Prefeasibility Report
for
Project Expansion in
Haldia Petrochemicals Ltd.

Submitted by:

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0 EXECUTIVE SUMMARY

Haldia Petrochemicals Ltd. (hereafter referred as HPL) is a naphtha based petrochemical complex, located at Haldia, East Medinipur, West Bengal. It is a joint venture project promoted between The Chatterjee Group, Government of West Bengal, TATA group and Indian Oil Corporation. HPL was founded in 1985 and received the first environmental clearance in 1992 for 420KTA. It had planned for an expansion in 2005 and expanded its capacity to 520 KTA vide EC Letter No. J-11011/19/ 2005-IA II (I). Later, as part of Project Supermax, HPL expanded it's production to 700KTA in 2007 vide EC Letter NO. J-11011/176/2007-IA II (I) and Corrigendum No. J-11011/176/2007-IA II (I). Post expansion in 2007, HPL produces 700KTA ethylene by cracking naphtha.

HPL, now proposes to enhance it's maximum design capacity of Naphtha Cracker Unit leading to increased production of intermediates i.e. Ethylene and Propylene. The expansion process would not only lead to increase in production of the existing products manufactured such as HDPE but also result in the addition of new products. The new products that are likely to be produced include:

- Butene-1 and Methyl Tertiary Butyl Ether (MTBE)
- Phenol and Acetone
- Poly Butylene Terephthalate (PBT) and Tetrahydrofuran (THF)
- Vinyl Acetate Ethylene (VAE)
- Additional Chain of HDPE (Train-3)

To support the expansion program augmentation of ancillary facilities such as storage, loading/unloading, utilities system, equipment will also be necessary for the proposed project.
The salient features of the project along with the resources required are summarized in the Table below.

Table.0.1 Summary of project capacity, capital and resources required for the expansion units

Units	**Project Capacity** (KTA)	**Est. Capital, Rs. Cr.**	**Area (ha)**	**Energy**	
				Electricity (KWH)	**Steam, TPH**
Ethylene Capacity Expansion	70	450	0.1	3049	6.6
Butene-1 and MTBE	30.2	350	0.29	425	23.7
MS capacity expansion and quality up-gradation (Including Py-Gas Hydrotreatment)	332	120	0.27	210	4
Phenol & Acetone	200	1,650	1.10	4,550	75.25
Polybutylene Terephthalate	70	400	0.19	686	2.8
Vinyl Acetate Ethylene	60	300	8.64	2,000	20
HDPE Train-3	160	400	2.44	5,500	11.2
Captive Cogeneration power plant	1 x 35 MW CSTG + 3 x 120 TPH Boilers	530	17.6		
Storage Tanks & Spheres		110			

Units	Project Capacity (KTA)	Est. Capital, Rs. Cr.	Area (ha)	Energy	
				Electricity (KWH)	**Steam, TPH**
Total Project Investment		4,310			

Due to this proposed capacity expansion, HPL estimates that the power consumption would increase from the present capacity of 85 MW (generated from a captive power plant of 116 MW power and 480 TPH superheated steam). To meet the additional demand of power of new projects and also to build redundancy (to take care of steam and power generation facilities during periodic planned turnaround of steam and power generating assets for inspection and maintenance), a 1x 35 MW CSTG and 3 x 120 TPH coal fired boiler is proposed to be added within the co-generative captive power plant.

To prevent the pollution from the plant, control measures have been adopted by HPL. The emission from the vents and pressure relief valves containing hydrocarbons are discharged via blowdown vessel to flare stack for combustion and safe disposal. Off gases would be reused as fuel gas as per convenience. For liquid effluents a Waste Water Treatment Plant of capacity 4,090 m3/d is in operation and can handle both Industrial Waste and Sanitary Waste. The effluent generated from each unit is treated partially in Inside Battery Limit (ISBL). The partially treated effluent from each unit is sent to the WWTP at the premises. The treated effluent is discharged into Green Belt Canal.

In the proposed expansion additional emissions and discharges are expected. The quality and quantity of emissions and effluents are presented in
Table 1 2.

Table.0.2 Summary of Pollutants

Units	Effluent		Emission	Hazardous waste	Quantity
	Type and flow rate	**Characteristics**			
Ethylene Capacity Expansion in Naphtha Cracker Unit	Dilution Steam Drum Blowdown - 1.2-2.4 m^3/hr Continuous blowdown from SHP Steam Drum - ~1.0m^3/hr Pre-treated (Gasoline was) Spent Caustic – 1.3m^3/hr Polymeric oil	pH-8.5-10 Oil and grease-10-100mg/l TSS- 200mg/l BOD-100-300mg/l COD-200-500mg/l pH-9.5, TSS-20mg/l, BOD-5mg/l, COD-15mg/l NaOH-1.25% (w/w) Na_2CO_3-5.44%(w/w) Na_2S-2.91%(w/w) TOC-6000ppm; Phenols-50 ppm,Free oil – 1000ppm	Cracker Heater Flue Gas during normal; operations: About 90 TPH at 105-110°C majorly containing N_2, O_2, CO_2 and H_2O. Major pollutants are: • NOx-80ppmv @ 3 Mol%O_2 (dry) • CO- 9-11ppmv @ 3 mol %O_2 (dry) • Hydrocarbons-6-	• Spent catalysts and dessicants • Coke from Portable TLE Hydrojetting Separator • Coke from Portable Quench Oil suction and discharge filters • Coke from fuel oil/purge oil filters	

Units	Effluent		Emission	Hazardous waste	Quantity
	Type and flow rate	Characteristics			
	from caustic/water wash tower Wash water from caustic/water wash tower	Marginal increase from current generation Marginal increase from current generation	11ppmv • Particulates-5-10ppmw • SO2-Nil Gas Emission during decoking:60-90 TPH at 250°C with characteristic as: • NOx :20-25 ppmv@3 mol %O2 (dry) • CO:10-25 ppmv@3 mol%O2(dry) • Hydrocarbons:5010ppmv • Particulates-5-10ppmw Acetylene converter regeneration offgas MAPD Converter Regeneration offgas		
Butene-1	MTBE Unit Spent Wash waters – $2.6 m^3/h$	Nitrogen impurities - 20ppm; Methanol – 100 ppm; Hydrocarbons (especially C4) – 400 ppm	Methanol Stripper Purge - 50Nm3/hr, Stripper purge gas 53Nm3/hr, C4 Selective Hydrogenation Catalysts treatments 3000Nm3/hr (1 day per 2.5 years)	MTBE Reactor Catalyst (Styrene divinylbenzene copolymer/Sulfonic acid/Water) Catalyst beds from MTBE Catalytic Distillation (Styrene divinylbenzene copolymer/Sulfonic acid/Water) Resins from guard pots (Styrene divinylbenzene copolymer/Sulfonic acid/Water)	20400/2 years 18700/4 years 2400/ year

Units	Effluent		Emission	Hazardous waste	Quantity
	Type and flow rate	Characteristics			
				C4 hydrogenation catalyst	6585/6 years
MTBE	Raffinate -1 Feed surge drum boot Purge – Not Normally flowing (NNF) Stripper Reflux Drum Boot Purge Not Normally flowing (NNF)	Hydrocarbons (especially C4) – 400 ppm, T=43°C, Density= 990 kg/m3, pH=6.8-8.5 Hydrocarbons (especially C4) – 400 ppmw, T=43°C, Density= 990 kg/m3, pH=6.8-8.5			
Phenol & Acetone	Effluent after dephenolation - ~25.34m3/hr	Phenolic (<50 ppmw), Sodium salts (4.9 wt%), COD- 3.9kg/ton phenol	Spent air- 31,000Nm3/hr Vent gas- 60 Nm3/hr MSHP Vent Gas 30Nm3/hr	Spent catalyst from phenol resin treater	
Polybutylene Terephthalate & THF	$47m^3$/day	Main contaminants include 3-Buten 1-ol, 1,4-Butanediol, Tetrahydrofuran (THF), 1-Butanol COD-12100mg/l; BOD-6,900mg/l pH-3-6		PBT Oligomers Prepolymer with steel sieves Polymer with steel sieves Side stream THF column	10-20k/day 6kg/day 8-12kg/day 2-5 kg/day 2000-3000kg/day
HDPE	• Start up drain from Extruder -1m3/hr • Pellet cutting water - 1m3/hr • Process Effluent- 1.5m3/hr		Flaring load - 135 ton/hr		
Vinyl Acetate Ethylene[1]	$5m^3$/hr	Major constituents:			

[1] https://books.google.co.in/books?id=lB07AAAAIAAJ&pg=PA305&lpg=PA305&dq=ethylene+vinyl+acetate+production+process+pollutants&source=bl&ots=yMF5AeaXev&sig=jF2Le_IathKMi1-

Units	Effluent		Emission	Hazardous waste	Quantity
	Type and flow rate	Characteristics			
		BOD_5-0.20kg/1000kg, TSS-0.55kg/1000kg; pH-6.0-9.0			
Pyrolysis Gas Hydrogenation Unit	None		Off-gas composed of Hydrogen (8.9%), H_2S (9.3%), Methane (23.7%), C3-C4 (5.8%), Cyclopentane (28.5%), Pentane (16.7%), Benzene (4.1%), Toluene (2.8%)	Spent hydrogenation catalysts	
Coal based Energy generation			Particulate Matter - 50mg/Nm3	Coal ash	15TPH (70:30 Import/Dom Mix)/40 TPH (Dom. Coal)

A stack of 140m has been proposed with boiler in the Captive Power Plant for proper dispersion of the emissions. Further, the volatile organic compounds generated from different processes will be routed to the existing flare stack for combustion. The characteristic emission from stack will be as per the CPCB guideline for industry specific discharge standard – Petrochemicals (Basic and Intermediates) [1].

Apart from the process effluent additional effluent will be generated from Cooling Tower Blowdown (CTBD) and DM Plant Neutralization Waste that has been estimated to be 1,500m^3/day. The effluent generated from processes and other utilities will be treated as per the existing practice defined above.
The effluent will be disposed in accordance to CPCB guideline for industry specific discharge standard – Petrochemicals (Basic and Intermediates). Hazardous Waste would be handled as per the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. Fly ash from coal burning would be sold to cement manufacturers and/or brick manufacturers. HPL would sell the bottom ash for preparation of road embankments.

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[1] http://www.cpcb.nic.in/Industry-Specific-Standards/Effluent/432-1.pdf

1 INTRODUCTION

1.1 INTRODUCTION

Haldia Petrochemicals Ltd. (hereafter referred as HPL) is naphtha based petrochemical complex, located at Haldia, East Medinipur, West Bengal. It is a joint venture project promoted by West Bengal Government, The Chatterjee Group, TATA group and Indian Oil Corporation. HPL was founded in 1985 and received the first environmental clearance in 1992 for 420KTA. It had planned for an expansion in 2005 and expanded its capacity to 520 KTA vide EC Letter No. J-11011/19/ 2005-IA II (I). Later, as part of Project Supermax, HPL expanded it's production to 700KTA in 2007 vide EC Letter NO. J-11011/176/2007-IA II (I) and Corrigendum No. J-11011/176/2007-IA II (I). Post expansion in 2007, HPL produces 700KTA ethylene by cracking naphtha.
The other range of products is the following:

- Linear Low Density Polyethylene (LLDPE)
- High Density Polyethylene (HDPE)
- Polypropylene
- Benzene
- Butadiene
- Cyclopentane
- C4 hydrogenated (LPG)
- Pyrolysis Gasoline (Py Gas)
- Carbon Black Feedstock (CBFS)
- Motor Spirit

The ancillary facilities present with the existing project are:

- Captive Power Plant (CPP)
- Offsets and Utilities Power Plant (O&U)
- Integrated Waste Water Treatment Plant (IWWTP)

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- Butene-1 and Methyl Tertiary Butyl Ether (MTBE)
- Phenol and Acetone
- Poly Butylene Terephthalate (PBT) and Tetrahydrofuran (THF)
- Vinyl Acetate Ethylene (VAE)

To support this expansion, new units will be setup and it would also require augmentation of ancillary facilities such as storage, loading /unloading, utilities system under the expansion project.

Due to this proposed capacity expansion, HPL estimates that the power consumption would increase from the present capacity of 85 MW (generated from a captive power plant of 116 MW power and 480 TPH superheated steam). To meet the additional demand of power of new projects and also to build redundancy (to take care of steam and power generation facilities during periodic planned turnaround of steam and power generating assets for inspection and maintenance), a 1x 35 MW CSTG and 3 x 120 TPH coal fired boiler is proposed to be added within the co-generative captive power plant.

1.2 NEED FOR THE PROJECT AND ITS IMPORTANCE TO THE COUNTRY AND OR REGION

As per a report by McKinsey & Company on “Building a self-sufficient petrochemical intermediates industry in India by 2025”, the following issues have stated:

- There has been an expansion in the refining sector and surplus availability of naphtha[1].
- India has a dependency of 45% on imported intermediates due to it’s shortage.
- Further, it has also been reported that there will be significant growth in downstream industries (due to demand of construction and consumer goods) that will drive the demand for petrochemical intermediates.

In view of the above aspects and to take advantage of the situation HPL has:

- Taken advantage of the growth in aphtha feedstock and achieved full design capacity and now proposes to take advantage of the marginal surplus production (10%) beyond design capacity.
- Along with ethylene capacity additions, HPL is also adding capacity in derivatives to broaden product basket
- The proposed project will help reduce the import of intermediates and products such as Butene-1, VAE, PBT, HDPE etc.

Hence, the proposed project will help HPL cater to the expanding need of downstream industries

1.3 DEMAND-SUPPLY GAP

The demand-supply scenario of the intermediates, by products and products has been described in the subsequent sections.

1.3.1 Ethylene

Subsequent to commissioning of new cracker by GAIL and BCPL, ethylene capacity in India is 4.5 mMTPA. Additional 2.7 mMTPA capacity is under construction, which would increase the overall capacity to 7.2 mMTPA by 2017.

On demand side, demand of ethylene derivatives as per Petrochemical Sub-committee Report under 12th Five Year Plan can be summarized as below:

[1] Petrochemicals are derived from refining of crude oil and natural gas. Olefins (ethylene, propylene and butadiene) and Aromatics (Benzene, Toluene and Xylenes) are the major building blocks from which most chemicals and petrochemical are produced.

Table 1.1 Demand of Ethylene derivatives in India

	Demand Based on Petrochemical Subcommittee Report, KTA		Derived Ethylene (KTA) Demand, as per Industry Estimates	
	2011-12	**2016-17**	**2011-2012**	**2016-17**
LDPE	405	597	405	597
LLDPE	1,198	2,076	1,102	1,910
HDPE	1,657	2,573	1,657	2,573
PVC	2,087	3,102	960	1,427
MEG	1,836	3,024	918	1,512
Styrene	496	647	134	175
Total Ethylene Demand (Excluding EPDM, EVA, etc)			**5,176**	**8,194**

MEG- Monoethyl Glycol, EPDM-Ethylene, Propylene Diene Monomer, EVA-Ethylene Vinyl Acetate

As it can be seen above, even after proposed capacity expansion, derived demand of ethylene and its derivatives is higher vis-à-vis installed capacity and India would remain dependent for some of the ethylene derivatives.

1.3.2 Butene-1

HPL requires about 18-20 KTA Butene-1, which is currently being imported. Out of 30 KTA Butene-1, 18 KTA is assumed to be consumed internally for LLDPE manufacturing. Out of balance 12 KTA Butene-1, product may be sold to domestic consumer like BCPL where HPL has logistics advantage vis-à-vis other domestic producers.
MTBE: Global MTBE capacity is about 24 mMTPA in 2014. Major producers are China, Middle East, Europe and US. The global demand during 2015-2020 is expected to increase by ~6.7 mMTPA, led mostly by China, Europe and Middle East.

Table 1.2: Growth in Methyl Tertiary Butyl Ether Demand ('000 MT) 2010-2020

Continent	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	11yr Total
Asia	1152	1035	1162	691	1198	813	854	916	980	875	927	10603
North America	-84	-46	10	10	590	16	16	17	16	12	13	570
South America	-43	-95	-38	-17	-16	-15	0	-3	12	12	13	-190
Europe	11	10	3	1069	43	59	75	82	82	82	83	1599
Russia	166	-240	55	70	12	1	27	39	39	40	42	251
Middle East	88	68	63	137	165	132	175	65	125	92	73	1183
Africa	-	-	-	-	-	-	-	-	-	-	-	0

Source: MMSA

Global capacity during the same period is likely to increase by ~4.3 MMTPA. Most of the planned capacity additions are in China and USA.

Normally, MTBE is not blended as oxygenate in India. Old refineries like NRL use MTBE to upgrade their naphtha and other blends to meet MS quality requirements. Besides these, MTBE is used as a chemical feedstock by producers like M/s Vinati Organics. Domestic exports during previous years had been:

Table 1.3: Domestic exports of MTBE

Period	Quantity, MT
Jan-Dec 2012	18,944
FY 14-15	33,405
Apr-Aug 2015	10,287

Using MTBE route for Butene-1 production, HPL is likely to produce 98 KTA MTBE. Tentative product placement shall be as given below:

- **Domestic Placement to NRL:** HPL can substitute imports. Expected volume has been assumed equal to ~18 KTA.
- **Exports in SEA:** Singapore is one of the largest importers of MTBE. Annual net imports are in the range of 600-700 KT. Most of these imports are from Middle East. HPL plant at Haldia can be equally competitive with Middle East suppliers. Export realizations have been considered based on FOB Singapore prices after making adjustments for freight and demurrage at Haldia jetty.
- **Alternate Blending in MS:** HPL is currently producing about 200 KTA MS by blending different chemical components. This quantity is planned to be increased further to 332 KTA in next phase. Considering MTBE can be blended @ 8% w/w with HPL MS so that to ensure overall product meets Euro-IV quality norms, , HPL in-house requirement would be about 15-30 KTA.
  It is also anticipated that to meet Euro-VI quality norms from 2020 onwards, HPL MS as well as MS from other refineries would require blending of MTBE. While removing the sulfur and aromatics to meet Euro-VI norms, octane number of MS is likely to be decreased. To boost the octane number, MTBE blending would be needed.

1.3.3 Pyrolysis Gasoline

Low Sulfur Py-Gas stream is proposed to be used for production of MS meeting Euro-VI specifications in terms of Sulfur. Estimated production of MS is about 332 KTA.

Total production of MS in India (2014-15) was about 32 mMTPA, whereas domestic consumption is 17-18 mMTPA. HPL already places about 200 -250 KTA Euro-IV MS in domestic market. As the fuel specifications are becoming stringent over times, HPL does not foresee in placing the production volumes in domestic market.

Current production capacity of Phenol and Acetone in India is 77 KTA and 48 KTA respectively, which are old and operate at 50-60% capacity utilization. Major producers are - M/s Hindustan Organics Chemical Limited and M/s SI group.

