Petrochemicals Sdn Bhd, Pasir Gudong, Johor	Malaysia	0.287	1995	Operational; debottlenecked to 0.43 MMT	HDPE, LDPE, LLDPE, PE, Butadiene, tertiary Butyl ether, benzene, Toluene	No
Angarsk Rosneft orgsintez, Angarsk, Siberia	Russia	0.060 + 0.240	2008; 2010	Operational; expended to 0.45 MMT	0.135 MMT of ethylene, 0.08 MMT of propylene, 0.065 MMT of HDPE, 0.021 MMT styrene, 0.015 MMT of polystyrene and 0.06 MMT of benzene	Yes, Angarsk Refinery
Sibur-Neftechim, Nizhny Novgorod	Russia	0.30	2006	Operational	NGL Cracking Unit making LDPE & PP	No
Slovnaft/ AS, Bratislava	Slovakia	0.22	1980	Operational; expended to 0.35 MMT	LDPE, HDPE, PP	Yes, Bratislava Refinery
SK. Corp, Ulsan	South Korea	0.185	1972	Operational; debottlenecked to 0.20 MMT	HDPE, LLDPE, LDPE, PP, butadiene, MBTE, Butene	Yes, Ulasan Refinery
TNK-BP, Lisichansk	Ukraine	0.20	1979	Decommissioned in 2012-13	NIL	Yes, Lisichansk Oil Refinery

Source: Compiled from International Survey of Ethylene Steam Crackers 2015, Oil & Gas Journal

J. Transportation Cost

Both means of transportation i.e. pipeline and coastal shipping were considered for evaluating the transportation cost. Accordingly, two separate workings were carried out for estimating the transportation cost by each mean.

Existing POL Pipelines

List of existing crude and petroleum, oil & lubricant (POL) product pipelines by individual oil corporations (connecting the shortlisted locations), their length, carrying capacity and % utilization in 2014-15 is provided below for analysing the sections needing dedicated pipelines for the purpose.

Table 42: Crude & POL Pipelines

Section	Owner	Length	Capacity (MMTPA)	Utilization 2014-15
Crude				
Paradip-Haldia-Barauni	IOCL	1384	11.0	147%
Panipat-Mathura-Koyali-Salaya	IOCL	1870	21.0	113%
Mundra Panipat	IOCL	1194	8.4	93%
Mundra Bhatinda	HMEL	1017	12.0	~75%
Product				
Koyali Ahmedabad	IOCL	116	1.10	68%
Koyali Sanganer (Jaipur)	IOCL	1287	4.60	75%
Koyali Ratlam	IOCL	265	2.00	66%
Koyali Dahej	IOCL	197	2.60	6%
Barauni Kanpur	IOCL	745	3.50	65%
Haldia Mourigram Rajbandh	IOCL	227	1.35	131%
Haldia Barauni	IOCL	526	1.25	96%
Mathura Delhi Biijwasan Panipat	IOCL	258	3.70	71%
Mathura Tundla	IOCL	56	1.20	27%
Mathura Bharatpur	IOCL	21	1.20	53%
Guwahati Siliguri	IOCL	435	1.40	128%
Panipat Bhatinda	IOCL	219	1.50	90%
Chennai-Trichy-Madurai	IOCL	526+157		
Chennai-Bangalore	IOCL	290		
Bina Kota (MS/SKO/HSD)	BPCL	259	4.40	58%
Mumbai Refinery - Santacruz Airport (ATF)	BPCL	15	1.44	54%
Kochi Refinery - Kochi Airport (ATF)	BPCL	34	0.60	29%
Vizag - Vijayawada - Secunderabad	HPCL	572	5.38	81%
Mangalore-Hassan Bangalore	MRPL	364	2.14	147%

Source: PPAC

It can be noted that refineries operate on territorial basis i.e. to fulfil the fuel requirements of the region, and hence there are only few instances where any two refineries are connected with each other for transferring products. However, should dedicated product pipelines should be developed for the purpose, these shall have to be –

- overdesigned to cater requirements of multiple crackers
- developed as a network routed through existing or upcoming refineries and product terminals

As per this philosophy, none of the existing pipelines could be useful for pooling additional volumes of naphtha over what are being handled at present for exports from land-lock refineries.

Pooling with New Pipeline Infrastructure

Tentative routes and distances for pooling naphtha to Mangalore and Vishakhapatnam from locations of availability have been explored below, capital cost for which is estimated between ₹1.30 to 1.50 Crore/running Km[60], including tank terminals and pumping stations.

