

Pre-Feasibility Report (PFR)

For

**Proposed Crude to Chemical, A Refinery cum
Petrochemical Complex at at A.V. Nagaram village,
Thondangi Mandal of East Godavari district, Andhra
Pradesh**

By

M/s Haldia Petrochemicals Limited

Submitted by



Prepared by





**Proposed Crude to Chemical Complex at A.V. Nagaram village,
Thondangi Mandal of East Godavari district, Andhra Pradesh By M/s
Haldia Petrochemicals Limited**

PROJECT DETAILS

**Name of Proposed Crude to Chemical Complex at at A.V. Nagaram village,
Publication Thondangi Mandal of East Godavari district, Andhra Pradesh By M/s
Haldia Petrochemicals Limited.**

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*Proposed Crude to Chemical Complex at A.V. Nagaram village,
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Haldia Petrochemicals Limited*

CHAPTER 1

INTRODUCTION

CHAPTER 1: INTRODUCTION

1.1 PREAMBLE

Haldia Petrochemicals Limited (HPL) is one of the largest petrochemical plants in India, located at Haldia in West Bengal. The company is promoted by The Chatterjee Group (TCG), one of the country's leading business conglomerates with operations spanning across several sectors and continents. TCG offers a wide gamut of services across multiple industries including Petrochemicals, Pharmaceuticals, Biotech, Financial Services, Real Estate and Information Technology sectors.

The hydrocarbon vertical of the group also consist, other than HPL, a Purified Terephthalic Acid (PTA) manufacturing unit (MCPI Pvt. Ltd.) of capacity 1,200 KT per annum. The manufacturing facilities of these petrochemical units are located at the riverine port town, Haldia, West Bengal. These entities started operation in the year 2000 and are running consistently at maximum capacity utilization with steady profits and cash generation. The products are sold in domestic as well as export market through strong marketing network established over the years.

The primary feedstock for the hydrocarbon ventures of the group are Naphtha (HPL) and Paraxylene (MCPI Pvt. Ltd.) and both these Chemicals are the output of Refinery. Currently, the group is majorly dependent on imports for sourcing of their primary feedstock.

India is a net importer of most of petrochemical products, demand of which is expected to grow at healthy pace in future. To exploit the emerging opportunities in petrochemical segment and to ensure availability to competitive feed to existing ventures, an integrated refinery-cum –petrochemical complex “Crude to Chemical” is proposed at Kakinada which will produce major petrochemical products like HDPE, MEG, EO derivatives, PVC, Styrene, PP, Phenol, Isopropanol, Propylene oxide and derivatives apart from refinery products like gasoline and diesel to meet local demands.

HPL now proposes to set up Crude to Chemical (CTC) Complex, A Refinery cum Petrochemical Complex at at A.V. Nagaram village, Thondangi Mandal of East Godavari district, Andhra Pradesh.



Proposed Crude to Chemical Complex at A.V. Nagaram village, Thondangi Mandal of East Godavari district, Andhra Pradesh By M/s Haldia Petrochemicals Limited

Table 1.1: Salient Features of the Plant

Particulars	Details
Company Name	M/s. Haldia Petrochemicals Limited (HPL)
Location	A.V. Nagaram village, Thondangi Mandal of East Godavari district, Andhra Pradesh
Latitude	17° 9'30.38"N
Longitude	82°24'17.88"E
Category of the Project	As per EIA Notification dated 14th Sept., 2006 as amended from time to time, this project falls under S. No. 4 (Materials Processing), Project activity "4 (a)"- Petroleum refining industry and S. No. 5 (Materials Processing), Project activity "5 (c)"- Petro-chemical complexes (industries based on processing of petroleum fractions & natural gas and/or reforming to aromatics)
Land required	2,560 Acres
Greenbelt /Horticulture Plantation Area (Acres)	637 Acres
Estimated project cost	INR 62714 Cr
Manpower Requirement	Total Manpower Requirement: 5000. During construction, peak manpower would be in the range of 20,000 – 30,000 persons
Nearest highway	Kakinada-Tuni Road passing through the proposed project site.
Nearest railhead / Railway station	Nearest Railway Station is Durgada station about 7 km from project site (NW)
Nearest airport	Nearest airport is Visakhapatnam about 105 km from project site (NE)
Defence installations	None
Archaeological important places	None
Wild life sanctuaries	None
Nearest major city	Kakinada – 24 km (SW)
Rivers in 10-km radius	Polavaram Main Canal – 9.5 Km (NW)
Hill ranges	None
Seismic zone	The proposed plant-site area falls in Seismic Zone III as per IS 1893:2002 (Part-1), which is a Moderately sensitive seismic zone.

1.2 IDENTIFICATION OF PROJECT PROPONENT

Haldia Petrochemicals Limited (HPL) was set up as a joint venture between the Government of West Bengal (GoWB), the Dr. Purnendu Chatterjee-led Chatterjee Petrochem (Mauritius) and The Tata Group. With the sale of first tranche of shares by GoWB in December 2015, the majority shareholding is now with TCG and management control is under TCG. HPL manufactures commodity polymers like high-density polyethylene (HDPE), linear low-density polyethylene (LLDPE), and polypropylene (PP), and chemicals/fuels like benzene, butadiene etc with intermediates being sourced from a naphtha cracker (capacity: 700 KTA of ethylene) located at Haldia, West Bengal. The company is the third largest player in the domestic polyolefins market after Reliance Industries Limited and Indian Oil Corporation.

Haldia Petrochemicals Limited manufactures and supplies polymers and chemicals. The company's polymers include polypropylene and polyethylene, including high density polyethylene (HDPE) and linear low density polyethylene (LLDPE). It manufactures chemicals for the energy segment, including motor spirit, liquefied petroleum gas (LPG), raw pyrolysis gasoline (RPG), and carbon black feed stock (CBFS). It also manufactures chemicals for industrial products, including benzene, butadiene, carbon black feedstock (CBFS), and cyclopentane. The company serves packaging, consumer durables, houseware, automobiles, furniture, container, and luggage manufacturers. The company provides its products through vendors in India and internationally. Haldia Petrochemicals Limited was incorporated in 1985 and is based in Kolkata, India. The company has various locations and regional offices across India and an area office in Hyderabad.