M/s Deepak Nitrite Limited is setting up a 200 KTA Phenol which will also produce about 120 KTA Acetone as co-product.
Bulk of domestic demand of Phenol and its derivatives is met through imports. Year-wise imports can be summarized as below:

Table 1.4: Annual Imports of Phenol and Acetone

Years	Annual Imports - Phenol, KT	Annual Imports - Acetone, KT
2005-06	93	64
2006-07	65	60
2007-08	96	65
2008-09	92	68
2009-10	101	80
2010-11	122	78
2011-12	146	101
2012-13	172	96
2013-14	213	117
2014-15	200	127

Rising demand and lack of further capacity additions make this project lucrative for consideration.

1.3.4 Polybutylene Terephthalate

M/s Ester Industries Limited is the only PBT producer in India having a capacity to produce 14 KTA PBT.
Imports are gradually increasing over years necessitating a need of economic sized plant to meet emerging domestic demand.

Table 1.5: PBT Imports in India

Year	Annual Imports, MT
FY 07	5534
FY 08	7033
FY 09	6272
FY 10	8160
FY 11	10666
FY 12	12834
FY 13	13874
FY 14	19801

1.4 EMPLOYMENT GENERATION (DIRECT AND INDIRECT) DUE TO THE PROJECT

HPL is an existing operational industry. Presently, it employs approximately 800 employee. In construction phase, temporary employment will be generated. In operational phase, HPL will recruit 40-50 own employees and 100-150 contract employees to manage the proposed project.

2 PROJECT DESCRIPTION

2.1 BRIEF DESCRIPTION OF NATURE OF THE PROJECT

HPL is one of the largest petrochemical companies in India. It utilizes Naphtha for cracking into intermediate products such as ethylene and propylene and other by-products such as Cyclo pentane, pyrolysis gasoline, motor spirit and benzene. The intermediates are subsequently used for manufacturing polymers such as LLDPE, HDPE, PP, Butadiene, Mixed Butane.

Major process plants within the existing complex, their capacity and licensors are as given below:

Table 2.1: Existing Units, Licensors and Capacity

Plant	Technology Licensor	Capacity, TPA*
Naphtha Cracker Unit	Lummus, USA	7,00,000
Butadiene Extraction Unit	BASF, Germany	1,01,000
Benzene Extraction Unit	Lurgi, Germany	1,32,000
Pyrolysis Gasoline Hydrogenation Unit	Axens, France	5,20,000 (Feed Basis)
C4 Hydrogenation Unit	Axens, France	1,13,000
High Density Polyethylene	Mitsui, Japan	3,34,000
Linear Low Density Polyethylene	Lyondell Basell, Netherlands	3,86,000
Polypropylene	Lyondell Basell, Netherlands	3,41,000
CPP		116 MW + 480 TPH SHP Steam

Based on above mentioned capacity of the plants, current production capacity of different products is summarized below.

Table 2.2: Existing Production Capacity

Sl No.	Product	Capacity, TPA
1	Ethylene	700,000
2	Propylene	350,000
3	HDPE	334,000
4	LLDPE	386,000
5	PP	341,000
6	Pyrolysis Gasoline	130,500
7	Benzene	132,000
8	Butadiene	101,000
9	C6 Raffinate	36,600
10	CBFS	89,300
11	LPG	113,000
12	Cyclopentane	5200
13	Motor Spirit	250,600

To expand current capacity, to diversify product basket and to improve reliability and operational efficiency, HPL is contemplating several new projects.

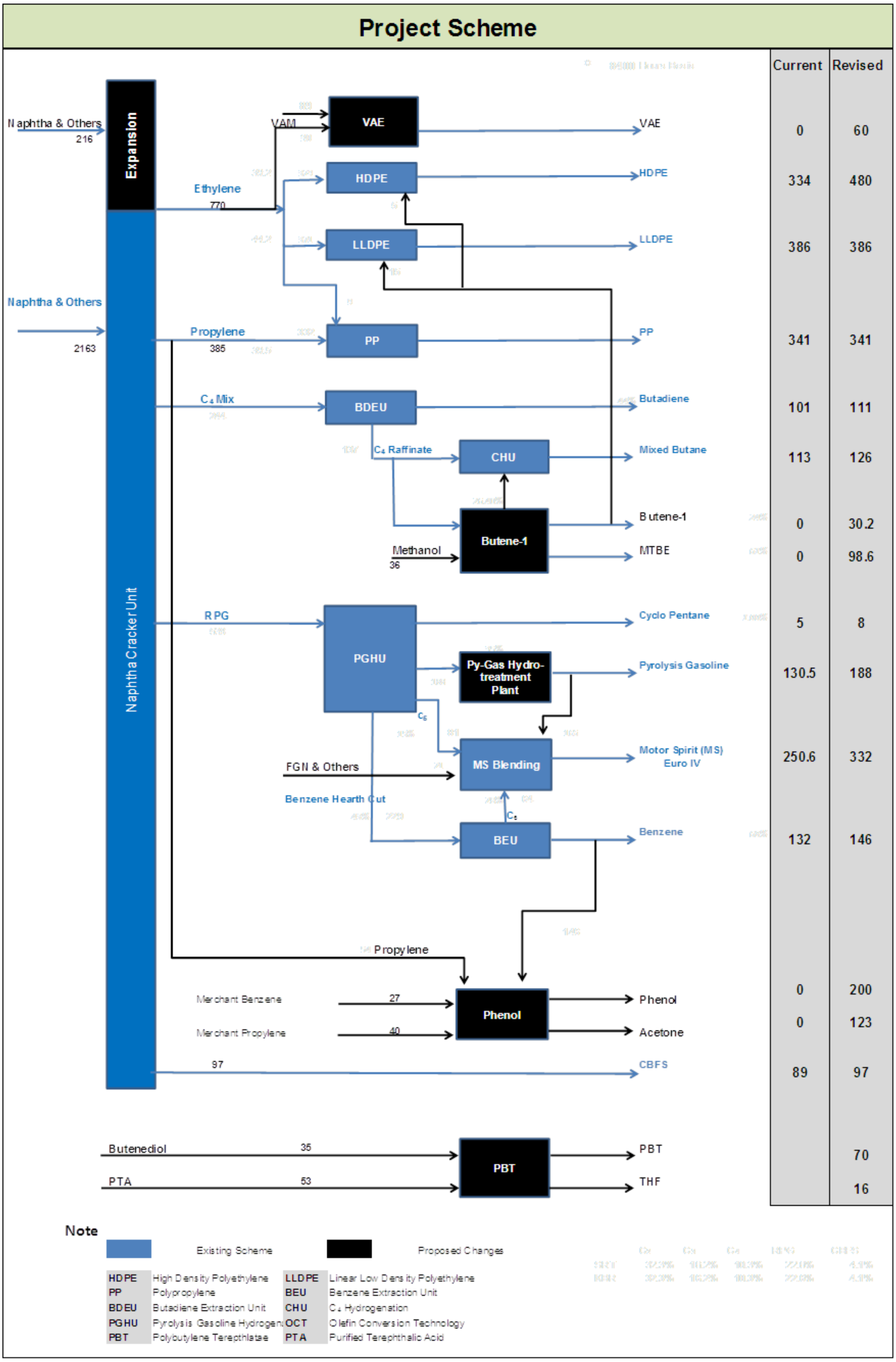
2.2 PROJECTS UNDER CONSIDERATION

Major projects under consideration are:

a. Ethylene Capacity Expansion
b. MS Capacity Expansion & Quality Up-gradation
c. Butene-1 and MTBE
d. Phenol & Acetone
e. Polybutylene Terephthalate
f. Vinyl Acetate Ethylene
g. HDPE Train-3
h. Infrastructure Augmentation

Proposed project scheme and its linkage to existing plant configuration are presented below in Figure 2.1.

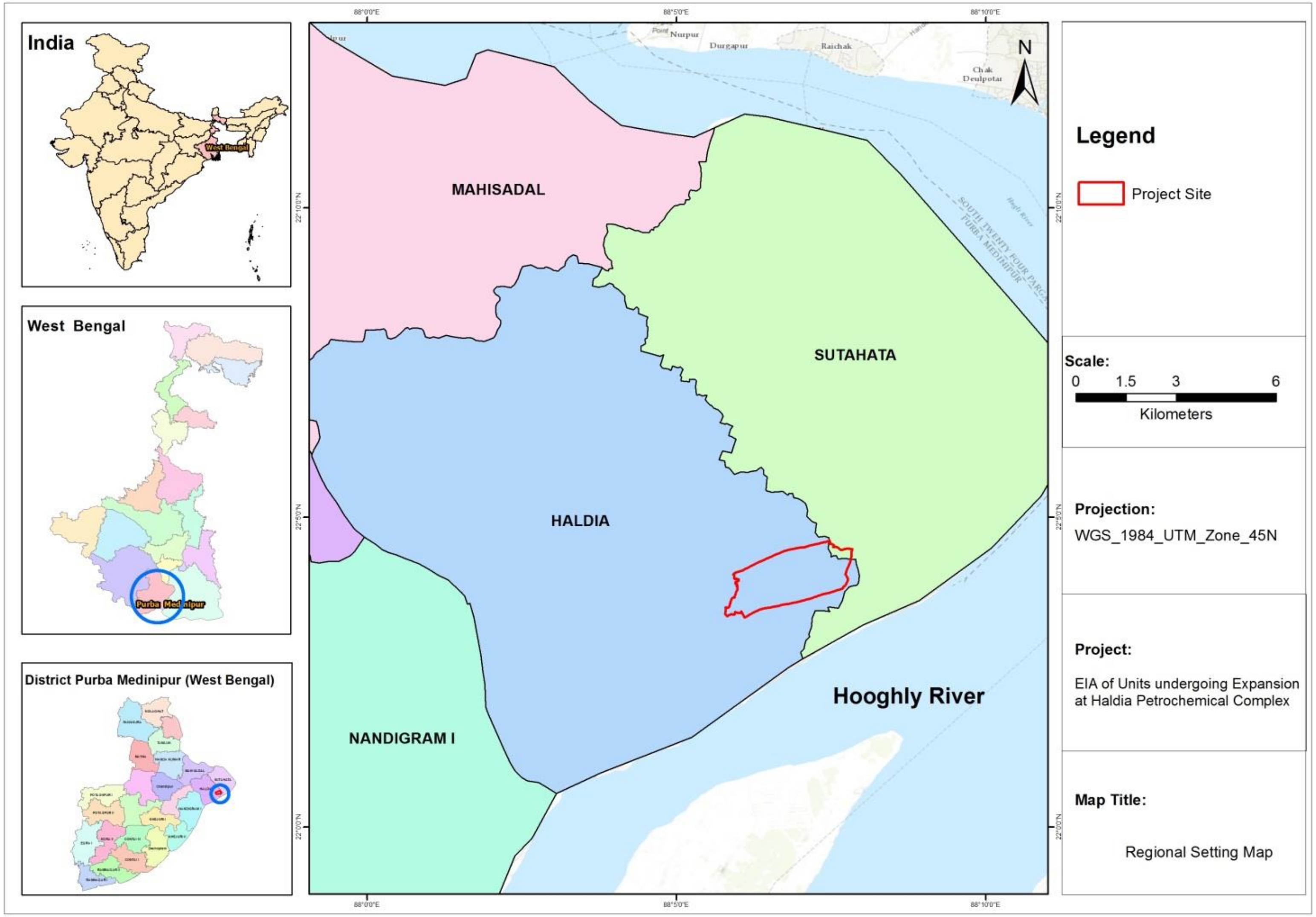
Figure 2.1: A schematic representation of units under going debottlenecking and expansion



2.2.1 Project Location

The proposed project is located at Haldia, East Medinipur, West Bengal. It is 135 km South-West of Kolkata. The regional setting of the project location is shown in Figure 2.2.

Figure 2.2 Regional Setting of Project Location



2.3 PROCESS DESCRIPTION & PROJECT DETAILS

The description of the process which would be covered under the expansion is described in the following sections

2.3.1 Ethylene Capacity Expansion

HPL had expanded its cracking capacity to 700KTA ethylene as part of Project Supermax in 2007. HPL proposes to increase ethylene capacity to ~770 KTA by exploiting the design margins of existing equipment newly installed during the Project Supermax and by providing additional equipment in Naphtha Cracker Unit. These additional equipment would include a heater similar in configuration to the existing heaters for better P+E results based on the simulation results, booster compressor and modification in towers. Refer Annexure – I

2.3.2 LPG Cracking in Naphtha Cracker Unit (NCU)

Currently naphtha along with in-house generated LPG and C5/C6 stream are used as feedstock in Naphtha Cracking Unit (NCU). After commissioning of Butene-1 plant, in-house LPG production would decrease substantially. HPL plans to source merchant LPG to the extent of 8-10 KTPM for better P+E yield and economics. HPL proposes to import LPG, transfer it through dedicated pipeline and store it in tanks and spheres.

2.3.3 Butene-1

HPL generates C4 Raffinate as one of the intermediate product streams, which contains significant amount of Butene-1. Currently, the entire stream is being hydrogenated to mixed butane and is mostly recycled as feedstock in naphtha cracker unit. It is proposed that Butene-1 plant would be set-up to extract Butene-1 for internal consumption in polyethylene manufacturing, thereby reducing dependence on imports. Proposed plant capacity of Butene-1 is 30.2 KTA along with co-production of 98.6 KTA MTBE. Process description and project details are enclosed as Annexure – II.

2.3.4 MS Up-gradation

HPL produces about 250 KTA Euro-IV Motor-Spirit to the characteristic variations in naphtha quality, often poses difficulty in maintaining the Sulfur content below 50 ppmw. Moreover, HPL also plans to convert balance C5/C6 and Py-Gas streams into MS by blending it along with naphtha which requires further addition in storage infrastructure to facilitate storage and proper blending control. MS production is likely to increase to 332 KTA after expansion. To achieve this objective, HPL proposes following additions:

- Additional MS Storage Tanks: 4,000 T
- Additional Py-Gas Storage Tanks: 4,000T
- Additional Naphtha Storage Tanks (FGN): 10,000 T
- Setting up a Py-Gas Hydro-treatment Facility to reduce sulfur content in Pygas to 1.0 -1.5 ppm. The plant is designed to process 30 TPH of Py-Gas. The details of the project scheme are enclosed as Annexure – III.

2.3.5 Phenol & Acetone

Benzene is manufactured by HPL within existing complex. HPL proposes to convert this Benzene along with merchant propylene (and along with Propylene manufactured through naphtha cracker expansion) to produce Phenol and Acetone by setting up a 200 KTA Phenol plant. The project scheme and other details are enclosed as Annexure – IV.

2.3.6 Polybutylene Terephthalate (PBT)

In order to diversify its product stream and to venture into engineering plastics sector, HPL proposes to set-up a 70 KTA PBT plant using PTA and 1,3 Butanediol as feedstock. The project scheme is enclosed as Annexure –V.

2.3.7 Additional Chain of HDPE

Part of the surplus ethylene is proposed to be utilized for setting up a 160KTA HDPE chain, similar to existing configuration. The details have been provided in Annexure-VI.

2.3.8 Vinyl Acetate Emulsion

It is proposed to set-up a 60 KTA VAE Plant utilizing ethylene and vinyl acetate monomer,. Details are available in Annexure – VII.

Based on these capacity additions, revised product configuration and capacity can be summarized as below:

Table 2.3: Current and revised capacity

Sl No.	Products	Current Capacity, KTA	Proposed Revised Capacity, KTA
1	Ethylene	700	770
2	Propylene	350	385
3	High Density Polyethylene (HDPE)	334	480
4	Linear Low Density Polyethylene (LLDPE)	386	386
5	Polypropylene	341	341
6	Butadiene	101	111
7	Mix Butane/C4 Raffinate	113	126 [Note-1]
8	Butene-1	0	30.2
9	MTBE	0	98.6
10	Benzene	132	146 [Note-2]
11	Pyrolysis Gasoline	130.5	188 [Note-3]
12	MS	250.6	432
13	Cyclopentane	5.2	8
14	CBFS	89.3	97
15	Phenol	0	200
16	Acetone	0	123
17	Polybutylene Terephthalate (PBT)	0	70
18	THF	0	16
19	Vinyl Acetate Ethylene (VAE)	0	600

Note-1: When Butene-1 plant would be out of operations,
Note-2: If Phenol plant is not operational
Note-3: To be produced in maximum when MS is not under production.

2.4 ANCILLARY INFRASTRUCTURE

To support these plants, existing infrastructure needs to be upgraded to accommodate additional requirements. These can be categorized under following sub-categories:

1. Storage Tanks & Spheres
2. Loading/Unloading Pipelines
3. Utilities System

2.4.1 Storage Tanks & Spheres:

Existing storage capacity of various hydrocarbons is enclosed as Annexure - VIII. Augmentation of storage capacity is needed to support

A. Existing plant configuration
B. New capacity additions in product basket as mentioned in Section III.

A. Augmentation of Storage Capacity for Existing Plant Configuration

To support existing plant in a safe and reliable manner considering local constraints, infrastructure additions need to be made for:

- Petrochemical Grade Naphtha Storage
- LPG Storage Tanks/Spheres
- Butadiene Storage Sphere

Requirement of Additional Feedstock/Petrochemical Grade Naphtha Storage Tank

Current, HPL has 5 x 42,735 m3 storage tanks for storing petrochemical grade naphtha, main raw material for the plant. At full capacity operations, tank storage capacity is adequate to store raw material for 24 days requirements (140-145 KT). However, 4 out of 5 tanks are about 16-17 years old and need periodic inspection and maintenance. Moreover, even to meet statutory requirements, these tanks are required to be inspected at least once in 5 years. Each internal inspection of these tanks requires complete decommissioning and would take 3-4 months for the entire process to be completed. Effective storage capacity of feedstock naphtha storage reduces to about 19 days during unavailability of one of these tanks.

Moreover, there has been gradual decline of river draft in Haldia over years. Since last several years HPL is forced to conduct Ship-to-Ship Transfer (STS) at Vizag into mother and daughter vessels to ensure at least LR1 cargo volume (50-55 KT) can be brought to Haldia with reasonable cost effectiveness. Even LR1 volume can be unloaded with STS only twice a month, when the draft is at its peak during full tide. To meet entire feedstock requirements, HPL need to unload two such cargoes of 55 KT each during one of these peak tides every month. Considering safety stock needed for supply variations, HPL requires availability of all five storage tanks every month.

Fuel Grade Naphtha (FGN) is used as a one of the fuels for steam and power generation in CPP. HPL was primarily sourcing FGN from Numaligarh Refinery Limited, Assam. The naphtha was brought to Haldia via road tankers and was supplied to HPL directly in tankers or via pipeline through NRL storage tanks at Haldia.

After recent quality upgradation and use as feedstock in Brahmputra Cracker Private Limited (BCPL), this source of FGN does not exist for HPL. As a result, HPL needs to source FGN from other domestic coastal refineries or need to import. Economic Parcel size of any of these sources is about 18-20 KT.
To facilitate unloading of economic size of FGN parcel, additional naphtha storage tank of similar capacity i.e. 42,735 m3 is needed for naphtha storage.