Table 43: Tentative Piping Networks for Pooling Naphtha

Refinery	Available Supply	to Vishakhapatnam		To Mangalore	
		Route	Distance#	Route	Distance#
IOCL Barauni	0.10	Barauni-Haldia-Paradip-Vizag	1,545	Barauni-Haldia-Paradip-Vizag	1,545
IOCL, Haldia	0.10	Haldia-Paradip-Vizag	-	Haldia-Paradip-Vizag	-
IOCL Koyali	0.60	Koyali-Ratlam-Raipur-Paradip-Vizag	1,535	Koyali-Mumbai	420
BPCL, Mumbai	0.20	Mumbai-Solapur- Vijaywada	1,020	Mumbai-Solapur-Mangalore	1,040
BPCL, Kochi	0.10	Kochi-Coimbatore-Cuddalore	493	Kochi-Coimbatore-Mangalore	593
CPCL, Chennai	0.40	Chennai-Vijaywada-Vizag	750	Chennai-Bangalore-Mangalore	750
HMEL, Bhatinda	0.20	Bhatinda-Mundra-Koyali & then Vizag	1,400	Bhatinda-Mundra-Koyali	1,400
HPCL Vizag	0.90		00	Vizag-Vijaywada-Chennai	750
MRPL, Mangalore	0.80	Mangalore-Bangalore-Chennai-Vizag	750		00
NOCL Cuddalore	0.40	Cuddalore-Chennai	170	Cuddalore-Chennai	170
Essar Oil, Vadinar	0.40	Vadinar-Koyali	420	Vadinar-Koyali	420
Total	**4.20**		**8,083**		**7,062**
Capital cost (₹ Crore)		**1.3/KM**			

Source: PPAC, MM Analysis

Note: # - Pipelines have been routed through established routes after avoiding repetitions

Adding Barauni-Mathura-Panipat stretch of around 1200 Km to above network shall enable networking all, but the North-Eastern refineries, for pooling POL. Since dedicated pipelines are not warranted for locations with lesser volumes of surplus LN, locations with surplus higher than 0.40 MMT were considered for pooling. Even then, it was estimated that minimum 2,600 running Km pipeline shall be required for pooling of 3.0 MMT of 4.2 MMT naphtha, entailing a capital cost of around ₹3,400 Crore. In addition, operating and maintenance cost were being estimated to be around ₹285-300/ Tonne.

Operating expenses per annum for pooling this capacity are understood to be around 6.0-6.50% when taken on gross block in respective year. This include consumables, utilities (power) at 1.50%, repair & maintenance cost of 1.0%, general O&M expenses of 1.0%, finance cost & interest of 0.50%, insurance cost of 0.1%, salaries, admin & overhead cost of 0.30% and marketing expense of 0.30% of gross block. Adding 15% operating profit margin and duties to above, overall cost sums up to 6.50% of gross block.

60 Cost has been referenced with IOCL's on-going pipeline projects like paradip-Raipur, Ennore-Trichy, Paradip-Haldia-Durgapur etc

However, the proposal was not considered as the piping network becomes a subject of techno-commercial feasibility in itself. Also, the expenditure and timelines required for developing same could be a discouraging element for the proposal at this stage. Pictorial representation of the proposed network is shown in Figure 44

Figure 44: Tentative Pipeline Network for Pooling Naphtha



Source: Compiled from existing pipeline networks published by PPAV, with few stretches added to existing lines based on least distance

Coastal Shipping with Existing Pipelines:

Table 43 provides approximate distances over which naphtha may have to be shipped and according costs for pooling to locations of availability. For comparative analysis, shipping costs have been estimated on unit basis i.e. ₹1.0 / MT-NM (nautical mile) as had been discussed in section 6.2 in this report – Unit charges have been considered on indicative basis. Actual charges may vary 20% depending upon the distance, nature of contract (frequency), exchange rate variations and shipping load (tonnage) of transport. Also, it is assumed that adequate infrastructure will be available or created on ports for handling the product.

Table 44: Comparative Analysis of Transportation Cost (Distance in nautical miles, cost in ₹ Cr)