1.3 NEED FOR THE PROJECT AND ITS IMPORTANCE

India is the 4th largest energy consumer in the world. India's primary energy mix is dominated by fossil fuels with oil accounting for the 2nd highest energy production after coal. The country's energy demand is expected to increase approximately 2.5 times by 2040, to reach 1,908 million tonnes of oil equivalent (mtoe) from 775 mtoe in 2013. This growth is projected to be driven by multiple factors including:

- ✓ Radical shift in India's GDP structure and promotion of the manufacturing sector
- ✓ Growing population and urbanization
- ✓ Rising income levels

- ✓ Target of universal access to electricity
- ✓ Step-up in agriculture and allied sectors

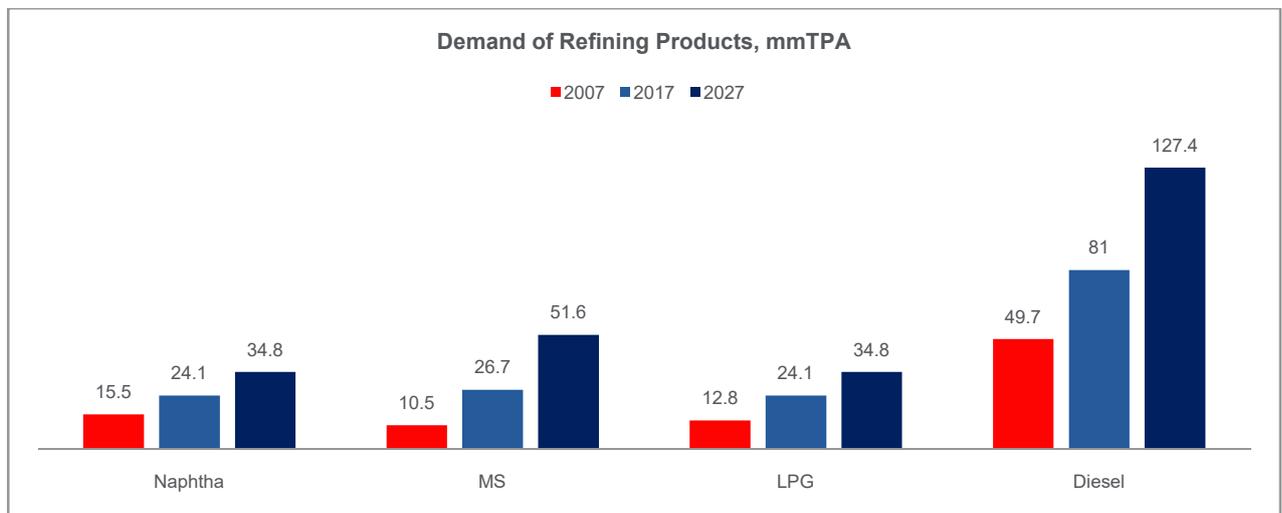
In line with the overall sectoral growth, India’s oil consumption is also projected to double in the period 2016-2040, as per an estimate by International Energy Agency in 2017.

1.3.1 DEMAND OF PETROLEUM REFINING PRODUCTS IN INDIA

India is one of the largest consumers of petroleum products in the world. The demand of petroleum products has increased from 129 mmTPA in FY 08 to 206 mmTPA in FY 2018, a CAGR growth of 4.8% in the last decade. MS, LPG and Diesel observed a high growth rate of 9.7%, 6.9% and 5.5% respectively and together accounted for about 64% of the total demand in FY 18.

Driven by the favourable macroeconomic parameters, the demand of light and middle distillate will continue to grow at healthy pace in next decade. Indian refining capacity, currently at 248 mmTPA, is slated to grow to 322 mmTPA in next decade to meet domestic demand. A significant part of the capacity addition is likely to take place along eastern coast considering that current refining capacity along the east coast is mere 28% of total Indian capacity serving 44% of the country population. The demand growth rate of states along the eastern coast is likely to be higher vis-à-vis other states, thereby justifying the need of additional investment in refining capacity.