Augmentation of LPG Storage Capacity

As mentioned in section 2.3.2, LPG production is likely to decrease after beginning of Butene-1 plant operation. HPL proposes to crack additional LPG as feedstock. To store merchant LPG, it is proposed to add storage volume of 10,000 T (20,000m^3) to existing storage infrastructure.

Augmentation of Butadiene Storage Capacity

Current, HPL has 4 storage spheres of capacity 2,050 m^3 each. HPL sells bulk of its volume in export market. Earlier, parcel size of most export consignment was of size 1,500 T. Recently, due to jetty congestion, HPL has increased the parcel size from 1,500 T to 3,000 T. However, even then, sometimes jetty congestion delays cargo loading from usual loading dates, thereby creating serious problems for Butadiene ullage.
Additionally, HPL needs to ensure statutory testing of these spheres requiring 3-4 months shutdown, HPL is facing serious challenge in storage management.

Considering that parcel size of current export consignments has increased to 3,000 T as well as to manage uncertainties in loading dates, HPL needs additional storage sphere of 2,050 m^3.

The summary of additional storage facilities proposed to be built for existing plant not undergoing expansion is provided in Table 2.4.

Table 2.4 Additional storage requirement for existing plant not undergoing expansion

Sl. No.	Proposed Plant	Chemical	No. of Tanks/ Spheres	Working Capacity of Each Tank, m^3	Total Capacity, m^3
1	MS	MS	1	4,000	4,000
2	MS	Py Gas	1	4,000	4,000
3	MS	MS Batch Tank	1	1,210	1,210
4	Naphtha	Naphtha	1	42,735	42,735
5	FGN	FGN	1	14,000	14,000
6	Butadiene	Butadiene	1	2,050	2,050

Sl. No.	Proposed Plant	Chemical	No. of Tanks/ Spheres	Working Capacity of Each Tank, m^3	Total Capacity, m^3
7	LPG	LPG	1	20,000	20,000

B. Augmentation of Storage Capacity for New Process Plants/Capacity Expansions

New storage facilities will be constructed for the proposed new plants/plants undergoing capacity expansions. The capacity of storage to be built for the chemicals that will be stored within the existing plant is summarized in Table 2.5.

Table 2.5: Storage Requirement for new capacity additions

Sl. No.	Proposed Plant	Chemical	No. of Tanks/ Spheres	Working Capacity of Each Tank, m^3	Total Capacity, m^3
1	Butene-1	Methanol	2	4000	8000
2	Butene-1	MTBE	2	6,500	13,000
3	Phenol	Phenol	3	5,000	15,000
4	Phenol	Acetone	2	5,000	10,000
5	PBT	Butanediol	2	3,100	6,200
6	VAE	VAM	2	5,500	11,000
7	VAE	VAE	2	4,000	8,000
8	PBT	THF	2	2,000	4,000

The addition in storage capacity for each new process plant and/or capacity expansions is defined during the process description of each unit (Refer Annexure -I to VII).

C. Consolidated Additions in Infrastructure for Hydrocarbon Storage (To Support New Process Plants and Existing Operations, Both)

The consolidated storage facilities that will be required to be built for infrastructure augmentation for existing plants not undergoing expansion and for proposed new plants/plants undergoing capacity expansions is summarized in Table 2.6.

Table 2.6 Consolidated storage requirement for new capacity additions

Sl. No.	Proposed Plant	Chemical	No. of Tanks/ Spheres	Working Capacity of Each Tank, m^3	Total Capacity, m^3
1	Butene-1	Methanol	2	4000	8000
2	Butene-1	MTBE	2	6,500	13,000

3	Phenol	Phenol	3	5,000	15,000
4	Phenol	Acetone	2	5,000	10,000
5	PBT	Butanediol	2	3,100	6,200
6	VAE	VAM	2	5,500	11,000
7	VAE	VAE	2	4,000	8,000
8	PBT	THF	2	2,000	4,000
9	MS	MS	1	4,000	4,000
10	MS	Py Gas	1	4,000	4,000
11	MS	MS Batch Tank	1	1,210	1,210
12	Naphtha	Naphtha	1	42,735	42,735
13	FGN	FGN	1	14,000	14,000
14	Butadiene	Butadiene	1	2,050	2,050
15	LPG	LPG	1	20,000	20,000

2.4.2 Loading/Unloading Pipelines

As explained in project descriptions of each projects, following additions in hydrocarbon loading/unloading lines are needed:

- Methanol Unloading Pipeline
- MTBE Loading Pipeline
- Propylene Unloading Pipeline
- Phenol Loading Pipeline
- Acetone Loading Pipeline
- Butanediol Unloading Pipeline
- VAM Unloading Pipeline
- LPG Unloading Pipeline

2.5 REQUIREMENT OF RESOURCES

The major resources required additionally are:

- Cooling Water
- Steam
- Power
- DM Water

Consolidated requirement has been summarized as below in Table 2.6

Table 2.7 Utility Requirement for Expansion

Units	Total Steam, TPH	Total Power, KWh	CW Handling Capacity, m3/h
Ethylene Capacity Expansion	6.6	3,049	3,500
Butene-1	23.7	425	1,490
MS Capacity Expansion & Quality Upgradation (Py Gas Hydrotreatment)	4	210	245
Phenol	75.25	4,550	7,550
PBT	2.8	686	845
VAE	20	2000	3,500
HDPE Train-3	11.2	5,500	4,350

Units	Total Steam, TPH	Total Power, KWh	CW Handling Capacity, m3/h
Miscellaneous (20% of Sum of Above)	**~28.7**	**~3,285**	**~4,295**
Total	**172.25**	**~19,705**	**~25,775**

To support additional steam and power, develop backup capacity and to take care of future requirements, HPL propose to add additional coal fired boilers and turbine. The details are enclosed as Annexure – IX.
To support the steam generation, HPL would set-up additional chain of DM Water Plant having production capacity of 150 m3/h.

Cooling Water Capacity of ~26,000 m^3/h would be provided to support proposed capacities.

2.5.1 Water Availability

The existing water requirement of HPL is 7.6 MGD on annual average basis. The break-up of the water requirement can be summarized below:

- Cooling Water Makeup : 5.3 MGD (24,250 m3/d)
- DM Water : 1.2 MGD (5,370 m3/d)
- Plant Water/Service Water : 0.3 MGD (1,240 m3/d)
- Drinking Water :0.2 MGD (1,020 m3/d)
- Fire Water & Others : 0.6 MGD (2,725 m3/d)
- Total Existing Water Requirement : 7.6 MGD (34, 605 m3/d)

From proposed projects, additional water requirement is in the form of:

- Cooling Water Makeup : 7,000 m3/d
- DM Water for Boiler Feed : 2,000 m3/d
- Additional Plant Water/Fire Water/Drinking Water : 1,000 m3/d
- Total Additional Water : 10,000 m3/d (2.2 MGD)

Total water requirement even after including proposed projects is about 10 MGD. HPL has a dedicated pipeline to get a supply up to 14 MGD. Existing agreement has a provision to get water up to 8.4 MGD from Haldia Development Authority. Existing water uptake agreement with Haldia Development Authority would be suitably revised to get assured supply of 10 MGD± 20% raw water supply.

2.6 POLLUTANTS AND THEIR MANAGEMENT

Environmental impacts of proposed projects have been described individually in each project description as mentioned in Annexure – I to VI. The management plan may broadly include:

2.6.1 Management of Air Emissions

Major air emissions and their management plans have been provided below.

A. Emissions from Process Vents

All hydrocarbons containing vent gases and the pressure relief valve gases would be discharged via blowdown vessel to flare stack for combustion and safe disposal. Wherever possible, off gases would be reused as fuel gas. If the off-gases/vent emissions contain some harmful substances and need incineration in controlled conditions, the same would be provided with existing incinerator. In case of specific treatment before disposal to flare/incinerator, the same would be provided as recommended by process licensors.
Adequacy of flare system would be checked and capacity would be augmented to take care of emergency load after finalization of Basic design.

B. Engineering Packages of Individual Plants

Fugitive Emission from Plant and Offsite Storage Tanks: Fugitive emissions would be managed through a combination of measures such as:

- Design of storage tanks and spheres will be constructed as per applicable standards. Nitrogen blanketing would be provided wherever possible.
- Foam of foam seals to prevent release of hydrocarbons to atmosphere
- Use of mechanical seals
- Closed Sampling System
- Sprinkler/Fog system for managing coal dusts during handling. Ash handling would be done in a closed system so that to reduce emissions to atmosphere.
- Comprehensive Leak Detection and Repair (LDAR) program

Stack Emissions: Major emissions would take place from the stacks of boilers proposed for coal based energy generation. Major pollutants likely to be emitted are:

- Oxides of Nitrogen and Sulfur
- Particulate Matter

Oxides of sulfur would be managed by sourcing low sulfur fuel, whereas, nitrogen oxide emissions would be controlled through proper burner design.
Stack of sufficient height would be provided to minimize the impact of particulate emissions during boiler stacks during coal burning.

2.6.2 Liquid Waste Management

Major sources of process effluents generated from various plants can be summarized as below:

- Ethylene Expansion : 3.5 m3/h
- Butene-1 : 2.6 m3/h
- Phenol : 25.3 m3/h
- PBT : 2 m3/h
- VAE : 5 m3/h
- HDPE Train-3 : 3.5 m3/h
- Total Process Effluent: ~42 m3/h i.e. ~1,000 m3/d

Apart from the above, additional effluent would be generated from Cooling Tower Blowdown (CTBD) and DM Plant Neutralization Waste. Estimated generations of these wastes can be summarized as below:

- Cooling Water Blow Down + DM Waste : 1,500 m3/d

The effluent generated from new projects is proposed to be treated within existing Wastewater Treatment Plant before disposal to Green Belt Canal. The amount of current effluent generation and design capacity of existing WWTP can be summarized in Table 2.8

Table 2.8 Characteristics of WWTP

Sl. No.	Type of Effluent	Design Capacity	Annual Average Generation – Current Condition*	Estimated Annual Average Generation after Expansion
1	Process Effluent	3,600 m3/d	2,394 m3/d	3,400 m3/d
2	Cooling Tower Blowdown + DM Waste	~28,200 m3/d	3,506 m3/d	5,000 m3/d
3	Sanitary Waste	490 m3/d	188 m3/d	225 m3/d

*Maximum of Annual Average Values of Last 5 Years

These quantities are within the design limit of the existing WWTP i.e. 4,090 m3/d (Industrial Waste + Sanitary Waste) and can be treated with the existing infrastructure. The process description of WWTP is enclosed as Annexure – XI.

2.6.3 Solid Waste Management

Major solid wastes from proposed projects are:

- Spent Catalysts & Additives
- Bio-sludge Generated from Wastewater Treatment Plant
- Ash Generation from Coal Burning

Spent catalysts and additives would be disposed of as recommended by the licensors either through buy-back arrangement and/or disposal in MoEF authorized solid waste disposal facility located in Haldia.

Bio-sludge would be incinerated and the ash would be disposed with MoEF authorized solid waste disposal facility.

Fly ash from coal burning would be sold to cement manufactures and/or brick kilns for its reuse. HPL would also sell the bottom ash for land-filling of low lying areas or preparation of road embankments.

Schematic representations of the feasibility drawing which give information of EIA purpose

3 SITE ANALYSIS

This section deals with the brief description of the baseline environmental features of the site. The in-depth study of the baseline environment will be conducted in EIA study.

3.1 CONNECTIVITY

The area in which the site is located is connected with road, railways and water ways. National Highway-41 connects Haldia with National Highway-6 at Kolaghat. There is another road Panskura- Durgachak that connects Haldia to main South-Eastern railway line at Panskura. The nearest station is Hatiberia, approximately 3km away. Haldia is also accessible from Diamond Harbour road through a ferry between Raichak and Kukrahati across River Hugli. The aerial distance of Kukrahati is approximately 13km from site.

3.2 LAND FORM, LAND USE AND LAND OWNERSHIP

The terrain of the land is plain, the proposed expansion will occur in an existing industry – Haldia Petrochemicals Limited. The industry is located in the Haldia Notified Area governed by Haldia Notified Area Authority.

3.3 CLIMATIC DATA

The climate of the project area is humid and tropical. It is characterized by hot and dry summer from March to May, a south-west monsoon or rainy season from June to September, a pleasant post-monsoon or retreating monsoon from October to November and a cool winter from December to February. In winters, minimum and maximum temperatures range from 9.6 to 29.3°C and in summers, it range from 24 to 42°C. The humidity in the region ranges from 68 to 80% throughout the year.

3.4 PLANNING BRIEF

The industry is located in Haldia Notified Area. New infrastructure for connectivity will not be required to be built as part of the proposed project. The source and supply for drinking water will remain same and will not change due to the proposed project. The existing sewerage system will be utilized during construction and operation in the proposed project. The solid waste generated during construction and operation of the proposed project will be disposed as per the existing practice. The process in-detail will be described later in EIA study report

The existing land details of HPL complex can be summarized as below:

- Total Area : 453 ha
- Area within Boundary Wall : 292 ha
- Greenbelt Area : 103 ha
- Vacant Land within Boundary Wall : 63 ha
- Vacant Land outside Boundary Wall : 51 ha (Including Road & Water Bodies)

Plants proposed under current expansion are proposed to be located within the vacant land available with HPL and does not require any additional land acquisition. The plot plan is enclosed as Annexure- IX.

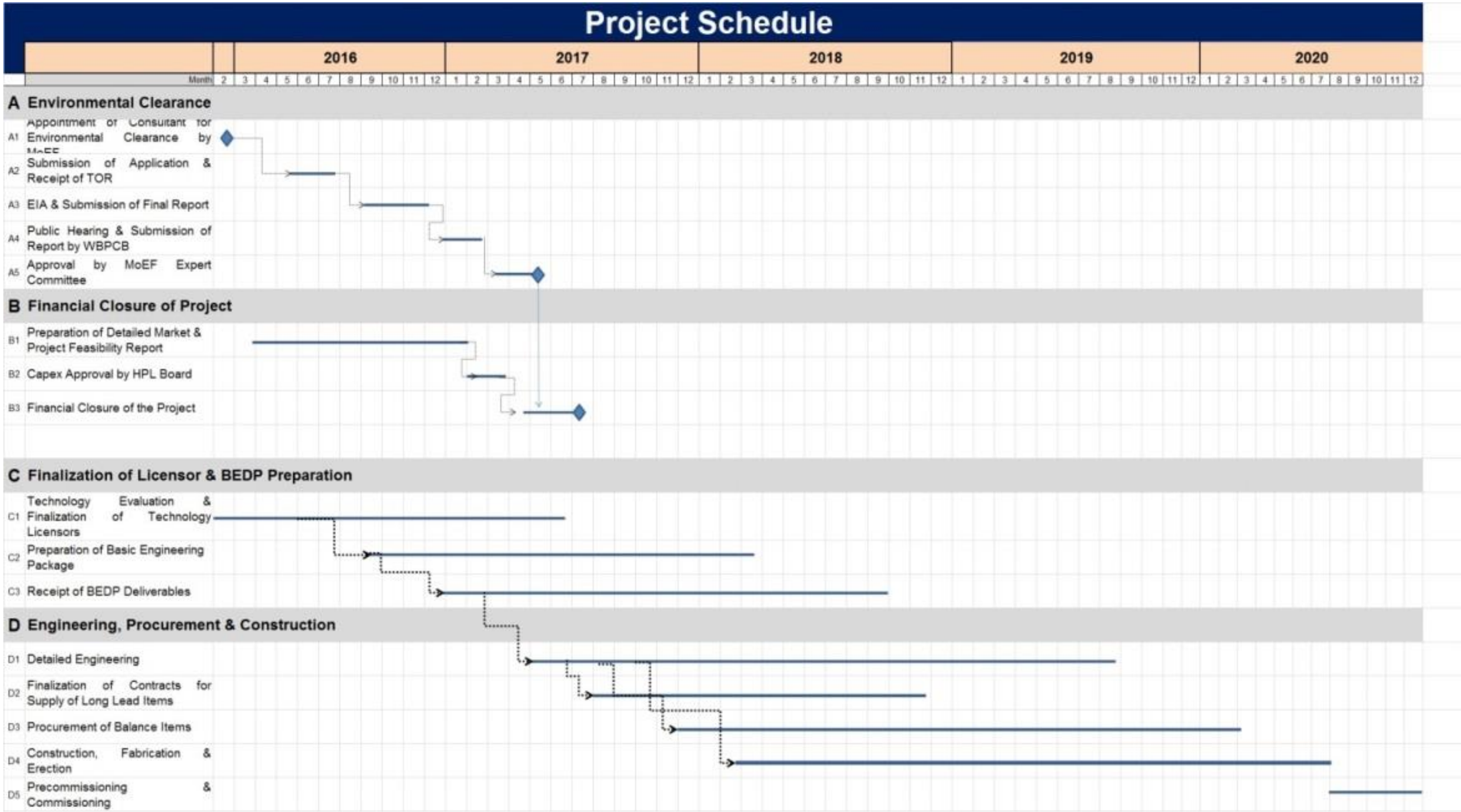
3.5 REHABILITATION AND RESETTLEMENT

Rehabilitation and resettlement plan will not be required for this project since the proposed project is located in an existing industry and will not entail acquisition of land.

3.6 PROJECT SCHEDULE AND COST ESTIMATES

The duration of the entire process from appointment of an environmental consultant to commissioning of the project has been estimated to be for five years.
It has been estimated approximately sixteen months will be required for environmental clearance from MOEFCC.
In between the time required for environmental clearance, the financial estimation of the proposed project will be finalised in parallel.
The finalization of the licensor and the basic engineering design is estimated to be finalised by the end of August, 2018.
The basic engineering, procurement and construction is estimated to be completed by 2020.

The estimated cost of the proposed project is 4310 crores of INR.


Project Schedule
2016
2017
2018
2019
2020
Month
A Environmental Clearance
A1 Appointment of Consultant for Environmental Clearance by MoEF
A2 Submission of Application & Receipt of TOR
A3 EIA & Submission of Final Report
A4 Public Hearing & Submission of Report by WBPCB
A5 Approval by MoEF Expert Committee
B Financial Closure of Project
B1 Preparation of Detailed Market & Project Feasibility Report
B2 Capex Approval by HPL Board
B3 Financial Closure of the Project
C Finalization of Licensor & BEDP Preparation
C1 Technology Evaluation & Finalization of Technology Licensors
C2 Preparation of Basic Engineering Package
C3 Receipt of BEDP Deliverables
D Engineering, Procurement & Construction
D1 Detailed Engineering
D2 Finalization of Contracts for Supply of Long Lead Items
D3 Procurement of Balance Items
D4 Construction, Fabrication & Erection
D5 Precommissioning & Commissioning

3.7 ANALYSIS OF PROPOSAL (FINAL RECOMMENDATION)

3.7.1 Financial Benefits

This section includes analysis of (a) the financial and social benefits both direct and indirect

A. Direct Economic Benefits

Employment will be generated during construction phase as labourers from local work force will be engaged.