Refinery	Available Supply	to Vizag		To Mangalore		To Chennai		To Kochi		To Dahej (Koyali)		To Mumbai		To Haldia/Paradip	
		Distance	Cost	Distance	Cost	Distance	Cost	Distance	Cost	Distance	Cost	Distance	Cost	Distance	Cost
IOCL Barauni*	0.10	406*	6.56	1518*	17.68	867	11.17	1483	17.33	2335	25.85	2073	23.23	0	2.5
IOCL, Haldia *	0.10	406*	4.06	1518*	15.18	867	8.67	1483	14.83	2335	23.35	2073	20.73	0	0
IOCL Koyali	0.60	1886	113.16	670	40.20	1467	88.02	872	52.32	0	15	262	15.72	2187	131.22
BPCL, Mumbai	0.20	1625	32.5	409	8.18	1206	24.12	611	12.22	262	5.24	0	0	1926	38.52
BPCL, Kochi	0.10	1035	10.35	202	2.02	616	6.16	0	0	872	8.72	611	6.11	1336	13.36
CPCL, Chennai	0.40	420	16.8	797	31.88	0	0	616	24.64	1467	58.68	1206	48.24	721	28.84
HMEL, Bhatinda**	0.20	2052*	41.04	1039*	25.78	1634	37.68	1039	25.78	391	12.82	429	13.58	2354	52.08
HPCL Vizag	0.90	00	00	1216	109.44	419	37.71	1035	93.15	1886	169.74	1625	146.25	406	36.54
MRPL, Mangalore	0.80	1216	97.28	00	00	797	63.76	202	16.16	669	53.52	409	32.72	1518	121.44
NOCL Cuddalore	0.40	490	19.60	742	29.68	0	10	616	24.64	1467	58.68	1206	48.24	721	28.84
Essar Oil, Vadinar	0.40	2052	82.08	836	33.44	1612	64.48	1017	40.68	369	14.76	407	16.28	2333	93.32
Total	**4.20**		**423.43**		**313.48**		**351.77**		**321.75**		**446.36**		**371.10**		**546.66**
Cost (₹ /T)			**1283**		**922**		**926**		**785**		**1240**		**928**		**1333**

Source: MM Analysis

Notes: * - from Paradip Port, ** - from Mundra Port

Glossary

ACD	Additional Customs Duty
APM	Administered Price Mechanism
ATF	Aviation Turbine Fuel
BBL	Billion Barrel
BCPL	Brahmaputra Cracker and Polymer Limited
BORL	Bharat Oman Refineries Limited
BPCL	Bharat Petroleum Corporations Limited
BTX	Benzene Toleuene & Xylene
CAGR	Cumulative Average Growth Rate
CFR	Cost & Freight
CPCL	Chennai Petroleum Corporation Limited
CPMAI	Chemicals & Petrochemicals Manufacturers Association Of India
EA	Ethylene Acetate
EC	Environment Clearance
EDC	Ethylene Di Chloride
EIA	Environment Impact Assessment
EOL	Essar Oil Limited
EPP	Export Parity Price
FBP	Final Boiling Point
FCCU	Fluidized Catalytic Cracker
FICCI	Federation of Indian Chamber of Commerce and Industry
FMCG	Fast Moving Consumer Goods
FO	Fuel Oil
FOB	Free On Board
Forex	Foreign Exchange
GAIL	Gas Authority of India Limited
GDP	Gross Domestic Product
HCU	Hydro Cracker Unit
HDPE	High Density Polyethylene
HMEL	HPCL- Mittal Energy Limited
HN	Heavy Naphtha

HPCL	Hindustan Petroleum Corporation Limited
HPL	Haldia Petrochemicals Limited
HSD	High Speed Diesel
IBP	Initial Boiling Point
IIP	Index of Industrial Production
IOCL	Indian Oil Corporation Limited
JCC	Japanese Custom Cleared
JNPT	Jawaharlal Nehru Port Trust
Kcal	Kilo calorie
Kg	Kilogramme
KT	Kilo Tonne
LDO	Light Diesel Oil
LDPE	Low Density Polyethylene
LLDPE	Linear Low Density Polyethylene
LN	Light Naphtha
LNG	Liquefied Natural Gas
LSHS	Low Sulphur Heavy Stock
MCF	Mangalore Chemicals and Fertilizers Limited
MEG	Mono Ethylene Glycol
MM	Mott MacDonald
MMBTU	Million British Thermal Unit
MMT	Million Metric Tonne
MMTPA	Million Metric Tonnes Per Annum
MoP&G	Ministry of Petroleum and Natural Gas
MoU	Memorandum Of Understanding
MRPL	Mangalore Refinery & Petrochemicals Limited
MS	Motor Spirit
NELP	New Exploration licensing policy
NGL	Natural Gas Liquid
NOCL	Nagarjuna Oil Corporations Limited
NRL	Numaligarh Refinery Limited
NTPC	National Thermal Power Corporation
OMPL	ONGC Mangalore Petrochemical Limited
ONGC	Oil and Natural Gas corporation
OPaL	ONGC Petro additions limited
OPEC	The Organisation of Petroleum Importing countries

PCPIR	Petroleum, Chemicals and Petrochemical Investment Region
PNGSTAT	Petroleum and Natural Gas Statistics
PPAC	Petroleum Planning and Analysis Cell
PPN	PPN Power Limited
PSC	Production Sharing contract
PTA	Purified Teraphthalic Acid
PVC	Polyvinyl Chloride
PX	Paraxyelene
RIL	Reliance Industries Limited
RTP	Refinery Transfer price
SEZ	Special Economic Zone
SKO	Superior Kerosene Oil
SoW	Scope Of Work
SPIC	Southern petrochemical Industries Corporation
UAE	Unite Arab Emirates
USD	US Dollar
VAT	Value Added Tax
VBU	Vis breaker Unit
VCM	Vinyl Chloride Monomer