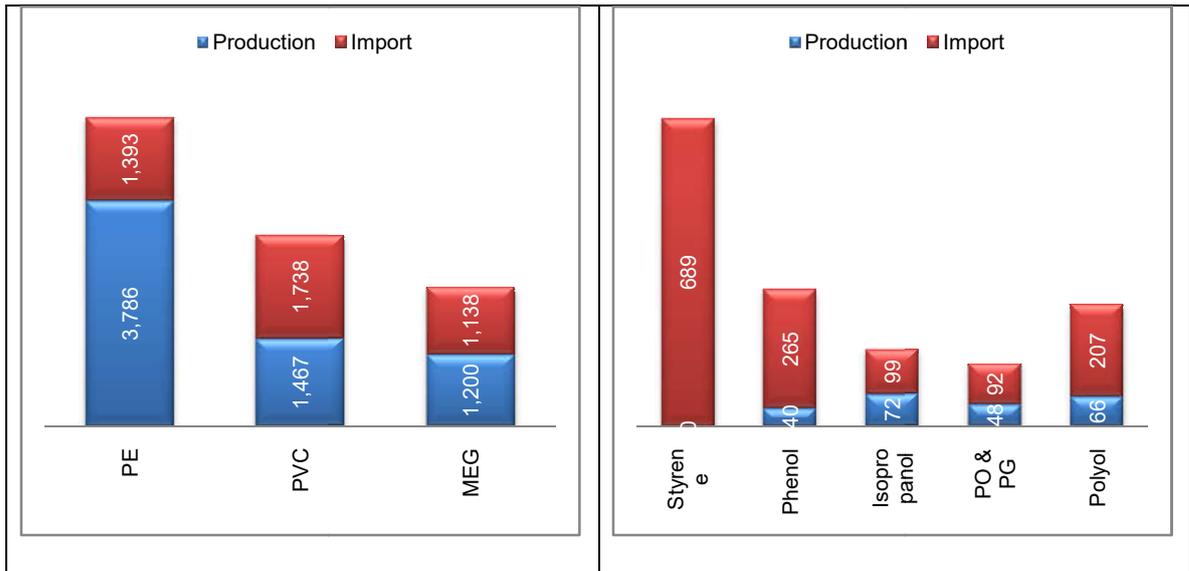
Table 1: Demand of Refining Products



Demand of Petrochemical Products

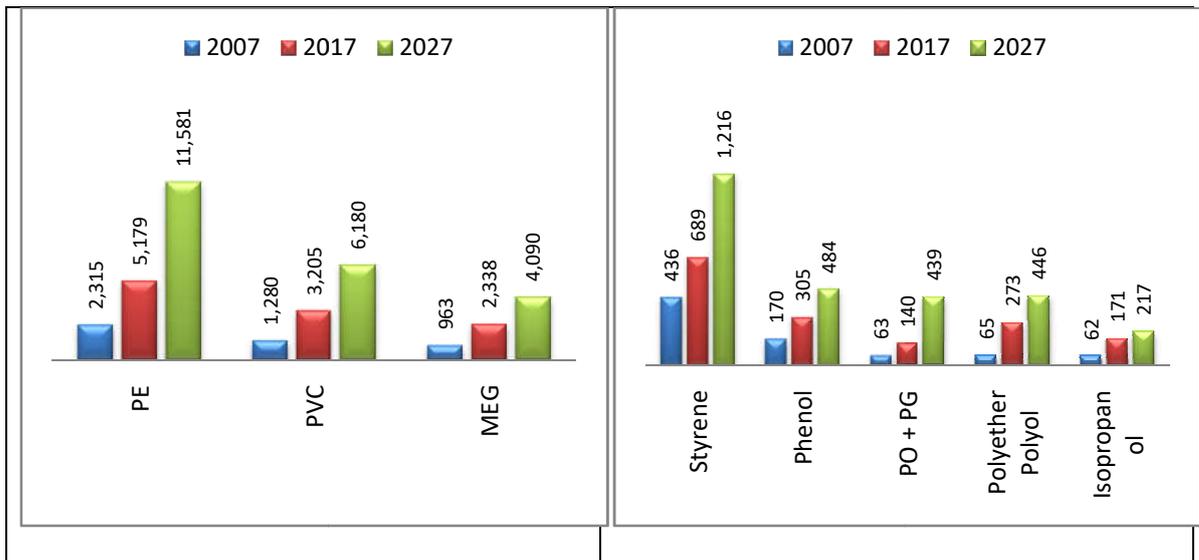
India is a net importer of almost all petrochemical products, except Polypropylene. The demand of various petrochemical products is growing at the rate of 8-10% CAGR. Bulk of the demand is being met through imports.

Table 2: Demand of Major Petrochemical Products in 2017



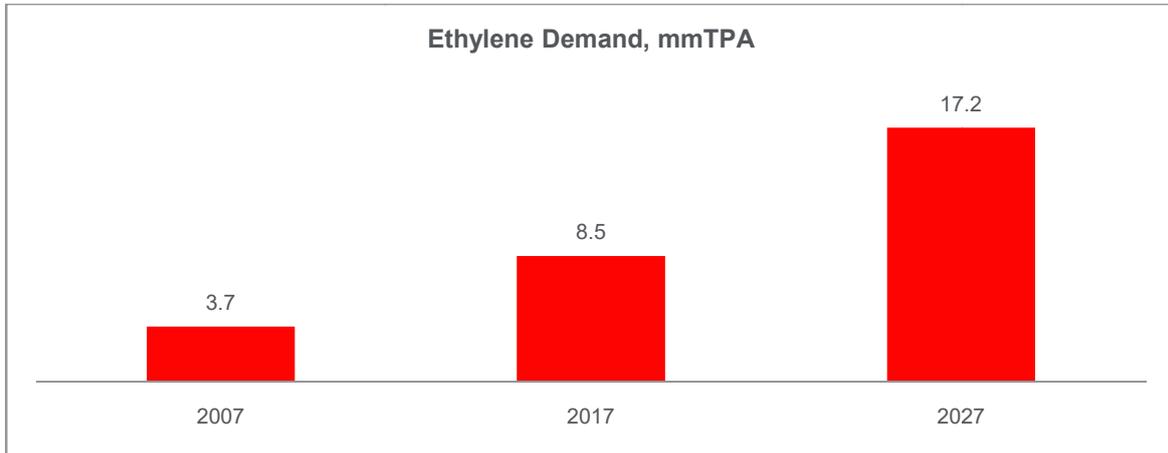
Driven by favourable demographics and macroeconomic factors, the demand of these products will continue to grow at faster rate in next decade, thereby increasing the gap between the production capacity and consumption levels.

Table 3: Growth Trend of Major Petrochemical Products



In terms of Ethylene, demand of petrochemical products is expected to grow from 8.5 mmTPA in 2017 to 17.2 mmTPA in 2027. To meet the emerging demand, India need to set-up 6-8 global sized crackers in the next decade.

Table4: Petrochemical Demand – Ethylene Equivalent



Paraxylene

Paraxylene (PX) demand is primarily driven by PTA demand, which in turn is mainly driven by the demand of Polyester fibers, yarns and PET.

Table 5: PX Demand & Outlook



India had turned net importer of PX in recent years and imported about 500 KTA PX in 2016. TCG Company MCPI imports about 800 KTA, which may grow double going forward after the expansion of PTA capacity.

Strong dependency on imports for various petrochemical products, petroleum products like LPG and current and forecasted internal demand of Naphtha and PX necessitate further investment in crude to chemical projects. Thus vertical integration through setting-up of a refinery in the light distillate category along with suitable sized cracker and downstream projects is proposed to meet internal demand of feedstock and growing product demand of products in domestic market.

1.4 LEGAL ASPECTS

HPL will comply with the prescribed limits laid down for air, effluent and noise emissions for protection of the environment under the following Acts, Rules and amendments:

Statute/Policy	Year	Relevant objectives
<i>Environment (Protection) Act</i>	1986	<i>To protect and improve the quality of the environment and to prevent, control and abate environmental pollution</i>
<i>Environment (Protection) Rules,</i>	1986	
<i>Environmental Impact Assessment Notification,</i>	1994	<i>To provide environmental clearance to new development project/activities following environmental impact assessment</i>
<i>Water (Prevention and Control of Pollution) Act,</i>	1974	<i>To provide for the prevention and control of water pollution and the maintaining or restoring wholesomeness of water</i>
<i>Air (Prevention and Control of Pollution) Act</i>	1981	<i>To provide for the prevention, control and abatement of air pollution and for the establishment of Boards to carry out these purposes.</i>
<i>The Forest Conservation Act</i>	1972	<i>To check deforestation by restricting conversion of forest area into non forest areas</i>
<i>The Forest (Conservation) Act</i>	1980	
<i>The Forest (Conservation) Rule</i>	1981	
<i>Wildlife (Protection Act), 1972</i>		<i>To protect wild animals and birds through the creation of National Parks and Sanctuaries</i>
<i>National Forest Policy</i> <i>National Forest Policy</i>	1952	<i>To maintain ecological stability through preservation and restoration of biological</i>



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Statute/Policy	Year	Relevant objectives
<i>(Revised)</i>	<i>1988</i>	<i>diversity</i>
<i>Motor Vehicles Act, 1988 Motor Vehicle Rules, 1989</i>		<i>To check control vehicular air and noise pollution</i>
<i>Ancient Monuments and Archaeological sites and Remains Act</i>	<i>1958</i>	<i>To protect and conserve cultural and historical remains To regulate construction activities near the monuments and sites protected by the Government</i>
<i>Land Acquisition Act,</i>	<i>1894 and 1989</i>	<i>Set out rule for acquisition of land by government</i>

Compliance to State Rules and Notifications will also be ensured.