B. Indirect Economic Benefits

HPL is an existing operational industry with approximate employee strength of 800. Indirect economic benefits are already accrued by the local people. Considering the rise in economic activities, increased logistics demand etc., there will be incremental indirect benefits to local manpower from proposed projects.

Annexures

Ethylene Capacity Expansion

I. Introduction

Current ethylene capacity of Naphtha Cracker Unit is 700 KTA Ethylene. During the operations in last one year, plant capability to produce at design capacity has been established.

Based on the preliminary study done by the process licensor M/s Lummus Technology, design margins to the extent of 10-15% have been observed in certain sections of the plant. HPL envisages exploiting design margin and expanding ethylene capacity by 10% to 770 KTA Ethylene by addition of new furnace and augmentation of charge gas compression system. During the design stage, decision would be taken to tweak the configuration and decide on:

1. Augmentation of capacity by adding additional heater of configuration similar to existing heater /configuration higher to existing heater

2. Augmentation of capacity by adding additional heater for Catalytic Cracking using naphtha or Olefinic feed to get better P+E generation

Demand-Supply Scenario

Subsequent to commissioning of new cracker by GAIL and BCPL, ethylene capacity in India is 4.5 mMTPA. Additional 2.7 mMTPA capacity is under construction, which would increase the overall capacity to 7.2 mMTPA by 2017.

On demand side, demand of ethylene derivatives as per Petrochemical Sub-committee Report under 12th Five Year Plan can be summarized as below:

	Demand Based on Petrochemical Subcommittee Report, KTA		***Derived Ethylene Demand, KTA***	
	2011-12	2016-17	2011-12	2016-17
LDPE	405	597	405	597
LLDPE	1,198	2,076	1,102	1,910
HDPE	1,657	2,573	1,657	2,573
PVC	2,087	3,102	960	1,427
MEG	1,836	3,024	918	1,512
Styrene	496	647	134	175
Total Ethylene Demand (Excluding EPDM, EVA etc.)			***5,176***	***8,194***

As it can be seen above, even after proposed capacity expansion, derived demand of ethylene and its derivatives is higher vis-à-vis installed capacity and India would remain dependent for some of the ethylene derivatives.

II. Project Scope

The project scope includes the following:

- Addition of new furnaces
- Augmentation of Charge Gas Compression Section
- Debottlenecking of Fractionators etc.

III. Project Investment

Indicative investment for heater, reactors and debottlenecking of purification sector is 60-70 Mn USD.

IV. Process Description

Naphtha Cracker Unit (NCU) mainly consists of five different sections as shown in the above process flow diagram. These sections are:-

1. *Furnace Section*
2. *Quench Tower (QT), Pyrolysis Fuel Oil (PFO) and Gasoline Fractionator (GF)*
3. *Compressor Section*
4. *Chilling Section*
5. *Cold and Hot Section*

Furnace Section

Furnace section comprises of eight main furnaces and one recycle furnace. The fresh Naphtha and recycle C5 and C6 from battery limits is received from the feed handling system at pressure, combined, and preheated by quench water to 60oC before being sent to the cracking heaters. This feed is distributed in any combination to the eight main cracking heaters.

The C3 and C4 LPG from battery limits are fully vaporized and preheated to $60^{o}C$ by LP steam before being sent to the cracking heaters. This feed can be cracked in separate passes of three SRT IV heaters. The internal recycle ethane stream, is superheated to $60^{o}C$ with quench water after process refrigeration has internal recycle ethane stream is superheated to 60oC and sent to the first cracking heater. The cracking effluents are then cooled in the transfer line exchangers (TLE) and sent to the Gasoline fractionator for further heat removal and distillation. In the process of cooling the effluents superheated steam is formed in the TLEs.

Quench Tower (QT), Pyrolysis Fuel Oil (PFO) and Gasoline Fractionator (GF)

After the heater effluents have been cooled, they are sent to the Gasoline Fractionator, where further high level heat is removed, and pyrolysis fuel oil (PFO) is recovered. The vapor overhead from the GF is sent to the Quench Tower. This stream contains the dilution steam and Pyrolysis Gasoline and lighter hydrocarbons. Overhead vapor from the gasoline fractionator is cooled and partially condensed by direct countercurrent contact with recirculating water in the quench tower. The hot recirculating water from the quench tower supplies low level heat to various process users. The dilution steam, condensed in the quench tower, is sent to the Process Water Stripper, where it is stripped with steam to remove acid gases and volatile hydrocarbons before being re-vaporized and sent back to the furnaces. High level heat is removed from the system by heat exchange of the fractionator bottoms stream (circulating quench oil) with process water from the quench tower to generate dilution steam. A major portion (87%) of the quench oil is then circulated back to the liquid cracking heater quench points to control quenched effluent temperatures.

Compressor Section

The quench tower overhead vapors move to the five-stage centrifugal compressor with interstage water cooling. Cooling at the interstages and compressor discharge results in both water and hydrocarbon condensation. The condensate from the third stage discharge drum is recycled to the third stage suction drum; the condensate from the third stage suction drum is recycled back to the second stage suction drum where hydrocarbon and water separation takes place. Water condensed in the second stage suction drum is recycled to the first stage suction drum and then to the quench tower. Hydrocarbon condensed in the second stage suction drum is heated by LP steam and flashed in the medium gasoline flash drum. Vapor from this drum is sent to the quench tower. The remaining liquid, which is medium gasoline, is pumped and split into two streams. One stream is recycled to the bottom of the quench tower to maintain adequate hydrocarbon inventory for gasoline fractionator reflux and remainder is combined with heavy gasoline from quench tower and light gasoline from debutanizer bottoms to make up the total raw pyrolysis gasoline product.

Chilling Section

The charge gas from the dryers is progressively cooled against the process and ethylene and propylene refrigeration. Various process streams are used at the appropriate temperature level to maximize the overall thermal efficiency of the plant. Ethylene and propylene refrigerant streams are used to supply trim chilling to achieve the required terminal temperatures necessary for proper charge gas vapor and liquid compositions. As it is cooled, condensed liquid is separated from the vapor at various points in demethanizer feed separator drums. Liquid from these drums supplies the four feeds to the demethanizer. The residual vapor is used to produce concentrated hydrogen and methane streams.

Cold and Hot Section

The condensed liquids from the charge gas chilling train are sent to the appropriate feed locations of the Demethanizer. This tower is operated at a pressure high enough to permit using the overhead methane product for dryer regeneration before finally entering the fuel gas system. The bottoms product (Deethanizer feed) is heated by sub-cooling liquid ethylene and propylene refrigerant, after which it is split into two streams. One stream is fed directly to the Deethanizer. The other is further preheated with charge gas leaving the dryers before feeding the Deethanizer. Net overhead vapor product from the Deethanizer, made up mainly of C2's, is fed to the Acetylene Converters, while net bottoms (C3+) feeds the Depropanizer for further fractionation. Acetylene is removed from the net Deethanizer overhead product by selective catalytic hydrogenation of the acetylene to ethylene and ethane. After removal of acetylenes, the stream is fed to the ethylene fractionator. The Ethylene Fractionator fractionates ethylene from ethane, and removes lighter components from the ethylene thus producing a polymer grade ethylene product of high purity. The Depropanizers are designed to reject C4 and heavier components from the process streams, in preparation for propylene fractionation. The Propylene Fractionator fractionates propylene from propane, and removes lighter components of hydrogen and methane from the propylene, thus producing a polymer grade propylene product. The Debutanizer separates C4's from C5+ components in the Depropanizer bottoms. The overhead is totally condensed with cooling water to provide reflux and a net mix C4 stream is sent to battery limits to storage or for further processing in the butadiene extraction unit. Bottoms liquid from the tower, containing C5+ compounds, forms the light gasoline, which is mixed with the heavy and medium gasoline from the Quench Tower and Charge Gas Compressor train, cooled, and sent to storage outside battery limits as Raw Gasoline Product.

VI Environmental Factors

Due to processing of additional feeds in proposed heater, there would be corresponding increase in generation of effluents/solid waste and emissions. It can be summarized as below:

A. Aqueous Effluent

Additional liquid effluent would be generated from following sections:

- Dilution Steam Drum Blowdown
- Continuous Blowdown from SHP Steam Drum
- Intermittent Blowdown from SHP Steam Drum & Transfer Line Exchangers
- TLE Hydrojetting Water
- Pretreated (Gasoline Wash) Spent Caustic
- Polymeric Oil from Caustic/Water Wash Tower
- Wash Water from Caustic/Water Wash Tower

Tentative increase in effluent generation and its quality can be summarized as below:

Source	**Avg. Vol, m^3/h**	**Max Vol. m^3/h**	**pH**	**O & G, mg/L**	**TSS, mg/L**	**BOD, mg/L**	**COD, mg/L**
Dilution Steam Drum Blowdown	1.2	2.4	8.5-10	10-100	200 max	100-300	200-500
Continuous Blowdown from SHP Steam Drum	~1.0	-	9.5		20 max	5	15
Pre-treated (Gasoline Wash) Spent Caustic	1.3	-	**Sodium Hydroxide** – 1.25% (w/w); **Sodium Carbonate** – 5.44% (w/w); **Sodium Sulfide** – 2.91% (w/w); **TOC** – 6,000 ppm; **Phenols** – 50 ppm max; **Free Oil** – 1,000 ppm max				
Polymeric Oil from Caustic/Water Wash Tower	Marginal Increase from Current Generation						

Wash Water from Caustic/Water Wash Tower	Marginal Increase from Current Generation

Additional effluent would be treated in existing Wastewater Treatment Plant before final disposal.

B. Gaseous Emissions

Following gaseous emission streams would be produced from the proposed enhancement in capacity –

- **Cracking Heater Flue Gas During Normal Operation**: About 90 TPH at 105-110^0 C majorly containing N_2, O_2, CO_2 and H_2O. Major pollutants are:
  - **NO_x** : 80 ppmv @ 3 Mol % O_2 (dry)
  - **CO** : 9-11 ppmv @ 3 Mol % O_2 (dry)
  - **Hydrocarbons** : 6-10 ppmv
  - **Particulates** : 5-10 ppmw
  - **SO_2** : NIL
- **Gas Emission during Decoking**: 60-90 TPH @ 250^0 C having characteristics as:
  - **Pollutants** : 20-25 ppmv @ 3 Mol % O_2 (dry)
  - **CO** : 10-25 ppmv @ 3 Mol % O_2 (dry)
  - **Hydrocarbons** : 5-10 ppmv
  - **Particulates** : 5-10 ppmw
- **Acetylene Converter Regeneration Offgas**
- **MAPD Converter Regeneration Offgas**

C. Solid Waste Generation

There may be marginal increase in frequency of generation of following kinds of solid wastes:

- Spent Catalysts & Desiccants
- Coke from Portable TLE Hydrojetting Separator
- Coke from Quench Oil Suction & Discharge Filters
- Coke from Fuel Oil/Purge Oil Filters

These waste generations would be incinerated/sold to authorized re-processors in a manner similar to current practice.

Butene-1 Plant

1.0 INTRODUCTION

Butene-1 is a colorless, flammable, liquefied gas with a slightly aromatic odor.Major applications of Butene-1 are:

- As co-monomer in LLDPE & HDPE manufacturing. Accounts for more than 70% of total demand
- Manufacturing of Polybutene-1 by polymerization of butene-1
- Manufacturing of Valeraldehydes, 1,2butylenes oxide, butyl mercaptan, and butyl phenols.

Global demand of Butene-1 is rising led by rising demand and capacity of LLDPE polymer. However, Butene-1 supply in Asia is extremely tight and it is projected to further tighten in future. Most of the new ethylene capacity additions taking place are from gas based plant which does not produce C_4 stream. Hence C_4 stream which is used as raw material for Butene-1 plant is becoming a scarce commodity day by day. Butene-1 produced from alternate route, ethylene dimerization will also not be cheap as it consume high value product, ethylene, as raw material.

Sourcing of butene-1 for HPL is becoming increasingly difficult due to shortage of supply in domestic and international markets. In view of growing demand of LLDPE and shortage of Butene-1 in market, it has become a product of strategic importance.

HPL is planning to set-up a Butene-1 manufacturing plant where C_4-raffinate, a by-product of Butadiene plant will be used as feed stock. The Butene-1 produced will be used for in-house consumption in LLDPE plant and balance will be sold in domestic market.

2.0 PROJECT SCOPE

The project scope includes:

1. Butene-1 Manufacturing Plant for extracting Butene-1 from C_4 Raffinate
2. Methanol Unloading Pipeline from Haldia Oil Jetty (HOJ) to HPL Tankages
3. Methanol Storage Tanks (2 x 3,000 T)

4. MTBE Storage Tanks (2 x 5,000 T)
5. MTBE Transfer Pipeline from HPL Tankage to HOJ
6. Unloading Bays for Methanol Tanker Unloading
7. Loading bays for MTBE Tanker Loading
8. Loading Bays for Butene-1 Tanker Loading
9. Augmentation of Utilities and/or new connections for Cooling Water System, Steam, Power, Effluent Collection & Treatment, Flare System etc.

3.0 PROJECT CAPACITY

The plant capacity is designed to process a 126 KTA C_4 Raffinate generated within HPL.

Handling Capacity of Major Feedstocks and Products are as given below:

Sl. No.	Name	Capacity	Sourcing/Destination
A. **Feedstock**			
1	C_4 Raffinate	126 KTA	Produced internally after extraction of Butadiene from C_4 Mix Stream
2	Methanol	35.6 KTA	To be imported or sourced from domestic market through tankers
3	Hydrogen	0.5 KTA	Internally generated from Naphtha Cracker Unit
B. Products			
1	Butene-1	30.6 KTA	About 20 KTA to be consumed internally, balance to be sold in domestic/export market
2	MTBE	98.6 KTA	Part quantity to be blended with existing MS Stream of HPL; Balance to be sold in domestic and export market

3	Balance C_4 Stream (Mixture of n-butane, Isobutane, Butene-2 etc)	33.3 KTA	To be recycled to the cracker as feedstock

4.0 CAPITAL INVESTMENT

Estimated Investment is about 53 million USD which is equivalent to ~360 Rs. Cr. at current exchange rate.

5.0 DEMAND – SUPPLY SCENARIO

Butene-1: HPL requires about 18-20 KTA Butene-1, which is currently being imported. Out of 30 KTA Butene-1, 18 KTA is assumed to be consumed internally for LLDPE manufacturing. Out of balance 12 KTA Butene-1, product may be sold to domestic consumer like BCPL where HPL has logistics advantage vis-à-vis other domestic producers.

MTBE: Global MTBE capacity is about 24 mMTPA in 2014. Major producers are China, Middle East, Europe and US.

The global demand during 2015-2020 is expected to increase by ~6.7 mMTPA, led mostly by China, Europe and Middle East.

Growth in Methyl Tertiary Butyl Ether Demand (-000- metric tons)

2010-2020E

	2010	2011	2012	2013	2014	2015E	2016E	2017E	2018E	2019E	2020E	11 Yrs Total
Asia	1,152	1,035	1,162	691	1,198	813	854	916	980	875	927	10,604
North America	-84	-46	10	10	590	16	16	17	16	12	13	570
South America	-43	-95	-38	-17	-16	-15	0	-3	12	12	13	-192
Europe	11	10	3	1,069	43	59	75	82	82	82	83	1,599
Russia	166	-240	55	70	12	1	27	39	39	40	42	250
Middle East	88	68	63	137	165	132	175	65	125	92	73	1,183
Africa	-	-	-	-	-	-	-	-	-	-	-	0
TOTAL	**1,290**	**732**	**1,255**	**1,960**	**1,992**	**1,006**	**1,147**	**1,114**	**1,254**	**1,113**	**1,151**	**14,014**

Source: *MMSA*

Global capacity during the same period is likely to increase by ~4.3 mMTPA. Most of the planned capacity additions are in China and USA.

Normally, MTBE is not blended as oxygenate in India. Old refineries like NRL use MTBE to upgrade their naphtha and other blends to meet MS quality requirements. Besides these, MTBE is used as a chemical feedstock by producers like M/s Vinati Organics. Domestic exports during previous years had been:

	Quantity, MT
Jan-Dec 2012	18,944
FY 14-15	33,405
Apr-Aug 2015	10,287

Using MTBE route for Butene-1 production, HPL is likely to produce 98 KTA MTBE. Tentative product placement shall be as given below:

- **Domestic Placement to NRL**: HPL can substitute imports. Expected volume has been assumed equal to ~18 KTA.

- **Exports in SEA**: Singapore is one of the largest importers of MTBE. Annual net imports are in the range of 600-700 KT. Most of these imports are from Middle East. HPL plant at Haldia can be equally competitive with Middle East suppliers. Export realizations have been considered based on FOB Singapore prices after making adjustments for freight and demurrage at Haldia jetty.

- **Alternate Blending in MS**: HPL is likely to produce about 200 KTA MS by blending different chemical components. This quantity is planned to be increased further to 400 KTA in next phase. As per the industry advisor, MTBE can be blended @ 8% w/w with HPL MS so that to ensure overall product meets Euro-IV quality norms. Considering 8% blending is made, HPL in-house requirement would be about 15-30 KTA.

  It is also anticipated that to meet Euro-V quality norms from 2020 onwards, HPL MS as well as MS from other refineries would require blending of MTBE. While removing the sulfur and aromatics to meet Euro-V norms, octane number of MS is likely to be decreased. To boost the octane number, MTBE blending would be needed.

6.0 PROCESS DESCRIPTION

Major sections are:

- Selective Hydrogenation Unit
- Etherification Section
- Superfractionation Section

Process description of each section is given below:

A. Selective Hydrogenation Section

The C_4 Feed is received in a Feed Surge Drum. The H_2 make-up is sent to the reactor under flow control.C_4 Feed is mixed first with the Main Reactor recycle and then with the hydrogen make up gas. The C_4/H_2mixture enters Main Reactor top and flows downwards through the catalyst where the selective hydrogenation reaction occurs.

The inlet temperature of the reactor is minimized (in order to prolong the active life of the catalyst) to be consistent with achieving the required conversion rate of di-olefin hydrocarbons. During start-up, reactor inlet may need to be preheated by SHU Start-up Heater to reach the proper reactor inlet temperature and start the reactions. The partially hydrogenated C_4 cut is withdrawn from the reactor bottom and flows to the Recycle Drum, which is equipped with a boot. The boot collects and removes potential free water which is likely tobe formed during transient operation such as start-up (no free water is expected in normal operation due to the high reactor effluent temperature). Water (if any) is sent to a water closed drain. The liquid from recycle drum is pumped by the Recycle Pumps, and cooled in SHU Recycle Cooler. Product of the Main Reactor is routed towards the Finishing Reactor.

The hydrogen make-up is done to the Finishing Reactor. The mixture of first stage effluent and hydrogen is routed toward the Finishing Reactor, where the remaining butadiene is hydrogenated.

As the catalyst activity reduces, during the run life, the reactor temperature is increased thanks to the Finishing Reactor Preheater. The reactor effluent, after being preheated in Stabilizer Feed/Bottom Exchanger is sent to Stabilizer. The purpose of the Stabilizer is to remove the light compounds resulting from hydrogen make-up quality and excess. The Stabilizer is reboiled by LP steam in the Stabilizer Reboiler. The reflux drum overhead vapor is routed to the Fuel Gas System (Purge gas) under pressure control. The liquid hydrocarbon which constitutes the stabilizer reflux is pumped back to the column by the Stabilizer Reflux Pumps. The column bottom stream constitutes the hydrogenated product that feeds the downstream MTBE section.

B. Etherification Section

Hydrocarbon from Stabilizer reflux drum is pumped to the C_4 Feed Water Washing Column. This is a sieve tray column, contacting the dispersed

C_4hydrocarbon feed in a continuous water phase. The hydrocarbon/water interface is maintained in the column top, below the hydrocarbon draw-off. This interface level is maintained by controlling the washing water leaving the column bottom. The hydrocarbon is pumped to the reaction system and mixed with methanol from the methanol recovery section.

The feed is also mixed with the liquid recycle before entering the Main Reactor. Most of the isobutylene conversion occurs in the main reactor. The main reactor temperature is maintained sufficiently high to keep a high conversion while keeping the side reactions and the loss of catalyst activity at a very low level. After the main reactor, the feed is sent to the Finishing Reactor, in order to achieve a higher conversion. The Finishing reactor is a down-flow fixed bed reactor. The pressure is set to ensure the hydrocarbon flow remains liquid in the main reaction section. After the pressure control valve, the feed is preheated and then feeds the reactive distillation tower. This tower consists of successive proprietary reaction and distillation modules. Each module is optimized to achieve the highest efficiency in terms of reaction and distillation. Each module is composed of a catalytic basket and three distillation trays. Reaction is achieved in liquid phase in the up-flow mode. The tower enables a high degree of isobutylene conversion by removing the MTBE product through distillation as soon as it is formed. By contacting only the liquid phase in the catalytic bed section of each module, the catalyst utilization is greatly enhanced compared to contacting the catalyst bed with both the liquid and vapor phases. The liquid/vapor contact is re-established over the three fractionating trays below the catalytic basket. The MTBE product is washed down in the liquid phase as it is formed and more of the isobutylene is transferred to the reactive liquid phase from the vapor phase rising to the column top. A small amount of methanol can be injected on flow control in the catalytic zone to maintain an alcohol excess favoring the etherification reaction. The excess of methanol in the catalytic column feed is lifted overhead as an azeotrope with the C_4 hydrocarbons, which enables to fractionate the MTBE product with no methanol contamination.

The distillate is cooled through the Raffinate Cooler and feeds the C_4 Raffinate Water Wash Column.The washing of the C_4 raffinate done to recover the excess of alcohol, is achieved with a counter current waterstream coming from the methanol / water distillation column.C_4 raffinate from the C_4 Raffinate Wash Column top is collected in the C_4 Raffinate Coalescerand entrained water droplets are coalesced and removed through the drum boot. The washed C_4 raffinate is sent to the Butene-1 recovery section under cascade level / flow control.The methanol / water mixture from the C_4 Raffinate Wash Column is sent to the Methanol Column Feed Drum. The methanol/water mixture is then sent under a cascade level flow control, to the Methanol / Water Distillation Column.

The column overhead is condensed and the condensed methanol flows toward the Methanol Column Reflux Drum. Theliquid from the Reflux Drum is sent back tothe reaction section.

The bottom water product from the Methanol / Water Distillation Column is recirculated to the C4 Raffinate Wash Column after being cooled. The Methanol / Water Distillation Column are reboiled using Medium Pressure Steam.

C. Super-fractionation Section

The C_4 Splitter separates n-butane and butene-2 rich cut at the bottom and a butene-1 and iso-Butane rich cut at the top.Due to the high number of trays needed for this distillation and layout limitations, the C_4 Splitter is usuallydivided into two columns: C_4 Splitter Top Section and C_4 Splitter Bottom Section. The C_4 raffinate coming from the C4 Raffinate Coalescer feeds the C_4 Splitter and the bottom product is pumped by the C_4 Splitter Bottom Product Pumps and cooled in the N-Butane/Butenes-2 Cooler, under flow control reset by level control. The C_4 Splitter distillate product is routed to the De-Isobutanizer under flow control.

This distillation column is reboiled by conventional reboiler, and its overhead is condensed through conventional water condenser.

The C4 Splitter separates a butene-1 cut at the bottom (the Butene-1 product) and an Isobutane cut at the top. Due to the high number of trays needed for this distillation and layout limitations, the De-Isobutanizer is usually divided into two columns: De-Isobutanizer Top Section and De-Isobutanizer Bottom Section. This is equivalent to having only one distillation column: the bottom liquid of the top section is pumped by the De-Isobutanizer Interstate Pumps toward the top of the bottom section, and the top vapor of the bottom section flows toward the bottom of the top section. The De-Isobutanizer distillate product from the De-Isobutanizer Reflux Drum is routed to storage or downstream unit under flow control.

7.0 *UTILITIES REQUIREMENTS*

Based on preliminary estimate, major utilities consumed in above process are:

	UOM	Hourly Consumption,	Consumption per MT of Butene-1
MP Steam	T	4.8	1.27
LP Steam	T	18.9	5.01
Power	KWh	425	113
Cooling Water	m^3	1,490	395

8.0 Environmental Factors

A. Gaseous Emissions

Gaseous emissions, effluent generation and solid waste generations from various process streams of the plant can be summarized as below:

Table 1 – Off Gas Emissions

Stream Description	Flow rate (Nm^3/h) <normal/Max>	Emission Frequency	Before Treatment Composition	Discharge Parameters			Emission Destination
				T (°C)	Pressure (kg/cm^2g)	MW	
Methanol Stripper Purge Gas	50	Continuous	N2 (85 vol%) + Methanol	45	2.0	29	flare
Stripper Purge Gas	53	Continuous	H2 (68 %vol) + HC (C4)	45	13.5	19	fuel gas
C4 Selective Hydrogenation Catalyst treatments	3000 Nm3/h	1 day per 2.5 years	H2+N2+ HC	Up to 250	Suitable to route to flare	21	flare

B. Liquid Effluent Generation

The estimated water amount required for feed washing is 2.6 t/h for Feed Water Wash. This washing column uses once-through feed water. The spent water will be sent to bacterial treatment. No modification is required on the treatment to cope with this stream containing

- Nitrogen impurities: 20 wtppm N typical (based on 3-4 wtppm Nitrogen in the C4 Feed)
- Methanol: 100 wtppm max
- Saturated with C4 hydrocarbons : 400 wtppm

Apart from above continuous discharges, other intermittent discharges can be summarized as

Table 2 – Waste Water Emissions

Stream Description	Flow rate (m^3/h) <normal/Max>	Emission Frequency	Before Treatment Composition	Discharge Parameters			Emission Destination
				T (°C)	Density (kg/m^3)	pH	
MTBE Unit Spent Wash Waters	2.6	Continuous	Nitrogen impurities: 20 wtppm N typical (1) Methanol: 100 wtppm max Saturated with hydrocarbons C4 Hydrocarbons : 400 wtppm	Ambient	990	7.5<pH<9.5 (2)	Process waste water
Raffinate-1 Feed Surge Drum Boot Purge	NNF/ 0.15 max	Intermittent	Saturated with hydrocarbons C4 Hydrocarbons : 400 wtppm	43	990	6.8<pH<8.5	Onsite Wastewater System
Stripper Reflux Drum Boot Purge	NNF/ 0.15 max	Intermittent	Saturated with hydrocarbons C4 Hydrocarbons : 400 wtppm	43	990	6.8<pH<8.5	Onsite Wastewater System
Water for MTBE catalyst loading/defining	NNF/ 16 max	2 days per 2 years					Sewer

Note (1): Depends on the amount and type of Solvent (nitrogen based molecule, such as Acetonitrile, DMF or NMP) present in Raffinate-1. To be defined by Licensor of upstream Butadiene Extraction Unit.
Note (2): Depending on the initial pH of the water used for feed water wash; to be confirmed at design stage.

C. Solid Waste Generation

There may be marginal increase in frequency of generation of following kinds

Table 3 – Waste Solid or Liquid (non-Waste Water Liquids) Emissions

Stream Description	Emission Frequency	Composition	T (°C)	Batch quantity (kg)	Density (Bulk) (kg/m^3)	Emission Destination
MTBE Reactors Catalyst	2 years	Styrene-Divinylbenzene copolymer / Sulfonic acid / Water	Amb	20 400	770 (1)	Incineration or landfil
Catalyst beds from MTBE Catalytic Distillation	4 years	Styrene-Divinylbenzene copolymer / Sulfonic acid / Water	Amb	18 700	770 (1)	Incineration or landfil
Resins from guard pots	1 year (2)	Styrene-Divinylbenzene copolymer / Sulfonic acid / Water	Amb	2 400 (2)	770 (1)	Incineration or landfil
C4 Hydrogenation Catalyst	6 years	Alumina / Pd	Amb	6 585	730/740	Pd recovery

Note (1): Shipping weight of resins under water. To be confirmed by resin vendor.
Note (2): Typical quantity and life-time for guard pots are provided by Axens. The amount of resins in the guard pot shall be reviewed at design stage depending on the amount of contaminants defined in the Methanol make-up.

These waste generations would be incinerated/sold to authorized re-processors in a manner similar to current practice.

Py-gas Hydro-treatment Plant

1.0 INTRODUCTION

Pyrolysis Gasoline (Pygas) is one of the major product stream derived from processing of Raw Pyrolysis Gasoline (RPG), one of the product steams derived from steam cracking of naphtha. Currently, a major part of the Py-gas volume is blended with other product streams of naphtha cracking to produce Euro-IV Motor Spirit (MS).

Due to variations in sulfur content of the naphtha being processed in Naphtha Cracker, sulfur content of the Py-gas stream also fluctuates, sometimes making it unsuitable for use as blend stream for MS production. Moreover, sulfur content in Euro-VI MS is also likely to be reduced to 10 ppm, which requires that sulfur content of the Py-gas stream shall be controlled to ensure uninterrupted MS production.

It is proposed that a new section 2nd stage Pygas hydrogenation unit to the C7-C9 pygas product to reduce the sulphur content to fulfill the new sulphur requirement in the gasoline pool in India.

This unit will be located downstream of existing 1st stage selective hydrogenation unit of raw Pygas cut followed by a dehexanizer and a rerun column. The design capacity of the new unit is 250 kt/year of product.

The purpose of the pygas second stage hydrogenation unit is to remove sulfur and olefins of monohydrogenated product while maintaining high RON of the feed.

1.0 PROJECT SCOPE

The project scope includes:

10. 250 KTA Pygas Hydrotreatment Plant
11. Augmentation of Utilities and/or new connections for Cooling Water System, Steam, Power, Effluent Collection & Treatment, Flare System etc.

2.0 PROJECT CAPACITY

The plant capacity is designed to produce 2,50,000 TPA Pygas having sulfur content less than 1 – 1.5 ppmw.

Feed Quality & Sourcing: Feed is one of the streams being processed in existing Pyrolysis Gasoline Hydrogenation Unit (PGHU) within existing complex having following characteristics:

Raw Gasoline Product	Composition WT%
BENZENE	0.5
C7 – C9 Aromatics	79
Olefins content	6.4
Styrene	0.3
Others	13.8
Total	100%
Total Flowrate	30 000 kg/h

Product Quality: After the proposed treatment, it is proposed to generate similar volumes of pygas having following characteristics:

The following performances have been targeted for unit product:

	Expected	Requirement for gasoline pool
Products sulphur content:	Typical 1 / 1.5 ppm wt	10 ppm wt max
Delta RON loss from feed to product:	Typical 1.0	Minimized

3.0 DEMAND-SUPPLY SCENARIO

Low Sulfur Py-Gas stream is proposed to be used for production of MS meeting Euro-VI specifications in terms of Sulfur. Estimated production of MS is about 432 KTA.

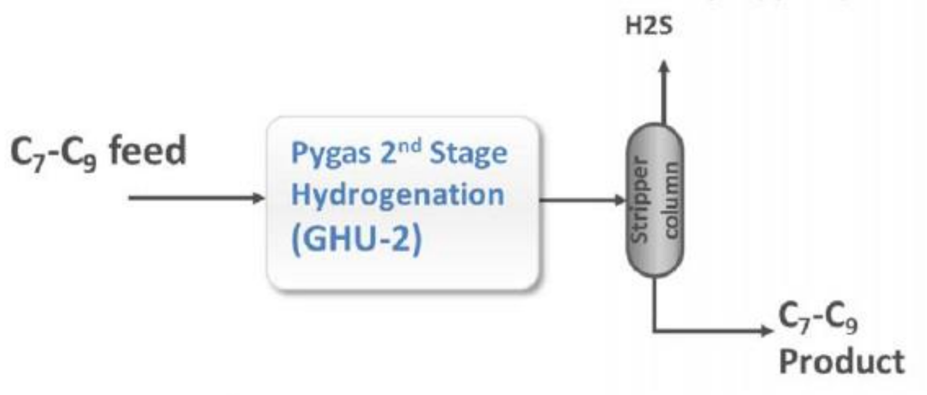
Total production of MS in India (2014-15) was about 32 mMTPA, whereas domestic consumption is 17-18 mMTPA. HPL already places about 200 -250 KTA Euro-IV MS in domestic market. As the fuel specifications are becoming stringent over times, HPL does not foresee in placing the production volumes in domestic market.

4.0 CAPITAL INVESTMENT

Estimated ISBL Investment is about ~8.5 million Euros which is equivalent to ~65 Rs. Cr. at current exchange rate.

5.0 PROCESS DESCRIPTION

The purpose of the 2nd stage Pygas Hydrotreatment unit is to remove sulfur and olefins while preserving aromatics thus making it suitable for the downstream processes.



The desulfurization and hydrogenation reactions of the Selective hydrotreatment unit take place in vapor phase on a dual catalyst system specially designed for this service, in order to reach very low residual sulfur and olefins content, while maximizing aromatics yield and minimizing pressure drop and deactivation issues.

Major sections in the treatment scheme are:

- Reaction Section
- Stripping Section

Reaction Section

The C7-C9 cut coming from the dehexanizer column is then pumped to the reaction section undercascade level / flow control.

The hydrocarbon feed is mixed with recycle and make-up hydrogen gas before being heated upthrough feed-effluent exchangers and a fired heater.

The reactions, hydrogenation of olefins and desulfurization, take place in vapor phase on a fixed bedtype reactor filled with two types of catalysts:

- **Special NiMo LD 145:** mainly hydrogenation. This catalyst exhibits an extremely low acidity and prepares the feedstock to the downstream desulphurization catalyst through residual diolefins and large olefins hydrogenation, while minimizing pressure drop and deactivation issues.

- **High activity CoMo HR 606:** mainly desulphurization. This highly active catalyst is used to achieve very low residual sulfur and olefins content while displaying good selectivity and aromatics preservation.

The effluent is flashed in the second stage separator after consecutive cooling in the feed/effluent exchangers and air coolers.

The vapor phase is partly purged, and the remaining is recycled to the recycle compressor suction. The recycle hydrogen gas recovered at compressor discharge is then mixed with the hydrogen makeup.

To avoid aromatic hydrogenation that could cause a run-away, the maximum temperature in the reactor is limited. An injection of a liquid quench between the two catalytic beds allows a good control of the reactor temperature profile.

After the consolidation of the feed, quench equipment (pump and cooler) can be removed if the olefins and diolefins content is confirmed to be low.

Stripping Section

The liquid phase coming from the separator is sent to the stripper column. The purpose of this column is to eliminate H2S, which is the form under which the sulfur present in the feed will have been turned through the catalytic system, and light components.

Estimated Material Balance

Estimated overall material balance is given below at SOR conditions.
"Purges" stream is the sum of the separator V-102 purge plus the stripper purge.

	SOR (kg/h)		SOR (kt/year)	
	IN	OUT	IN	OUT
Pygas Feed	30 000		252	
H2 Make-Up	101		0.8	
C7-C9 Pygas product		29 970		252
Purges of GHU-2		132		1.1
TOTAL	30101	30101	253	253

6.0 UTILITIES REQUIREMENTS

Based on preliminary estimate, major utilities consumed in above process are:

	UOM	Hourly Consumption,	Consumption per MT of Pygas
MP Steam	T	4	0.14
Power	KWh	210	7
Cooling Water	m^3	245	8
Fuel	MMKcal	1	0.034

7.0 *ENVIRONMENTAL FACTORS*

Aqueous Effluent

There is no major addition on the liquid effluent generation from the proposed unit.

Gaseous Emissions

Continuous effluent gases

The compositions of Off-gas are described below as by-products of 2nd stage hydrogenation unit: "Purges" stream is the sum of the separator V-102 purge plus the stripper purge.

Composition, % wt	Purges stream
Hydrogen	8.9%
H2S	9.3%
Methane	23.7%
C3-C4	5.8%
Cyclopentane	28.5%
Pentane	16.7%
Benzene	4.1%
Toluene	2.8%
Total	100%

All hydrocarbon containing vent gases and the pressure relief valve gases are discharged via the blow down drum to the flare system OSBL.

Solid Waste

Spent hydrogenation catalysts are classified as hazardous waste. They may be sent to specialized companies for metal reclaiming and / or disposed in hazardous landfill. Spent catalyst are self-heating material and fall under the UN3190 regulations with respect to transport and spontaneously combustible material (class 4.2; packaging group II or III). After hot stripping for hydrocarbon removal, spent catalyst is unloaded under nitrogen and shipped to the Catalyst Regeneration Company or metal reclaimer in inert flow bins.

Phenol

1.0 INTRODUCTION

Phenol is extensively used in manufacturing of Bisphenol A, Phenolic Resins, and Caprolactum etc. which are further processed and used in a variety of industries. In India, there are only two small Phenol manufacturers without any upstream/downstream integration. The domestic production is inadequate to meet emerging demands. India is a net importer of Phenol and all its derivatives and demand is growing at a healthy rate every annum. Major growth drivers in India are – Construction Industry, Entertainment, Pharmaceuticals and Wind Energy.

Acetone is a by-product produced during Phenol manufacturing. India is also a net importer of Acetone, Major growth drivers are – Paints, Pharmaceuticals and other applications as solvents.

Phenol manufacturing involves reacting Benzene and Propylene to form Cumene, which is then converted into Phenol. Acetone is the by-product of the process.

The main chemical intermediates and derivatives of phenol are Bisphenol-A (BPA), Phenolic resins, Caprolactum, Alkyl phenols, Aniline and Adipic Acid.

- The largest market for phenol is BPA which has been driven by the strong growth in polycarbonate resins. The driving force in polycarbonate demand had been growth in optical media such as compact discs (CDs), CD-ROMs, recordable CDs and digital versatile discs (DVDs).