*Proposed Crude to Chemical Complex at A.V. Nagaram village,
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CHAPTER 2

PROJECT DESCRIPTION

CHAPTER 2: PROJECT DESCRIPTION

2.1 PROJECT INTRODUCTION

The proposed project is Crude to Chemical (CTC) Complex which has been conceptualized considering the integration with demand of PX and Naphtha within the group company and demand supply scenario of the downstream products. The product focus of this CTC Refinery will be petrochemical feedstock which is different from conventional Refinery where main products are fuel catering to the energy market. Therefore, the main product of the proposed refinery will be LPG, Naphtha, Paraxylene etc. catering to the feedstock requirement of the petrochemical units and fuel generation from the refinery will be limited to the extent it can be sold in domestic market. However, depending on the volume, some amount of diesel may have to be exported considering low demand growth rate in domestic market.

The Refinery will be integrated with a downstream petrochemical complex. The heart of the petrochemical complex, i.e., the naphtha cracker unit, will utilize Naphtha; LPG and other intermediate streams generated in refinery and process it to produce the basic building blocks viz. Ethylene, Propylene, Benzene and Butadiene. These basic building blocks will be feed to various units in the petrochemical complex for converting it to final products of the complex.

2.2 PROJECT LOCATION

The proposed CTC Complex will be located at A.V. Nagaram village, Thondangi Mandal of East Godavari district, Andhra Pradesh. The proposed complex is spread across 2,500 Acres within the jurisdiction of Kakinada SEZ under GMR Infrastructure Limited. The site is located at a distance of 30.0 km from Kakinda Town. Nearest airport is Rajahmundry (87km) from proposed site. The location map of the area is shown in Fig 2.1. The study area of the proposed project falls in Survey of India Toposheet and is bounded by the following coordinates:

Latitude: 25°30'7.57"N

Longitude: 85°19'2.62"E

The general location of the project area is shown in Figure 2.1.

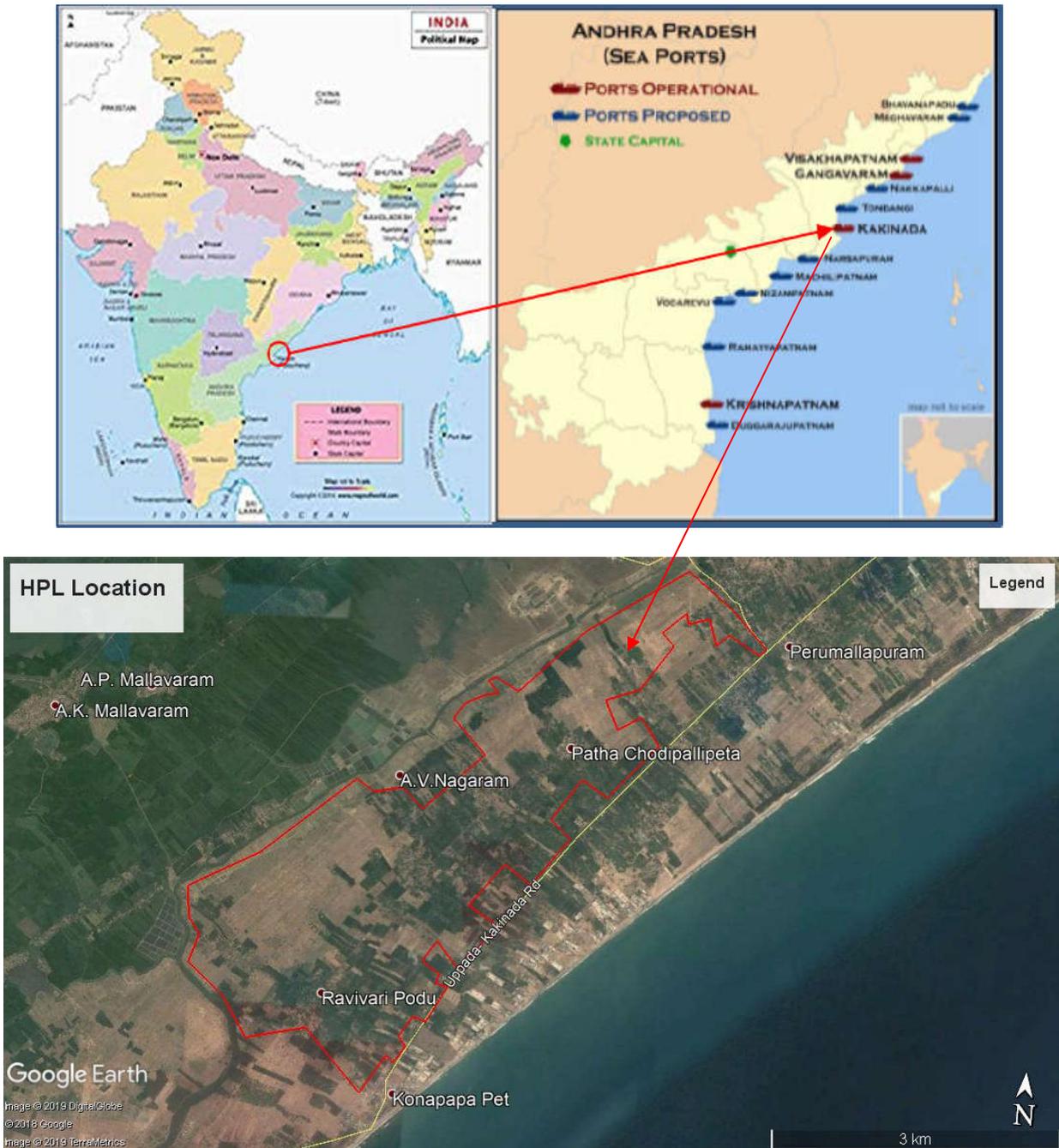


Figure 2.1: Location map of Project site

❑ Communication

Road Link: Kakinada-Tuni Road passing through the proposed project site.

Rail Link: Nearest Railway Station is Durgada station about 7 km from project site (NW).

Air Link: Nearest airport is Visakhapatnam about 105 km from project site (NE).

2.3 COORDINATES OF THE PLOT AREA

A preliminary plot plan of the CTC Complex is attached in the annexure – II.

Project Site Co-ordinates are:

17° 8 ' 18.528" N, 82° 22' 50.376" E

17° 8 ' 8.448" N, 82° 23' 39.480" E

17° 9 ' 11.232" N, 82° 24' 22.320" E

17° 9 ' 39.204" N, 82° 24' 39.708" E

17° 10' 0.984" N, 82° 24' 26.784" E

17° 10' 24.780" N, 82° 25' 10.272" E

17° 10' 22.116" N, 82° 25' 21.216" E

17° 10' 56.424" N, 82° 24' 48.744" E

17° 10' 7.068" N, 82° 23' 50.784" E

17° 9 ' 10.080" N, 82° 22' 25.428" E

2.4 SIZE OR MAGNITUDE OF OPERATION

2.4.1 PROJECT CONFIGURATION

The product slate from the CTC project is shown in the table below:

Table 2.1: Details of Products

Sl. No.	Products	Quantity, KTA
A. Refinery Products/Fuel Products		
1.	Diesel (Euro VI)	2775
2.	Gasoline (Euro VI)	604
3.	ATF / Jet Fuel	500
4.	C9+ Aromatics	261
5.	Sulfur	125
6.	Anode Coke	331
B. Petrochemical Products		
7.	HDPE	1,200
8.	MEG	750
9.	PVC	600
10.	Styrene	600
11.	Ethylene Oxide Derivatives (MEA, DEA, TEA, Ethoxylates, in terms of Ethylene Equivalent)	100
12.	PX	1600
13.	Butadiene	230
14.	1-Butene	100
15.	Benzene	750

Sl. No.	Products	Quantity, KTA
16.	Polypropylene	1,300
17.	Phenol	300
18.	Acetone	180
19.	Isopropanol (IPA)	100
20.	Propylene Oxide/ Propylene Glycol	300
21.	Polyether Polyol	300

2.4.2 PROCESSING UNITS

The various process units considered as the part of CTC are given below along with the capacity of each:

Table 2.2: Process Unit Capacities

Sl. No.	Process Units	Capacity, KTPA ^{Note-1}
1.	Crude Distillation Unit	12,000
2.	Atmospheric Residue Desulfurization Unit	5,900
3.	Integrated Hydrotreating Unit	3,400
4.	Hydrocracker Unit	2,800
5.	Continuous Catalytic Reformer Unit	2,200
6.	Paraxylene Recovery Unit	1,600
7.	Delayed Coker Unit	1,750
8.	Coker Naphtha Hydrotreating unit	300
9.	Fluidized Catalytic Cracking	3,200
10.	Hydrogen Plant	200
11.	Hydrogen PSA Unit	21
12.	Sulfur Recovery Unit	200
13.	SWS (HT + NHT), m ³ /h	200
14.	ARU (HT + NHT), GPM	2,100
15.	Cracker and Associated Unit	1,600
16.	Butene-1	100
17.	Polyethylene Unit	1,200
18.	MEG Unit	750
19.	Ethylene Oxide Derivatives (MEA, DEA, TEA, Ethoxylates, in terms of Ethylene Equivalent)	100 (EO Equiv.)
20.	PVC Unit	600
21.	Styrene Unit	600
22.	Polypropylene Unit	1,300
23.	Phenol Unit	300
24.	Isopropanol Plant	100
25.	PO & Polyol unit (POL)	300 (PO Chain Equiv.)

Note-1: No. of chains of each unit would be decided after detailed engineering

A schematic arrangement of the proposed processing units is represented in Fig 2.2.