- The second largest outlet for phenol is Phenolic Resins which are largely used as durable binders and adhesives in structural wood panels and as binders in mineral wool insulation. They have a wide spectrum of uses in the automotive and construction industries including brake linings, foundry binders, insulation foams and composites.

- Caprolactum is the next largest consumer of phenol and is used mainly to make nylon 6 fibres, engineering resins and film. Growth in the fibre sector is stagnant but it is much more robust in engineering resins which are replacing metals in automobiles.

- Phenol is also used to make chemical intermediates for a wide range of other applications, ranging from plastics to pharmaceuticals and agricultural chemicals.

Benzene, a major raw material for Phenol, is produced by HPL and is largely exported. HPL plans to add value to this product stream by converting it into Phenol. It is proposed to set-up a 200 KTA Phenol Plant using Benzene and Propylene as raw materials. Phenol and byproduct Acetone is likely to meet domestic demand largely, however, surplus quantity may also need to be exported in profitable market.

2.0 PROJECT SCOPE

The project scope includes:

- 200 KTA Phenol Plant
- Propylene Unloading Pipeline from Haldia Oil Jetty (HOJ) to HPL Storage Spheres
- Propylene Storage Spheres **Installed Capacity:** 6,000 T
- Phenol Loading Pipeline from HPL Storage Tanks to HOJ
- Phenol Storage Tanks **Installed Capacity**: 12,000 T
- Acetone Loading Pipeline from HPL Storage Tanks to HOJ
- Acetone Storage Tanks **Installed Capacity**: 8,000 T
- Loading Bays for Phenol and Acetone Tanker Loading
- Augmentation of Utilities and/or new connections for Cooling Water System, Steam, Power, Effluent Collection & Treatment, Flare System etc.

3.0 PROJECT CAPACITY

The plant capacity is designed to produce 2,00,000 TPA Phenol on 8,000 operating hours per annum basis.

Handling Capacity of Major Feedstocks and Products are as given below:

Sl. No.	Name	Capacity	Sourcing/Destination

C. **Feedstock**			
1	Benzene	~174 KTA	About 80% of the requirement to be met fron internal generations. Balance to be sourced from nearby coastal sources/imports
2	Propylene	~94 KTA	To be sourced from domestic market or to be imported
3	Hydrogen	0.2 KTA	Internally generated from Naphtha Cracker Unit
D. Products			
1	Phenol	200 KTA	To be placed in domestic/export market
2	Acetone	123.2 KTA	To be placed in domestic/export market

4.0 CAPITAL INVESTMENT

Estimated Investment is about ~250 million USD which is equivalent to ~1,700 Rs. Cr. at current exchange rate.

5.0 DEMAND-SUPPLY SCENARIO

Current production capacity of Phenol and Acetone in India is 77 KTA and 48 KTA respectively, which are old and operate at 50-60% capacity utilization. Major producers are - M/s Hindustan Organics Chemical Limited and M/s SI group.

M/s Deepak Nitrite Limited is setting up a 200 KTA Phenol which will also produce about 120 KTA Acetone as co-product.

Bulk of domestic demand of Phenol and its derivatives is met through imports. Year-wise imports can be summarized as below:

Annual Imports of Phenol & Acetone

	Annual Imports	Annual Imports

	- Phenol, KT	- Acetone, KT
2005-06	93	64
2006-07	65	60
2007-08	96	65
2008-09	92	68
2009-10	101	80
2010-11	122	78
2011-12	146	101
2012-13	172	96
2013-14	213	117
2014-15	200	127

Rising demand and lack of further capacity additions make this project lucrative for consideration.

6.0 PROCESS DESCRIPTION

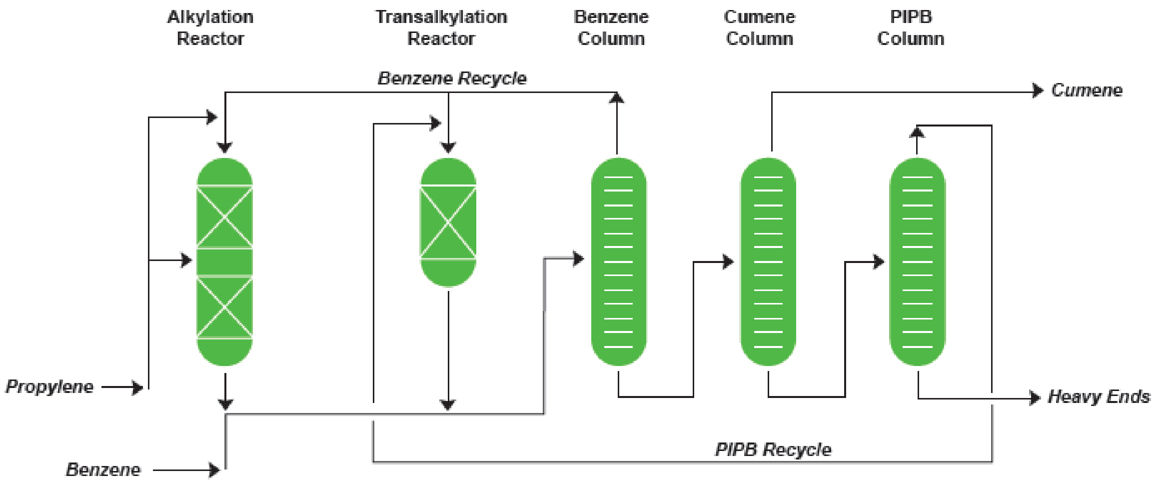
Major sections are:

- Conversion of Benzene and Propylene into Cumene
- Oxidation of Cumene to Cumene Hydroperoxide and subsequent cleavage to produce Phenol and Acetone
- Fractionation to recover and purify Phenol and Acetone

Process description of each section is given below:

D. Conversion of Benzene and Propylene into Cumene

Cumene is made by the alkylation of benzene with propylene, which yields a mixture of alkylated and polyalkylated benzenes. Excess benzene is used so propylene reacts completely. Propylene is injected before each catalyst bed to improve catalyst selectivity and enhance its activity and stability. The mixture of alkylated and polyalkylated benzenes is sent to a distillation train that consists of a benzene column, cumene column and poly-isopropylbenzene (PIPB) column. The polyalkylated benzenes recovered in the PIPB column are transalkylated with benzene to produce additional cumene for maximum Cumene yield. The alkylation and transalkylation effluents are fed to the benzene column, where the excess benzene is taken as the overhead product for recycle to the reactors.



The benzene column bottoms goes to the cumene column, where product cumene (isopropylbenzene) is taken as the overhead product. The cumene column bottoms are sent to the PIPB column, where overhead PIPB is recycled back to the transal-akylation reactor. The bottom of the PIPB column is composed of a small amount of high boilers that can be used as fuel. Propane and other non-condensables containedin the propylene feed pass through the process unreacted and are recovered as propane product or as fuel. The cumene unit has considerable flexibility to meet a variety of local site conditions (i.e., utilities) in an efficient man

E. Oxidation of Cumene to Cumene Hydroperoxide and subsequent cleavage to produce Phenol and Acetone

It has four major sections -

- Oxidation
- Cumene Stripping (Concentration)
- Cleavage Reactor
- Neutralization and Wash

<u>Oxidation</u>

- The main purpose of the oxidation section is to produce Cumene hydroperoxide (CHP) from the fresh and recycle Cumene streams. Cumene is heated to reaction temperature and fed to a series of oxidizers. Fresh air, fed by centrifugal compressor, enters the bottom of each oxidizer. As the air flows upward through the liquid column, it oxidizes Cumene to CHP.

- The oxidizer spent air contains a significant amount of cumene. In the spent air treatment section, cumene is recovered by condensation, and the remaining volatile organic compounds (VOCs) are incinerated.

Cumene Stripping (Concentration)

- The oxidizer effluent typically contains about 22-28 wt% CHP, with the remainder being unreacted cumene and a small portion of oxidation byproducts. The process system to remove cumene from oxidizer effluent utilizes vacuum distillation. Cumene, recovered in the overheads, is recycled to the oxidation area. The concentrated oxidate contains 80-85% CHP.

Cleavage Reactor

- Phenol and acetone are formed by the acid-catalyzed decomposition of CHP. This step is carried out in a 2-stage cleavage system, where the operating conditions are set to maximize yields of phenol, acetone and AMS and minimize formation of heavy by-products.
- The concentrated CHP solution from the cumene stripping section is fed to the first cleavage reactor. Acetone is recycled from fractionation, and is used to control the reaction temperature as well as minimize the formation of undesirable byproducts.
- Net reactor product is pumped to the 2nd stage reactor to complete the reaction of CHP and dicumyl peroxide (DCP). The cleavage product is cooled before entering the neutralization section.

Neutralization and Wash

- The cleavage effluent contains the acid used as catalyst for the cleavage reaction. In this section the acids are neutralized and extracted. These operations are performed using a two-stage neutralization system.

F. Fractionation to recover and purify Phenol and Acetone

Major sections are:

Acetone Fractionation

After cleavage and neutralization, the mixed organics are fractionated and purified. The acetone fractionation system serves the purpose of (1) crude separation of acetone and hydrocarbons from phenol and heavies in the neutralizer product and (2) purification of acetone product.

The acetone fractionation train consists of two columns: The Crude Acetone Column and the Acetone Product Column. In the Crude Acetone Column, the neutralizer product is fractionated to an overhead stream consisting of acetone, water, cumene, AMS, and other light materials, and a bottoms stream consisting of phenol and heavier components. The vapor distillate is sent to the Acetone Product Column for acetone purification. The purpose of the Acetone Product Column is to remove light ends, separate water and hydrocarbons, and produce on-spec acetone product.

Phenol Fractionation and Heavies Removal

The phenol fractionation section is fed with the bottoms of the crude acetone column. This stream consists of phenol, a small amount of organics lighter than phenol and heavy organics such as cumyl phenol, AMS dimer, and tars. The purpose of the phenol fractionation section is to isolate and purify the phenol product and to recover useful organics for recycle. This is achieved in a three-column fractionation train that includes the Crude Phenol Column, theHydrocarbon Removal Column, and the Phenol Finishing Column.

Crude acetone column bottoms are pumped directly to the Crude Phenol Column where the bulk of the phenol is taken overhead along with all of the lighter organics. The net overhead of this column is fed to the Hydrocarbon Removal Column. This column separates hydrocarbons from phenol using water as an azeotroping agent. A resin bed treater is provided between the Hydrocarbon Removal Column and the Phenol Finishing Column when very high purity phenol is desired. The treater improves the phenol purity by removing trace carbonyl impurities.

The bottoms stream of the Crude Phenol Column is fed to the Heavies Removal Column where phenol is recovered in the overhead stream and recycled to the

Crude Phenol Column. Heavy materials, including acetophenone, cumyl phenol and AMS dimers are removed from the bottom of the Heavies Removal Column.

AMS Fractionation and Hydrogenation

One of the major by-products of the phenol/acetone process is alpha-methyl styrene (AMS), which is formed by dehydration of dimethyl benzyl alcohol (DMBA), an oxidation by-product. In this section trace amounts of phenol are removed from the crude AMS, which is then fractionated and hydrogenated to cumene for recycle to oxidation.

Alternatively AMS can be recovered as a byproduct from the phenol plant, in which case the distillation is designed to produce high purity AMS.

Dephenolation

The purpose of this section is to prepare effluent water for biological treatment and recover phenol from water streams for process economic reasons.

Phenol removal and recovery is effected in the Dephenolation step. Collected process water is treated in a solvent extraction system for the recovery of Phenol.

Vent System and Emergency Relief Scrubber

The vent system is designed to collect vapor streams for recovery of phenol, acetone, and hydrocarbons and condense these materials from the vapor. The residual vents are then directed to the Spent Air Incinerator, thus resulting in a single-point vapor emission source virtually free of VOCs.

7.0 UTILITIES REQUIREMENTS

Based on preliminary estimate, major utilities consumed in above process are:

	UOM	**Hourly Consumption,**	**Consumption per MT of Phenol**
HP Steam	T	35.75	1.43
MP Steam	T	24	0.96
LP Steam	T	15.5	0.62
Power	KWh	4,550	182
Cooling Water	m^3	7,550	302

8.0 ENVIRONMENTAL FACTORS

Phenol plants employ state-the-art environmental control technologies to minimize or eliminate toxic releases and emissions. In general, these control technologies fall into one or more of the following categories:

- Absorption / Stripping
- Adsorption
- Incineration / Oxidation
- Condensation
- Reaction
- Distillation
- Solvent Extraction
- Equipment Design
- Maintenance Programs

The optimum choice for an emission control technology for a given waste depends on the plant site as well as local environmental regulations. The following is a brief description of the waste sources and the control systems normally used.

Aqueous Effluent

The aqueous effluent streams from the phenol plant are usually segregated into two categories: process effluents and padded area runoff. All these effluents can be discharged to the offsite biotreatment facilities.

- Dephenolation : Phenol bearing streams include the cumene wash spent caustic purge, cleavage neutralization salt purge, and the weak phenate purge from acetone recovery section. These streams are collected and directed to the dephenolation facilities where pH is adjusted and the phenol content is reduced substantially before discharge to the biotreatment facilities. The system for removal of phenol from aqueous process waste streams uses a solvent extraction method called dephenolation. Aquenous waste streams collected in the dephenolation feed tank normally contain 0.8 to 1.2% phenol. Dephenolation reduces the phenol content of these waste waters substantially to allow efficient biological waste treatment. Caustic used to extract phenol from the solvent is used for cleavage effluent neutralizer area improves overall plant yields.

The effective integration of the dephenolation system with the process area reduces the overall caustic requirements and results in a very low wastewater load.

Typically, the quantity of wastewater generated from a 200 KTA Phenol Plant before dephenolation can be summarized as below:

Source	**Rate**	**Na_2SO_4**	**COD**	**Peroxides**	**Phenol**	**Cumene**	**Benzene**
	m^3/hr	**wt-%**	**wt-ppm**	**wt-ppm**	**wt-ppm**	**wt-ppm**	**wt-ppm**
Oxidation Section	17.9		9,750	1,400	2	300	0.3
Phenol Fractionation Section	3.3		6,500		0-30	300	0.3
Phenol Recovery Section	4.1	7	3,500		50 - 150	300	0.3
Benzene Column waste water	0.04						1000
Total	**25.34**						

After dephenolation, dephenolated aqueous stream averages 0.27 m3 per ton of phenol product and has the following characteristics:

Phenolics : <50 wt ppm
Sodium Salts : 4.9 wt %
COD : 3.9 kg/ton phenol

A biotreatment system consisting of an equalization tank, aeration basin and a clarifier will further reduce the BOD, COD and the phenol contents to the levels such as phenol <5 wt-ppm, COD - 0.17 kg/ton phenol, and BOD/COD >0.45. Generally, in an existing petrochemical complex, for economic reasons, such a facility is centrally located to treat combined wastes from various process units.

- Drainage System : The KBR phenol plant design provides for a number of separate drainage systems. Two are closed systems handling and recycling process drainage, another handles phenolic effluents from equipment washing, while a fourth deals with padded area runoff, such as rain and other surface water. This segregated sewer system minimizes loading on waste treatment area, thus reducing waste generation and improving overall waste management system.

Gaseous Emissions

KBR employs a centrally-located vent management system. This centrally-located vent management system is recognized as the best in the industry. The system includes collection and segregation headers, chillers, scrubber, and other equipment. This system achieves highest recovery efficiencies while minimizing capital requirements.

- Process Vents : Process vent streams from atmospheric tanks, vessels and jet condensers in the oxidation and cumene concentration areas are routed to the oxidizer feed tank vent chiller, where they are condensed against brine with the non-condensable being directed to the spent air incinerator. The remainder of the process vents are directed to the main process vent header systems, which use the condensation by refrigeration to effectively remove and recover valuable hydrocarbons before directing to the spent air incinerator.

- Spent Air Incineration : To meet current USA environment regulations for new plants, a spent air incinerator is being employed to destroy the small quantities of Volatile Organic Compounds (VOC) remaining in the spent air and other process vents after overhead cooling and separation of condensates. The use of a high efficiency thermal oxidizer on the spent air stream results in a 99+ percent Destruction and Removal Efficiency (DRE) for te VOCs, and 99.99% overall. Typically, VOC of 0.04 kg per ton of phenol product can be achieved.

- Fugitive Emissions Control : Fugitive organic emissions from the phenol plant are typically minimized using the following approaches :

    - Installing dual mechanical seals on selected machinery or using sealless pumps.

- Collecting and recycling seal leaks back to the process, or treating in a separate emission control device.

- Capping or blinding of open-ended valves.

- Proving for closed sampling systems.

- Coupling relief valves with rupture disk to prevent leakage.

- Instituting a comprehensive inspection, leak detection, and maintenance program conforming with the requirements of the government.

Gaseous Emissions from Cumene unit:

Item	Phase	Disposal Method
Propane Vent	Gas	LPG or Fuel
Fractionator Overhead Receivers	Gas	Closed system type or vent to the relief header
Benzene Drag	Gas	Gas blanketed and vented to the atmosphere intermittently

Gaseous Emissions from Phenol unit:

Stream Name	Spent Air	Vent Gas	Vent Gas	Vent Gas	Tank Vents	Tank Vents	MSHP Vent Gas
Description	Charcoal Adsorber Effluent	Regen. and Ejector Non-condensable	Condensate - Separator Vent	Acetone-Containing Vents	Acetone-Containing Vents	Non-Acetone Vents	Hydrogen Purge
Point of Venting	Charcoal Adsorber	Oxidation Section Decanter	Fractionation Ejector Condensate Drum	Crude acetone column vent, Fractionation sump	Fract. Feed, Acetone Tanks	Phenol, AMS, Tar Tanks	Hydroge-nation Prod Separator

				vent			
Rate, NM^3/hr	31,000	60	small	small	small	small	30
Composition							
SO_2	nil	nil	nil	nil	nil	nil	nil
NOx	nil	nil	nil	nil	nil	nil	nil
HC	100 mol ppm	1 mol%	trace to saturated	trace to saturated	trace to saturated	trace	100 %
CO	nil	nil	nil	nil	nil	nil	nil
O_2	6.9 mol %	19 mol %	nil	nil	nil	nil	nil
Others	Inerts	Inerts	N_2 purge gas	N_2	N_2	N_2	N_2 purge gas
		Water - saturated	Water - saturated				Water - saturated
Venting Mode	continuous	continuous	continuous	continuous	Intermittent	Intermittent	continuous
Destination	Atm	Heater firebox (or vent gas scrubber)	Relief Header		Atm	Atm	Relief Header

Note: In addition to the above, blanketing or purge nitrogen gas used for various vessels & tanks will also be vented to relief header.

Solid Waste

The Phenol process produces no continuous solid residue effluents. Solid waste, however, is produced in the form of spent catalyst from the Phenol Resin Treater, that can either be landfilled or incinerated.