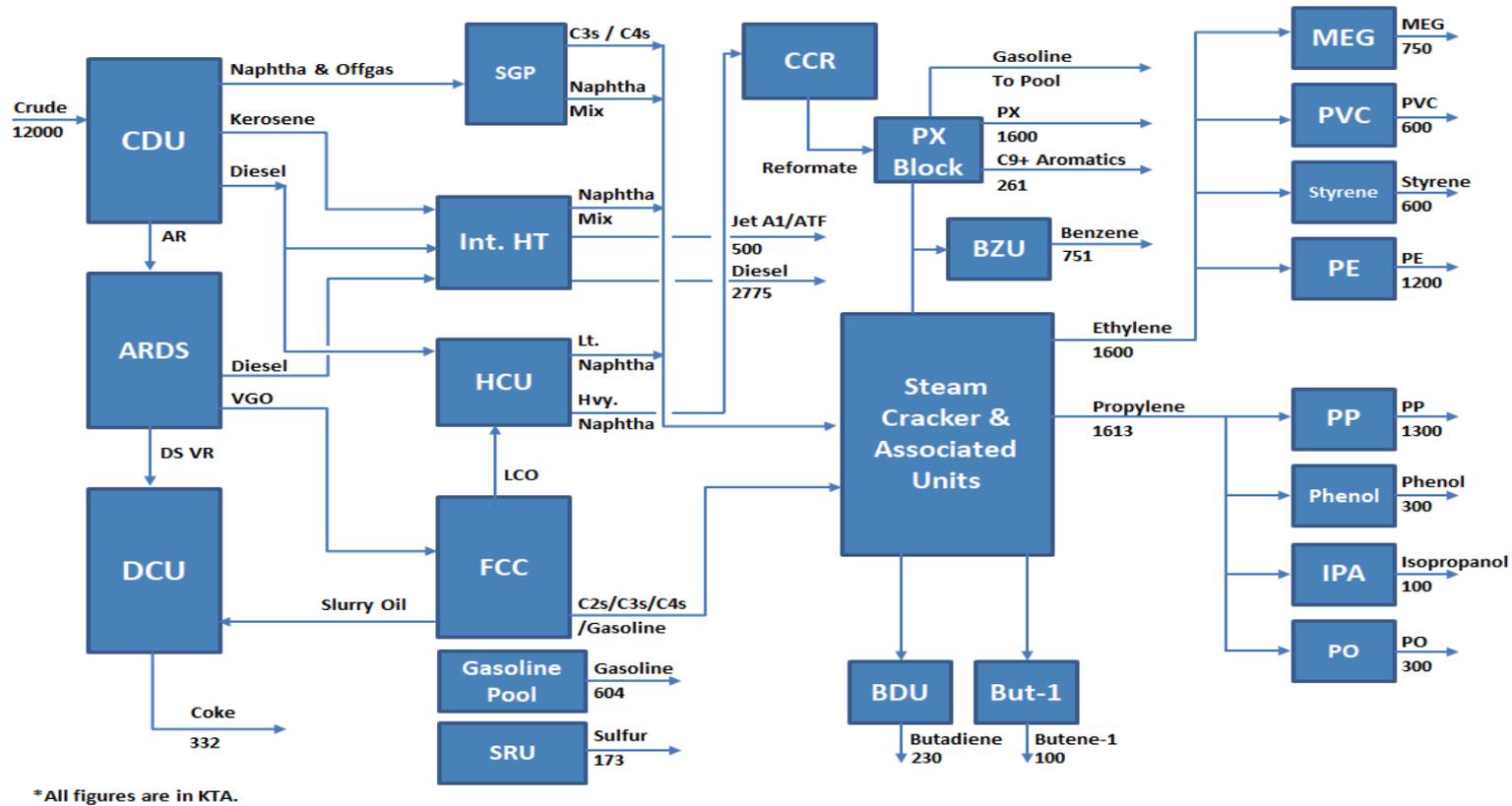


Fig 2.2: Schematic block flow diagram consisting of major units from the CTC complex

2.5 PROCESS DESCRIPTION

A brief description of the process including major units envisaged as a part of proposed refinery is presented in the below section.

2.5.1 CRUDE DISTILLATION UNIT

The purpose of CDU is to fractionate the crude feed into specific boiling range streams suitable for blending into final refined products (after treating, if necessary) or as feedstock to other downstream processing units.

Crude from battery limit is pumped by a charge pump through 1st preheat train, which utilizes low-level heat from crude column overhead vapors and lighter side-draws, to heat crude up to 125°C. Wash water is added to this hot stream and sent to a single stage electrostatic desalter to remove all emulsified water from crude. Brine from desalter is sent to Waste Water Treatment Plant (WWTP). Desalted crude is passed through 2nd preheat train, which utilizes high level heat from heavier crude and vacuum column side-draws, to heat flashed crude up to about 260 °C.

Desalted crude from 2nd preheater train flows to crude heater, where it is further heated to about 360°C and then fed to crude column. This column operating under near atmosphere pressure has typically 25 to 30 trays with flash zone above 5 to 7 trays from the bottom. The column has steam stripping section below the flash zone. Overhead vapors from crude column are partially cooled with cold crude. The column reflux drum is a V-L-L separator. Hydrocarbon liquid is divided into two streams, one stream sent back to crude column as hot reflux and other stream sent to Distillate HDS.

Crude column has one side stripper for every product withdrawn. The stripper may be reboiled or stream stripped. Strippers are utilized to meet cut points for heavy kerosene, light kerosene, light gas oil and heavy gas oil products. Several circulating refluxes maintain proper vapor load in rectification section.

The crude column residue mixed with diluents is processed through Residue Desulfurization Unit; the desulfurized residue again after mixing with diluents is routed to Fluidized Catalytic cracking Unit.

2.5.2 HYDROCRACKER UNIT

The hydrocracker unit processes gas oil from the Crude Distillation Unit to convert it into gasoline, jet and diesel blend stocks.

The gas oil feed streams are filtered, mixed with recycle and make-up hydrogen and are then heated in a gas-fired charge heater. The heated feed enters a series of two fixed-bed reactors where the hydrocracking reactions occur under conditions of high pressure and high temperature. The reactors contain fixed beds of catalyst impregnated with noble metals. The catalyst must be regenerated approximately every 18 to 24 months to remove carbon deposits and other catalyst deactivators. For regeneration, the unit is shut down and the catalyst is removed from the unit and regenerated off-site.

In the hydrocracking reactions, the cracked, unsaturated hydrocarbons (e.g. olefins) are converted to completely saturated species (e.g. paraffins) and long-chain molecules are cracked into distillate products. The hydrogen also combines with sulfur and nitrogen to produce hydrogen sulfide and ammonia, which can then be removed. Hot reactor effluent gas is washed with water, and is then scrubbed in an amine contactor to remove hydrogen sulfide and ammonia. The scrubbed gas is compressed and returned to the reactor section for additional conversion. Condensed stripping steam and wash water are sent to the sour water collection system. Amine, rich with hydrogen sulfide, is sent to the Amine Regeneration Unit.

The hydrocarbon liquid effluent from the hydrocracking reactors is sent to a group of fractionators where the various product streams are separated. Products from the fractionators include off-gases which contribute to the refinery fuel gas supply, gaseous light-ends that are routed to the Gas Concentration Plant, light and heavy naphtha, kerosene, diesel and an internal recycle stream (fractionator bottoms).

2.5.3 CONTINUOUS CATALYTIC REFORMING UNIT

Heavy naphtha from CDU preheated by exchange with reactor effluent, heated to reaction temperature in the charge heater and sent to the first of a series of three to four reactors. Reforming reactions that take place in the reactors are predominantly endothermic; hence inter-reactor heaters are employed to maintain a constant inlet temperature profile

for the individual reactors. Effluent from the last reactor is heat exchanged with the combined feed, condensed in the product trim cooler and sent to the separator.

The total H₂-rich gas from the separator is compressed in the recycle gas compressor. The recycle portion of the gas is returned to the combined feed exchanger and the net portion is sent to the recontact section. The net gas stream is first cooled in the net gas trim cooler, combined with the debutanizer overhead vapor, cooled further in 1st recontact trim cooler and separated in 1st recontact drum.

A part of the net gas is compressed in 1st stage net gas compressor, combined with separator liquid, cooled in 2nd recontact trim cooler and separated in 2nd recontact drum. Vapor from 2nd recontact drum is compressed in 2nd stage net gas compressor, sent to net gas chloride treaters and routed to other sections in the plant. The remaining part of net gas is combined with vapor from debutanizer receiver and sent to a cryogenic LPG recovery section. After recovery of LPG, the stream is routed to fuel gas header.

The liquid from separator is pumped to the recontact section in a countercurrent manner with high pressure net gas stream as described above. Liquid from 1st recontact drum is sent to the steam reboiler. Stabilized reformat is cooled in feed/bottom exchanger followed by air/trim coolers before being routed to storage. LPG from debutanizer receiver is sent to LPG chloride treaters, cooled in LPG trim cooler and routed to storage.

The regeneration section of the reformer provides a continual stream of clean coke-free active catalyst that is returned back to the reactors. Continuous circulation of regenerated catalyst helps maintain optimum catalyst performance at high severity conditions for long on-stream periods of reforming operation.

2.5.4 BENZENE EXTRACTION (BTX) UNIT

The purpose of Benzene Extraction Unit is to produce high purity benzene from the aromatic stream of toluene and xylene mixture. Extractive distillation (ED) is performed in the ED columns to separate benzene from the aromatic mixture (C₆ cut feed) which exits from the top of the ED column.

The top vapors are fed through a feed nozzle below the bottom tray of the raffinate column for removal of residual solvent from the raffinate by distillation. The vapor stream contains approx. 1.5 wt% benzene and 1-2 wt.% NMP beside the non-aromatics in the C₆

cut feed to the BTX Unit. The concentrated bottom product from the raffinate column is pumped back to the top tray of the ED column.

The bottoms product of the existing ED column is withdrawn at a temperature of about 136 °C under level control and is pumped as feed to the benzene stripper. It contains approximately 18.3 wt.% of benzene and only few wt. ppm of non-aromatics beside the NMP.

The overhead vapor stream from the ED column is fed into the vapor feed distributor of the raffinate column. The raffinate column connects directly to the top section of the ED column and operates at the pressure similar to the ED column bottom. The purified non-aromatics, the so called C6 raffinate, leave the top of raffinate column at about 55.7 °C and are condensed and cooled down to about 49.6 °C.

In the benzene stripper, the benzene loaded solvent streams from the extractive distillation columns are separated into benzene and solvent (NMP). It operates under vacuum condition with approx. 0.54 kg/cm²(a) pressure at the top and approx. 0.61 kg/cm² (a) at the bottom of the column. The benzene vapors leave the stripper top at about 60 °C and condense in the condenser from where the pure benzene is sent to product storage.

The stripped solvent from the stripper bottom is pumped back to the ED column from where it is sent back to the stripper. The residual benzene load of the solvent is an important parameter and has an impact on the efficiency of the distillation process.

BTX Unit is equipped with a vacuum system to maintain vacuum as mentioned above and a small solvent regeneration system to maintain the solvent selectivity in the unit.

There are several factors that determine the performance required in the extractive distillation, in order to produce pure benzene:

- Desired benzene purity,
- Desired benzene yield, determined by the benzene content in the raffinate,
- Concentration of non-aromatics in the C6 cut feed,
- Concentration of heavy boiling non-aromatics in the C6 cut feed, particularly naphthenes,

- Residual load of benzene returning to the ED columns.

The parameters, benzene purity and benzene yield can be directly influenced in the extractive distillation by:

- Changing the rate of circulating solvent,
- Changing the heat input into bottom of the EC column.

A very constant C6 cut feed to the BTX unit with respect to the rate and composition is the best prerequisite for a stable operation of the extractive distillation column, of the raffinate column and of the benzene stripper. The rate of evaporation of the benzene in the ED column bottom, mainly controlled by the heating steam rate provided by the reboiler is an important regulator in the ED column.

If Toluene is also to be produced instead of converting to Paraxylene (PX) in PX recovery unit, then necessary modification to be done in BTX Unit to recover Toluene as second product.

2.5.5 PARAXYLENE RECOVERY UNIT

The heavy end from Platformer unit (rich in benzene, toluene, C8 and heavier aromatic compounds) is sent to Reformate Splitter Column to separate C7-fractions from C8+ fractions. The C7-fraction is sent to the Aromatics Extraction Unit for benzene and toluene separation together as mentioned above. Benzene product is sent to storage whereas the toluene is fed to the Transalkylation Unit with C9- streams for additional benzene and xylene production or directly sold as such.

The C8+ stream from the toluene column bottoms is sent to xylene splitter mixed with the C8+ fraction from the reformate splitter. The overhead from the xylene splitter is transferred to Para-xylene Separation Unit and produce high purity para-xylene. The para-xylene depleted C8 aromatic stream is brought back to equilibrium in para-xylene concentration in Isomerisation Unit, thereby maximizing the yield of Paraxylene from available feedstock. The effluent from the isomerization unit is recycled to the xylene separation unit.

2.5.6 ATMOSPHERIC RESIDUE DESULFURIZATION UNIT

The heavy residue from the crude distillation unit contains 2 to 4wt% sulfur and some nitrogen which needs to be removed before feeding to the FCC Unit. The Residue Desulfurization Unit is a fixed bed reactor with CoMo + NiMo supported on alumina based catalyst.

The main purpose of this unit is separation of H₂S and nitrogen, however, cracking of small amount of hydrocarbon occurs which exits from the reactor overhead along with the H₂S gas.

2.5.7 FLUIDIZED CATALYTIC CRACKING (FCC) UNIT

FCC Unit is used to convert the heavy hydrocarbons to light olefins, LPG, gasoline and middle distillates. The heavy gas oil from the CDU after the ARDS Unit and unconverted oil from hydrocracker are sent to a surge drum to remove any water or vapor in the feed. This water free oil is heat exchanged with fractionator bottoms to a temperature of over 260 °C and sent to the riser near the base where it contacts the regenerated catalyst. The heat absorbed by the catalyst in the regenerator provides the energy to heat the feed to its desired reactor temperature of up to 505 to 575 °C for vaporization and reaction.

Catalytic reaction begins as soon as the feed is vaporized and the expanding volume acts as the driving force to carry the catalyst up the riser. The catalyst and the vapor travel the length of the riser with minimum back mixing. Steam is used to atomize the feed and increase its availability at the reactive acid sites of the catalyst.

After exiting the riser, the catalyst enters the reactor which serves as a housing for the cyclones. The cyclones collect and return the catalyst to the stripper through the diplegs and flapper/trickle valves. The product vapors exit the cyclones and flow to the main fractionator for recovery.

As the spent catalyst falls into stripper, hydrocarbons are absorbed on the catalyst surface, hydrocarbon vapors fill the catalyst pores, and the vapor entrained with the catalyst also fall into the stripper. Stripping steam is used to remove entrained hydrocarbons between catalyst particles. However, it do not address the hydrocarbon desorption, hydrocarbon filling the catalyst pores and reactions continue to occur in the

stripper. The higher temperature and longer residence time allow conversion of adsorbed hydrocarbons into “clean lighter” products.