Annexure – V

Polybutylene Terephthalate (PBT)

1.0 INTRODUCTION

Polybutylene terephthalate (**PBT**) is a thermoplastic engineering polymer that is used as an insulator in the electrical and electronics industries. It is a thermoplastic (semi-)crystalline polymer, and a type of polyester. PBT is resistant to solvents, shrinks very little during forming, is mechanically strong, heat-resistant up to 150 °C (or 200 °C with glass-fibre reinforcement) and can be treated with flame retardants to make it noncombustible.

Polybutylene terephthalate is used for housings in electrical engineering, but also in automotive construction as plug connectors and in households for example in showerheads or irons. It is also found processed into fibers in toothbrushes and is used in the keycaps of some high end computer keyboards because the texture is highly resistant to wear.

India is a net importer of PBT and demand is growing at a very healthy rate. PBT is manufactured from Purified Terephthalic Acid (PTA) and 1,4 Butanediol (BDO). One of the feedstock, PTA, can be sourced locally to manufacture PBT.

2.0 PROJECT SCOPE

The project scope includes:

- 200 TPD PBT Plant (Annualized Capacity: 70,000 TPA)
- Storage warehouse for PTA
- Storage warehouse for PBT
- BDO Storage Tanks: 4,000 T
- Augmentation of Utilities and/or new connections for Cooling Water System, Steam, Power, Effluent Collection & Treatment, Flare System etc.

3.0 PROJECT CAPACITY

The plant capacity is designed to produce 70,000 TPA Polybutylene Terephthalate using PTA and BDO as feedstock.

PTA may be sourced locally from M/s MCPI or from other domestic sources. For Butanediol, a dedicated pipeline would be setup for imports.

4.0 CAPITAL INVESTMENT

Estimated ISBL Investment is about ~50 million Euros which is equivalent to ~375 Rs. Cr. at current exchange rate.

5.0 DEMAND SUPPLY SCENARIO

M/s Ester Industries Limited is the only PBT producer in India having a capacity to produce 14 KTA PBT.

Imports are gradually increasing over years necessitating a need of economic sized plant to meet emerging domestic demand.

PBT Imports in India

	Annual Imports, MT
FY 07	5534
FY 08	7033
FY 09	6272
FY 10	8160
FY 11	10666
FY 12	12834
FY 13	13874
FY 14	19801
FY 15	31849
FY 16	14815

6.0 PROCESS DESCRIPTION

Major sections in the plant are:

1. Polycondensation Unit
2. Chip Production
3. THF Recovery
4. Process Water Pretreatment (Stripper)
5. Thermal Off-gas Incineration
6. Product Conveying and Storage

5.1 Polycondensation

- **Paste Preparation:** In this section, PTA and BDO are mixed in a defined ratio to form a paste. For this the continuous streams of the related components are measured and fed into the paste mixing vessel. The special designed agitator mixes the components to a homogeneous paste (slurry). The mixing ratio is controlled by the DCS Computer System to ensure a constant composition of the paste at varying throughput rates.

- **Esterification:** In the esterification section, PTA and BDO react to form bis-hydroxybutylene terephthalate (BHBT) and higher oligomers while water is split off. For this purpose, the PTA paste is fed into the esterification reactor under stirring. The degree of esterification is controlled by maintaining the pressure (vacuum), temperature and residence time at an appropriate level. The vapour which is split off during esterification is sent for rectification to the process column. The process column is heated with liquid heat transfer medium from secondary heating circuits, supplied directly with liquid heat-transfer medium from the primary heating circuit.

- **Prepolycondensation:** The polycondensation process initiated in the esterification stage is further continued in the pre-polycondensation section, and a low-molecular PBT isobtained.

  The degree of polycondensation is set by maintaining the pressure, temperature and residence time at an appropriate level. The BDO split off during pre-polycondensation is withdrawn in the form of vapour, condensed in the spray condenser with a cold BDO cycle and fed back into the process column.

The required vacuum is generated by a central vacuum system, serving the pre-polycondensation stage and the final polycondensation reactor. The product leaving the pre-polycondensation section is fed into the polycondensation reactor.

T

The reactor covers internal heat exchanger and all vapour lines respective all heated jackets of the reactor are traced by hot medium vapours.

- **Polycondensation:** The product leaving the prepolycondensation section is fed continuously into the final polycondensation reactor, where by rotating disk ring surface is generated and by adjusting residence time, intensity of vacuum and temperature the final product qualities are achieved.

The degree of polycondensation measured as viscosity is set to the desired final value by maintaining the pressure, temperature and residence time at an appropriate level. The BDO vapours are removed by suction with a BDO vapour jet and condensed with cold BDO in a spray condenser system.

The BDO which is split off during polycondensation reaction is collected in the general BDO collecting tank and sent back to the paste preparation vessel. The inert gases are removed by the vacuum pump system. The polymer is transferred by gear pumps though a polymer filtration unit and pellets are formed in the following chip production facilities.

The product lines are heated by secondary liquid heat transfer media systems. The disc ring reactor is heated by a secondary liquid heat transfer medium circuit. The vapour lines and the BDO jet are heated by a dowtherm vapour system.

5.2 Chip Production

In this section, the molten high viscosity polymer is converted into cylindrical chips. The product is transferred by a gear pump from the disc ring reactor to the granulator system. The polymer is pumped through a die head to form strands which are cooled by demineralized water and drawn off to the cutting unit below. Then, the chip/water mixture is conveyed to the water separating and pre-drying unit from where the chips after passing an over-length separator are collected in an intermediate silo.

5.3 THF Recovery

The condensed low boiler (THF/H2O etc.) coming from the process column are collected in the receiver tank of the THF recovery unit. From here this mixture is fed continuously into the first purification column. In this column a first separation into water and a water containing THF fraction is taking place.

The head fraction of water and THF appearing at the top of the separation column is sent via different heat exchanging steps for recovering most of the excess energy into the first THF purification column.

In this column the mixture of water and THF is purified by an aceotropic distillation under pressure. The pure raw THF leaving the column has less water and other by-product content, but for special use a higher quality is required.

The pure raw THF is then sent to a second THF-purification column where under further distillation and rectification steps the purity of THF is increased to the required demand. Depending on the desired THF-purity the design of the recovery is carried-out in two or three-stage design. After this processing the final product is transferred via different heat exchangers and temperature levels partially in current or counter-current flow to internal streams to an intermediate tank. This tank serves with short residence time as buffer for the discharge or transfer pumps.

The THF recovery is placed with a certain space to other units, which can serve as a source of Ignition for the cyclic ether tetrahydrofurane and air mixtures. All necessary equipment is explosion proof, designed for higher pressure and purged by nitrogen.

5.4 Process Water Pretreatment (Stripper)

The process water stream(s) discharged from esterification/polycondensation are contaminated with organic compounds. The combined process water flows from top to bottom through the stripper column which contains packing material. At the same time ambient air is blown counter-current through the process water stripper column by the strip-gas blower. In this process the volatile components such as acetaldehyde are stripped into the gaseous phase resulting in significantly reduced organic content in the process water. The treated process water is pumped as reflux to the process column(s) of the polycondensation line(s). The remaining process water is discharged as waste water.

5.5 Thermal Off-gas Incineration

The off-gas streams from condenser(s), vacuum pump(s) and process water stripper contaminated with acetaldehyde and other hydrocarbon components are combined and sent to the HTM heater for incineration.

The off-gas cleaning system mainly consists of an economizer, a temperature controlled electric preheater (for start-up) and a catalytic reactor with a catalyst charge. The catalyst volume and specification are selected in such a way as to efficiently oxidize all of the hydrocarbon components in the total off-gas stream in accordance with the limits set out in the pollution standard.

5.6 Product Conveying and Storage

The PBT chips are pneumatically conveyed into the the storage / bagging silos, from where they are filled into big bags.

Off-spec. chips can be separated through the off-spec silos.

Raw and Auxiliary Consumption per Tonne of Product (Expected)

PTA	: 755 kg
BDO	: 493 kg
Catalyst & Chemicals	: USD 3.65

The consumption figures are based on 60 kg THF per ton of PBT being released from the polycondensation unit together with reaction water and organic impurities. For higher THF formation the BDO consumption will increase by 1.25 kg BDO per kg of THF. Maximum THF production is 75 kg/t.

7.0 UTILITIES REQUIREMENTS

Based on preliminary estimate, major utilities consumed in above process are:

	UOM	Hourly Consumption,	Consumption per MT of Pygas
HP/MP/LP Steam	T	2.8	0.34
Power	KWh	686	82.3
Cooling Water	m^3	845	101.5
Fuel/Thermal Energy	GJ	25.5	3.06

8.0 ENVIRONMENTAL FACTORS

Aqueous Effluent

The effluents (waste water streams) from the several plant sections contaminated with relevant quantities of organics are summarized to total effluent for chemical/ biological waste water treatment (OSBL).

The quality parameters of the total effluent are given as:

Parameter	Description	Value	Unit
Flow rate	- average: - peak (incl. discont. effluents):	47 5.5	m^3/day m^3/h
COD	- average:	12,100	mg/l
BOD_5	- average:	6,900	mg/l
pH:	- without alkaline effluents from cleaning process	3 – 6	-

Main contaminants: 3-buten-1-ol, 1.4-butanediol, tetrahydrofuran (THF), 1-butanol

The waste water streams from PBT plants are contaminated mainly with

C_4–alcohols and THF which are well biodegradable. Therefore common technologies of waste water treatment can be used for purification of the total effluents.

Gaseous Emissions

The off-gas streams from polycondensation plant and THF recovery (if existing) contaminated with significant quantities of tetrahydrofuran (THF) have to be collected and sent by the off-gas blower to HTM heater(s) OSBL for incineration.

Solid Waste

Section	Residue / Waste	Amount in kg/day	Remarks	Disposal
BA	PBT	10 - 20 1)	granulation for a chip production of 200 t/day	d, a, b, c
BA	Oligomers	approx. 6 2)	cleaning (filter baskets)	b, c, a
BA	Prepolymer with steel sieves	8 – 12 1)	change of filter sieves	a, b, c
BA	Polymer with steel sieves	2 – 5 1)	change of filter sieves	a, b, c
BF	Side stream THF column	2,000 – 3,000 2)	water: 30-50 wt.% THF, furanes, C4-alcohols: 50 - 70 wt.-%	b

1) daily average of a month's production
2) depending on operation of column

Remark:
The side stream generated by the THF recovery (BF) is sent to HTM heater(s) for incineration.

Additional information about disposal methods (OSBL) for the listed residues/wastes generated by the plant are recommended in the table above:

a - recycling c – deposit
b - incineration d - for sale

High Density Polyethylene (HDPE)

1 Introduction

HPL has a currently 2 chains of 20 TPH HDPE chain to produce different grades of HDPE using Mitsui Technology.

Subsequent to generation of additional ethylene from expansion in Naphtha Cracker Unit, HPL proposes to enhance HDPE capacity further by setting up additional 20 TPH chain.

2 Project Scope

The project scope includes the following:

- Catalysts Preparation & Dosing System
- Polymerization Rector and Ancillaries
- Extrusion
- Product Storage & Bagging
- Solvent Recovery System
- Product Warehouse etc.

3 Investment

Estimated investment is about 400 Rs. Cr.

4 Process Description

The technology is the Slurry CX process of Mitsui. Mitsui Chemicals Ltd . This will be 3rd Line of HDPE Unit with separate Solvent Recovery Section . It will be located beside the existing HDPE Unit

This line consists of the following sections :

1. Catalysts, Cocatalyst handling & metering
2. Polymerization
3. Polymer separation & drying
4. Extrusion & pelletization
5. Product homogenisation
6. Product storage & bagging
7. Solvent recovery
8. Process facilities

Catalyst & co-catalyst are diluted to the required concentration with solvent and pumped to the reactors. Polymerization reaction is carried out in two continuous stirred tank reactors operating in series or parallel according to the grade required, in the slurry state at 8 kg/cm2 g and 85oC. Ethylene, comonomer and hydrogen are fed to the reactors. Unconverted monomer going with the product is separated in flash drums.

The reactor effluent is fed to a centrifuge to separate the polymer powder from the mother liquor. The wet polymer powder is dried in a rotary steam tube dryer.

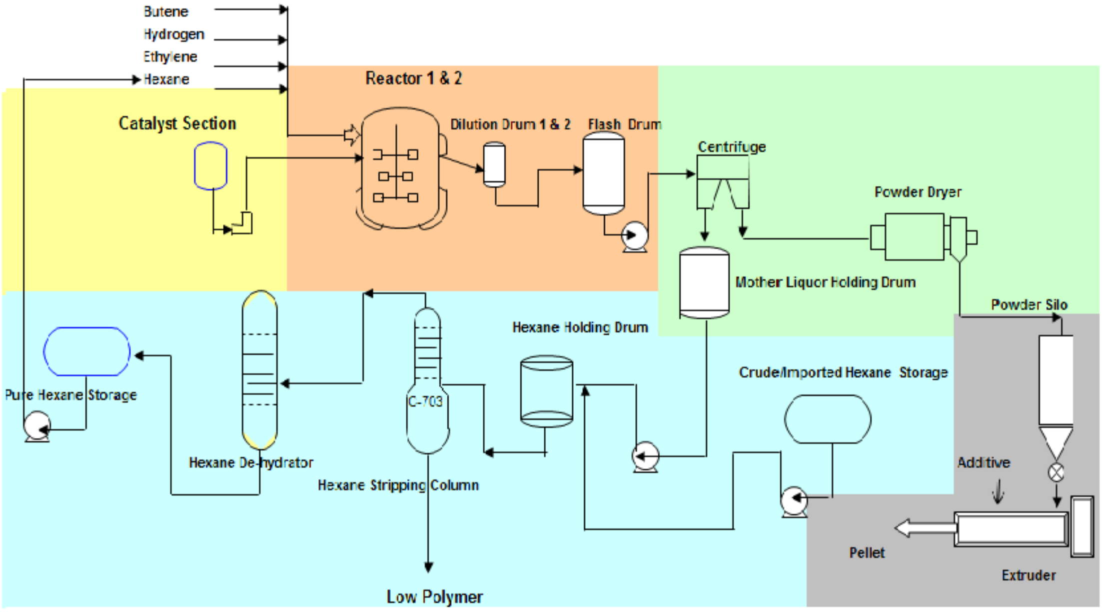
The mother liquor containing primarily solvent, from the centrifuge is divided into two streams. Major portion is recycled to the reactor. Rest is routed to the new solvent recovery section where it is washed first to neutralise the left out catalyst and then low polymer is separated from the solvent. The recovered solvent is further dried up to 5 ppm moisture level and recycled to the polymerization section and catalyst section.

The dried powder is transferred to the powder silo by a closed loop nitrogen conveying system. Dried powder and additives, in a pre-determined ratio, are fed to the extruder. Extruded material from the extruder is pelletized in an underwater pelletizer.

The pellets are blended in homogenization silos to achieve uniformity of product. The blended product is stored and then pneumatically conveyed to the bagging section. The product is bagged in 25 kg bags, palletized in 1 tonne pallet, stacked in the warehouse for ultimate despatch.

The low polymer, produced as a by-product, is flaked in a drum flaker. This is marketed as polyethylene wax.

HDPE(Mitsui) Process Flow Diagram



5 Demand Supply Scenario

The demand of HDPE grades produced from slurry process (mainly HDPE Film, Pipe & Blow Moulding Applications) is higher than installed capacity. Even after proposed capacity additions in the country, shortfall is likely to continue.

KTA

HM FILM, BLOW, PIPE	FY 15-16	FY 16-17 @ 10% Growth	F Y17-18 @ 10% Growth	FY 18-19 @ 10% Growth
DEMAND (A)	1400	1540	1694	1863
DOMESTIC CAPACITY	1064	1404	1404	1404
MAX. DOMESTIC SOURCE AVAILABILITY (B)	903	1234	1404	1404
GAP (B-A)	-497	-306	-290	-459

6 Utilities Requirements

Resources	Normal	Maximum
	m^3/hr	m^3/hr
Cooling Water (m^3/h)	4350.0	4850.0
HP Steam (TPH)	2.5	2.6
MP Steam (TPH)	3.5	4.2
LP Steam (TPH)	5.2	5.8
DM Water (m^3/h)	7.3	11.9
Power (MWh)		5.5

7 Environmental Factors

Effluent

Start-up drain from Extruder	1.0 m^3/hr
Pellet Cutting Water	1.0 m^3/hr
Process Effluent	1.5 m^3/hr

Flare Load 135 Ton/hr

Vinyl Acetate Ethylene Emulsion

1. Introduction

VAE emulsions are utilized globally in a wide variety of industrial and consumer applications, including:

- paints and coatings
- water-based adhesives for woodworking and paper packaging
- non-wovens (engineered fabrics)
- paper saturations/specialties
- paper and paperboard coatings
- carpet-backings
- apparel and textile finishing processes
- redispersible powders
- waterproofing coatings
- building and construction products
- glass-fiber sizings and secondary binder technologies

HPL is considering setting up a VAE plant to meet domestic demand.

2. Project Scope

It includes:

1. 60 KTA VAE Plant
2. VAM Storage Tanks
3. VAE Storage Tanks
4. VAM Unloading Pipeline & System
5. VAE Loading System
6. Utilities & Infrastructure Upgradation

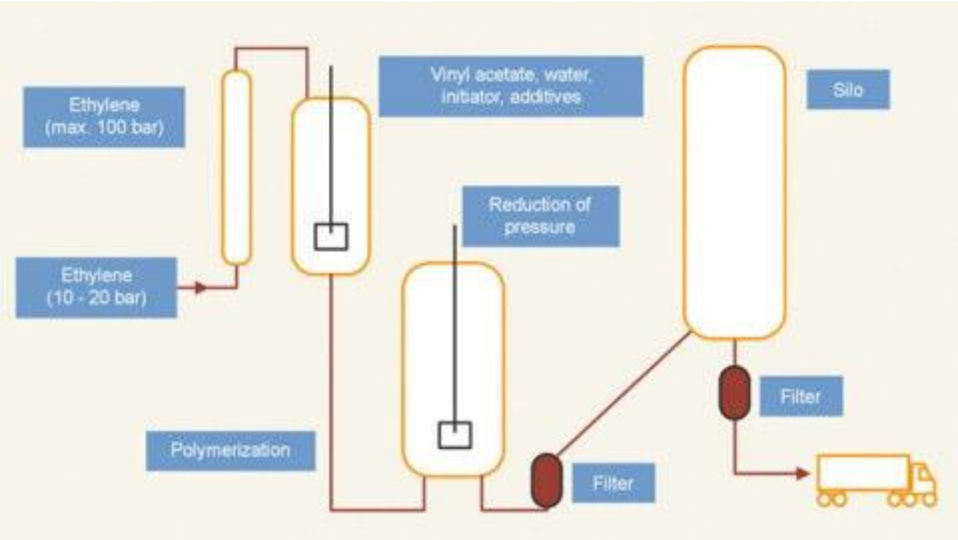
3. Investment

Estimated Investment in ISBL facilities is about 60 Mn USD.

4. Process Description

Vinyl acetate ethylene (VAE) emulsions are based on the copolymerization of vinyl acetate and ethylene, in which the vinyl acetate content can range between 60 and 95 percent, and the ethylene content ranges between 5 and 40 percent of the total formulation.

High-pressure reactors are required to synthesize VAE emulsions from vinyl acetate monomer (VAM) and ethylene.



8 Environmental Factors

Effluent

Rate	5.0 m^3/hr
pH	6.0-9.0
BOD_5	0.20kg/1000kg
TSS	0.55kg/1000kg

Storage Details of Hazardous Chemicals in HPL

The storage details of hazardous chemicals (classified in accordance to MSIHC Rules 2000) are provided in the following table.

Hazardous Chemicals Storage Details					
Tanks					
Stream	Nos. Existing Tanks & Spheres as on 01.02.16	Working Volume (m3)	Density (g/cc)	Density (kg/m3)	Max Storage Quantity (MT)
Naphtha	5	42735	0.67	670	143162
Hydrotreated PG	2	1825	0.89	890	3249
Multipurpose Tank (HPG)	2	4000	0.89	890	7120
Multipurpose Tank (MS)	1	4000	0.77	770	3080
RPG	2	2950	0.83	830	4897
FGN	1	600	0.7	700	420
FGN	1	750	0.7	700	525
FGN	1	800	0.7	700	560
BEU Feed Stock	3	1070	0.83	830	2664
Benzene	2	2110	0.88	880	3714
Benzene	2	4720	0.88	880	8307
CBFS	3	1780	1.05	1050	5607
Cyclopentane	2	1030	0.75	748	1541
Slop Oil	1	1000	0.9	900	900
Imported Hexane	2	750	0.67	670	1005
Crude Hexane	1	400	0.67	670	268
MS Blending Tank		1030			
MS Blending Tank	2	1210	0.77	770	1863
Motor Spirit Storage	2	4000	0.77	770	6160
C6 Raffinate	2	750	0.72	720	1080
Pentane	1	301	0.63	630	190
HSD	1	80	0.9	900	72
Sphere					
LPG	1	1900	0.55	550	1045
Butene-1	4	1880	0.6	600	4512
Ethylene	5	2500	0.44	440	5500
Propylene	4	2400	0.48	480	4608

Mixed C4	2	1710	0.58	580	1984
Butadiene	4	2050	0.62	620	5084
C4 Raffinate	3	915	0.57	570	1565

Bullet					
Propane	1	180			
Hydrogen	2	60			

Annexure – IX

Coal based Energy Generation

1. INTRODUCTION

HPL expanded its production capacity from 5,20,000 TPA ethylene to 7,00,000 TPA ethylene in 2010. During that proposed capacity expansion, no additional infrastructure was added in the captive power plant, which has a capacity to produce 116 MW power and 480 TPH superheated steam. The installed capacity of major steam and power generating equipment within captive power plant are:

Sl No.	Equipment	Installed Capacity	Fuels
1	GTG-1	34.5 MW	Naphtha & Fuel Gas
2	GTG-2	34.5 MW	Naphtha & Fuel Gas
3	CSTG	33 MW	
4	BPSTG	16 MW	
5	HRSG – 1	120 TPH SHP Steam	Naphtha & Fuel Gas
6	HRSG – 2	120 TPH SHP Steam	Naphtha & Fuel Gas
7	AB-1	120 TPH SHP Steam	Naphtha, CBFS & Fuel Gas
8	AB-2	120 TPH SHP Steam	Naphtha, CBFS & Fuel Gas

Considering internal consumption of captive power as well, HPL require about 85 MW power and 210 TPH SHP steam during normal operating conditions. The steam requirement increases substantially highduring plant start-up. In case of unavailability of any of the power or steam generating equipment due to periodic maintenance and/or breakdown maintenance, HPL operations become very vulnerable.

HPL is proposing to expand its current production capacity, diversify its product basket and add additional infrastructure for improved reliability and operational flexibility. Additional steam and power demand from proposed projects are as follows:

Table – I: Additional Steam & Power Demand

	Total Steam, TPH	***Total Power, KWh***
Ethylene Capacity Expansion	*6.6*	*3,049*
Butene-1	*23.7*	*425*
MS Capacity Expansion & Quality Upgradation (Py Gas Hydrotreatment)	*4*	*210*
Phenol	*75.25*	*4,550*
PBT	*2.8*	*686*
VAE	*20*	*2000*
HDPE Train-3	*11.2*	*5,500*
Miscellaneous (20% of Sum of Above)	***28.7***	***3,285***
Total	***~172.25***	***~19,705***

The additional steam and power demand cannot be met from the existing facilities in CPP. It is proposed to add additional steam and power generating system based on coal to meet:

- Additional requirements from proposed projects
- Create buffer capacity for future projects
- To improve efficiency and reliability of existing operations.

2. PROJECT SCOPE

The project scope includes:

- 3 x 120 TPH Coal Fired CFBC Boilers
- 1 x 35 MW Condensing Steam Turbine Generator
- Turbine Bypass Pressure Reducing Desuperheating Stations (PRDS) to generate different pressure steam
- Coal handling system of 200 TPH handling capacity

- Ash Handling System of 40 TPH to handle worse quality coal

3. Location & Area Requirements

Main Power Block	: 1.86 Ha	Near CPP
Cooling Water Circuit	: 1.73 Ha	Near CPP
Coal Yard	: 4.86 Ha	Near West Pond
Green Verge	: 3.5 Ha	Near West Pond
Others including Road, ETP, Guard Pond, etc .	: 1.74 Ha	Near CPP
Ash Handling	: 1.6 ha	Near North Pond

4. Fuel Requirement & Quality

Existing Monthly Fuel Requirement (Excluding Internally Generated Fuel Gas @ 5.5 TPH) : Naphtha: 9,000 T CBFS: 6,768 T.

Estimated Monthly Fuel Requirement after incorporation of new facilities (Excluding Internally Generated Fuel Gas of 5.5 TPH): Naphtha: 9,000 T; CBFS: 8,730 T Coal: 57,600 T

Coal details and specifications are given below

Coal Quality	**Imported Coal:** 70% (4,500 Kcal/Kg; 12% Ash) **Domestic Coal:** 30% (3,500 Kcal/kg, 35% Ash)
Hourly Coal Requirement	**Total:** 81 TPH; System has been designed assuming 4th boiler in future (110 TPH). Storage designed for 15 days total demand @ 110 TPH
System Description	Coal Unloading by Truck → Loading to Ground Hoppers → U/G Receiving Conveyors → Coal Crusher (2 stage; 250 mm --.6 mm) →Bunker Storage → Coal Firing
Major Equipment	(i) Belt Conveyors (2 x 200 TPH) (ii) Vibrating Feeder (200 TPH) (iii) Vibrating Screens (4 nos.) (iv) Primary Crusher (2 nos.) (v) Secondary Crusher (2

	nos.) (vi) Bulldozer (2 nos.)

5. *ASH GENERATION & HANDLING*

Ash Generation	**40 TPH** (with worse coal i.e. domestic coal with 35%) With 70:30 mix of imported and domestic coal, ash generation in different scenario would be **Total Capacity** (3 x 120 TPH): 15 TPH **With Future Capacity** (4 x 120 TPH): 20 TPH
Ash Storage & Handling System	**Fly Ash** (80% of Total Ash Volume): 2 x 800 m^3 Fly Ash Storage RCC silos **Bed Ash** (20% of Total Ash Volume): 1 x 275 m^3Bed Ash Storage MS silo Truck Loading System High Concentration Slurry Disposal (HCSD) system for emergency disposal in ash pond 4 (3W + 1S) Dense Phase Pneumatic Conveyor 4 (3W+1S) nos. each for ESP Fluidizing and Silo Fluidizing blowers

6. *CAPITAL INVESTMENT*

Estimated ISBL Investment is about ~530 Rs. Cr. including excise duty.

7. *UTILITIES REQUIREMENTS*

Based on preliminary estimate, major utilities consumed in above process are:

Water	**System Requirement:** ~220 m^3/h (continuous basis) to meet requirements of cooling water make-up, DM feed, service water, potable water, fire water etc. Bulk of the requirement can be met with water intended for existing Aux-Boilers. Balance to be taken through a new tap from running header. 2 x 15 m^3/h DM Water Chain to meet make-up requirements

	of boilers; However, HPL plans to set up a 150 m^3/h chain of existing configuration to meet additional demand. Additional 1,000 m^3 DM water storage capacity & 850 m^3 condensate storage tank. CW cell for 7,500 m^3/h circulating water with 3 (2W + 1S) pumps having 3,725 m^3/h capacity; Additional 2 pumps (1W+1S) of 700 m^3/h for auxiliary cooling; Design Cooling Range: 43^{0}C – 33^{0}C; Approach: 4^{0}C Fire Water System to Coal Handling & New CPP area
Compressed Air System	Tapping to be taken from existing HPL System
Fire Water System	Tapping to be extended from existing naphtha tank to coal handling area Existing header at south of CPP to be extended for fire water system for new construction around existing CPP system

8.0 ENVIRONMENTAL FACTORS

Aqueous Effluent

The major sources of liquid effluents from the proposed power plant which may induce water pollution will be as follows:

- Cooling Tower Blowdown (CTBD)
- Boiler Blowdown (BBD)
- Power House and Boiler Area Service Water Waste
- Coal Handling Plant's Waste Water
- DM Plant Regeneration Waste
- Run-off from Coal Pile Area and Wastes from DS System
- Ash Handling System Waste
- Sanitary Waste from Plant Toilets

Most of the above effluent will be required to be treated separately, mixed with other treated / untreated effluents, before disposal. The basic treatment philosophy to be adopted is to utilize treated/untreated effluents to the maximum possible extent and to allow discharge of wastewater through a single point. Any effluent to be discharged through plant effluent outfall, shall meet the General Standards for Discharge of Environment Pollutants Part A : Effluents as well as those specified Standards for Discharge of Liquid Effluents from Thermal Power Plants as provided in Environment (Protection) Rules, 1986 Schedule-I vide Notification dated 31.12.1993 and the latest notifications

Gaseous Emissions

The major sources of air pollution and the name of pollutants from the proposed plant will be as follows:

Sources	**Pollutant**
Stack	SPM, SO2 &NOx
Coal Handling Area	Fugitive Dusts
Ash Handling Silos	Fugitive Dusts

The air pollution mitigation measures have been conceived for the proposed project is summarized below:

- 140 m tall two flue RCC stack, as recommended by MoEF, conceived for proper dispersion of pollutants through the stack.
- High efficiency ESP will be provided to maintain particulate emission at chimney outlet limited to 50 mg/Nm^3 to ensure conformity to the "*Charter Of Corporate Responsibility for Environmental Protection* (CREP)" recommendation of the MOEF, Govt. of India.
- Dust extraction and dust suppression system conceived for the suppression of fugitive dust in crusher house, during truck unloading and other handling sections of coal.
- In ash silo area also dust suppression system will be provided.
- A green belt is also conceived around the air pollution sources and also along plant boundary to restrict air pollution.

Solid Waste

The main solid waste management of this proposed plant includes ash management generated due to combustion of coal. Main features of the solid waste management plan conceived for the project is as follows:

a. A dry mode of ash handling system has been considered for both fly ash & bed ash upto respective silos. From these storage silos, ash will be taken away from the plant premises by trucks. Fly ash utilization will be as per MOEF"s notification.

b. It is also proposed to explore the following possibilities where dry ash can be effectively utilized:

   i. Cement Plant.

   ii. Brick Manufacturing

   iii. Road construction, etc.

Under exigency, there would also be a provision of disposal of fly ash & bed ash from the outlet of respective silos to ash pond by HCSD system through suitable pumping system.

Afforestation (Green Belt Development) for the subject plant has been envisaged for minimizing the impact of any plant, which emits pollution on the environment. Green belt to be developed in the proposed plant area will be a measure to mitigate air pollution, noise pollution and will improve the general aesthetics of the surroundings. Eco-development conservation and pollution abatement through green belt are the two major components so vital for industrial activity, whether proposed, existing or under expansion stage.

Annexure – X

Plot Plan

Uploaded Separately

WASTE WATER TREATMENT PROCESS

1.0 INTRODUCTION

HPL utilizes dual mode of wastewater treatment system. The facilities are divided into two distinct sections, namely, pre-treatment section inside battery limits (ISBL) of the respective units and final treatments in Waste Water Treatment (WWTP).

2.0 ISBL TREATMENT SYSTEM

ISBL Treatment is provided for the following streams:
i) Spent caustic stream from Naphtha Cracker Unit (NCU): Spent caustic stream emerging from cracker unit is highly alkaline and contains high oxygen demand. In the spent caustic treatment plant, Na_2S is converted to sodium thiosulphate by oxidation process. After this treatment, the stream is sent to WWTP.
ii) Neutralization / free oil removal in NCU: Corrugated plate interceptors (CPI) have been provided in NCU for removal of floating oil from different waste streams of NCU.
iii) Polymer Plants: Wash water and effluent streams from process contain trace hydrocarbon and polymers, which is, collected ISBL and then sent to WWTP after oil skimming and removal. Provision for removal of polymer powers and floating oil has been provided in the polymer plants.
iv) Neutralization of effluent generated from regeneration in Demineralization of Water (DM) plant.

3.0 OSBL TREATMENT SYSTEM

The OSBL treatment facilities (Wastewater Treatment Plant) are designed for treating process wastewater for reduction free and emulsified oil, sulphide, phenol, thiosulphate, total suspended solids (TSS), Bio-chemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) and the contaminated rainwater for removal of oil and suspended solids. The treated effluents from the Wastewater Treatment Plant are meeting the discharge standards stipulated by West Bengal Pollution Control Board.

4.0 BIOLOGICAL TREATMENT SYSTEM

Activated sludge process has been adopted by HPL for reducing the biodegradable organic content of the effluents. The effluent from the DAF tank is routed to aeration tank operating in extended aeration mode for removal of biodegradable organic matter, resulting in reduction of
BOD & COD. Aeration conditions are maintained in the tank by entrapment of the atmospheric air with the help of surface aerators. The nutrients i.e. urea & DAP solution are dosed at the inlet of aeration tank to provide nitrogen, phosphorus for microorganisms. The overflow from the aeration tank will contain a high concentration of microorganisms. A secondary clarifier helps in

separating the microorganism from the liquid streams from the bottom sludge and the over flow is the treated effluent.

Then aeration tank effluent is routed under gravity to the clarifier. The clarifier is provided with a sludge scraper, which moves slowly to scrap the bio-solids, which settle at the bottom. The collected sludge is routed to the bio-sludge sump. Bio-sludge is recirculated to aeration tank inlet to maintain desired microorganism concentration. Sludge from recirculation line is bleed – off regularly to sludge thickener to remove dead microorganism cells. The overflow from the clarifier is the treated effluent, which is routed to the guard pond. Two guard ponds (2 X 4,090m3) are provided to take care of all types of functional eventualities of the Wastewater Treatment Plant (WWTP), if the effluent does not meet the standards. Moreover, the guard ponds are provided with impervious layers to prevent percolation possibilities and consequent contamination of soil and sub-soil water.

5.0 SANITARY SEWER TREATMENT SYSTEM

A dedicated underground sanitary sewer network is provided for entire HPL Complex including the Captive Power Plant of HPL Co-generation Ltd. and Nitrogen Plant of M/s Praxair India Ltd. Sanitary effluent after collection in various suitable pits, is pumped to Bar Screen Chambers and then the grit chamber for physical removal of scum and suspended solids. Finally, sewer effluent is pumped to Aeration Tank of WWTP for Biological Treatment along with other process effluents.

6.0 CONTAMINATED RAINWATER TREATMENT SYSTEM

During wet weather, the contaminated rainwater stream of HPL complex is received in the receiving sump of WWTP. This effluent is transferred to surge pond by dedicated high capacity WWF pumps (4 X 3,000 m3/h) after passing through bar screen and grit chamber. Floating oil skimmer is provided to remove the free oil layer formed in the surge pond and routed to the wet slop oil sump. TPI has been provided to remove floating oil and suspended particles from the effluent. Provision has been made to transfer the surge pond effluent to equalization tank for processing along with other normal waste streams. Otherwise, if all parameters are within limit, it can be transferred to guard pond for disposal along with treated effluent.

7.0 SLOP OIL COLLECTION SYSTEM

The slop oil is collected in wet slop oil tank from various untis e.g. TPI separator – I & II, Equalization tank, Dissolved air floatation tank and surge pond and transferred to slop oil tanks for storage. Slop oil is also received from KOD of flare system. The dry slop oil, retained in the tank after decantation of water, will be disposed as low grade fuel to authorized external agencies or burnt in incinerator. One 1,000 m^3 capacity tank has also been made to store the dry slop oil. The decanted water from slop oil tank bottom is recycled to receiving sump by gravity.

8.0 SLUDGE HANDLING SYSTEM

The oily sludge from the TPI Separators, DAF tanks and clarifiers is collected in chemical and oily sludge sump from where it is routed to sludge thickener.

The under flow from the sludge thickener is routed to the thickened sludge sump from where it is pumped to the centrifuge. Dewatering polyelectrolyte is dosed in centrifuge to achieve better sludge consistency. Periodically sludge is collected from centrifuge and is stored in secured On-site Storage Pit.

9.0 FINAL DISCHARGE SYSTEM

Co-generation power plant, Cooling tower, Nitrogen plant and DM water plant effluent is being collected in Cooling Tower Blow Down (CTBD) and DM waste pond. CTBD and DM waste pond overflow/ drain, which is totally free of any organics, or oil is routed to treated effluent sump along with treated effluent from guard pond for final disposal through a channel. Provisions of two Guard Ponds (with three days effluent holding capacity of approx. 8,180 m^3) are provided to take care of all types of functional eventualities of the Waste Water Treatment Plant (WWTP). The quality of effluents is checked as per specification of effluent standards. In case, the effluent does not meet the stipulated standards, it is recycled to the WWTP for the re-treatment to achieve the stipulated effluent quality standards.

Moreover, the guard ponds are provided with impervious layers to prevent all percolation possibilities. The treated effluent from WWTP is discharged into the river Hooghly through Haldia Green Belt Canal. Also, the treated effluent to the maximum extent possible will be utilized for irrigation of green belt developments. The final out-fall effluents confirm that there is immense dilution i.e. nearly 20,000 times adjacent to the green belt canal and more than 25,000 times at the confluence of river Haldi. Since, Hooghly and Haldi rivers are tidal in nature, the buffering capacity of the green belt canal will ensure to hold the treated effluent discharged (via green belt canal) during

the high tide period. The final effluent meets the WBPCB prescribed standards. Environmental Laboratory checks the quality of effluent daily as per specifications of effluent standards. In case, the effluent does not meet the stipulated standard, it is recycled to the WWTP for the re-treatment to achieve the stipulated effluent quality standards.