The regenerator has two functions – restoring the catalyst activity and supplying heat to crack the feed. The spent catalyst entering the regenerator contains coke which is burnt by using oxygen from air blowers. It also provides sufficient air velocity and pressure to maintain the catalyst bed in fluidized state. The air enters the regenerator through an air distributor located near the bottom of the vessel. The flue gas exits from the regenerator passing through the cyclones where the larger entrained catalyst particles are collected and fall back in the regenerator.

The hot product vapors from the reactor flow into the main fractionator near the base. Fractionation is accomplished by condensing and re-vaporizing hydrocarbon components as the vapor flows upward through the tray in the tower. The overhead vapor of the fractionator is sent to the LPG plant whereas the ethylene and propylene streams are sent to production/storage. Side diesel stream is sent to diesel Hydrotreater and naphtha is sent for further PX recovery through a splitter to PX Recovery unit. The heaviest bottoms product from the column is sent further to be used as the carbon black feedstocks.

2.5.8 DELAYED COKER UNIT

Delayed coking is a type of thermal cracking in which the heat required to complete the coking reactions is supplied by a furnace, while coking itself takes place in drums operating continuously on a 24 h filling and 24 h emptying cycles.

The coker feed is desulfurized vacuum residue and a small amount of heavy gas oil which is high on asphaltenes, resins, aromatics and metals. The deposited coke contains most of the asphaltenes, sulphur, and metals present in the feed, and the products are unsaturated gases (olefins) and highly aromatic liquids.

The process includes a furnace, two coke drums, fractionator and stripping section. Vacuum residue enters the bottom of the flash zone in the distillation column or just below the gas oil tray. Fractions lighter than heavy gas oil are flashed off and the remaining oil are fed to the coking furnace.

Steam is injected in the furnace to prevent premature coking. The feed to the coker drums is heated to just above 482 °C (900 °F). The liquid–vapour mixture leaving the furnace

passes to one of the coking drum. Coke is deposited in this drum for 24 h period while the other drum is being decoked and cleaned. Hot vapors from the coke drum are quenched by the liquid feed. Vapors from the top of the coke drum are returned to the bottom of the fractionator. These vapors consist of steam and the products of the thermal cracking reaction (gas, naphtha and gas oils). The vapors flow up through the quench trays of the fractionator. Steam and vaporized light ends are returned from the top of the gas oil stripper to the fractionator. Eight to ten trays are generally used between the gas oil draw and the naphtha draw or column top.

2.5.9 AMINE REGENERATION UNIT

The function of Amine Regeneration unit is to remove the acid gases (H₂S and CO₂) from the rich amine streams produced in the refinery processing units circulated to the Amine Regeneration Unit (ARU) for regeneration.

Rich amine from various absorber units is received in a flash column. Rich amine is allowed to flash in the column to drive off hydrocarbons and the bottoms are routed to the regenerator column. Some H₂S also gets liberated. The liberated H₂S is again absorbed by a slip stream of lean amine solution making counter current contact with liberated gases over a packed bed.

From the flash column, the rich amine is pumped by rich amine pumps under flow control to amine regenerator, after preheating in lean amine/rich amine exchanger. In lean amine/rich amine exchanger, the heat is supplied to rich amine by hot lean amine on shell side from the bottom of amine regenerator under level control. The lean amine from lean amine/rich amine exchanger is further cooled in lean amine air and trim cooler and routed to amine storage tank from where it is distributed to various refinery units by lean amine pumps. Another part of lean amine from tank is used as slip stream to cartridge filter to remove solid particles picked up amine in the system. It is also used to remove foam causing hydrocarbon substance.

In amine regeneration column, reflux water enters the column top and descends down. This prevents amine losses into the overhead and ensures complete removal of H₂S. The reboiler vapors from the bottom of the tower counter currently contacts the rich amine and strips off H₂S. The overhead vapors from regenerator are routed to regenerator

overhead condenser, where most of the water vapors condense and are pumped by amine regenerator reflux pumps as reflux to the column. The acid gases are routed to SRU. In case the pressure goes high, acid gases are routed to the acid flare. Reboiler heat by LP steam is supplied to the column through amine regenerator boiler.

2.5.10 SOUR WATER STRIPPER UNIT

The sour water stripper (SWS) removes H₂S and NH₃ from the sour water using a stripper tower having a steam-heated reboiler. Sour water streams containing H₂S, other organic sulfur compounds, ammonia and oil are collected from various process units and combined in a feed surge tank. Liquid hydrocarbons are decanted from the water and returned to the recovered oil tank.

Feed sour water is preheated by exchange with the stripper bottoms stream. The reboiler is heated with low-pressure steam to generate vapor traffic up the stripper column. Vaporization of water strips H₂S and NH₃ from the down coming sour water. Overhead vapors are cooled by an overhead condenser. Condensed water reflux is returned to the top tray in the stripper tower. The overhead, non-condensable materials, primarily H₂S and NH₃, are routed to the sulfur recovery unit as feed. The stripped water containing NH₃ and H₂S less than 50wt. ppm each is reused at the crude desalters and at process units requiring wash water (e.g. for ammonia removal). Any remaining stripped water is routed to the Wastewater Treatment Plant.

2.5.11 SULFUR RECOVERY UNIT

The Sulfur Recovery Plant provides for safe disposal of the acid gas product streams from the Sour Water Stripper and the Amine Regeneration Unit. The plant comprises three processing steps: three parallel Claus sulfur recovery units (normally with two operational and one on hot standby), a tail gas treatment unit (TGTU) and a gas thermal oxidizer.

Each Claus sulfur recovery unit (SRU) uses a three stage reactor train to convert approximately 97 % of the feed sulfur into elemental sulfur. The TGTU uses catalytic reduction and amine absorption technology to recover additional sulfur compounds from the Claus SRU tail gas and recycles them back to the SRU. The unrecovered sulfur compounds are oxidized to sulfur dioxide (SO₂) in the tail gas thermal oxidizer.

Feed to SRU comprises of acid gas from ARU and sour gas from SWSU. Acid gas from ARU passes through acid gas knock out drum, to remove any liquid carryover, before feeding to main burner. Similarly, any liquid carryover in sour gas from SWSU is removed in sour gas knock out drum.

The air to main burner is supplied by an air blower, which also supplies air to Super Claus stage and sulfur degassing. The air to the main burner is exactly sufficient to accomplish the complete oxidation of all hydrocarbons and ammonia present in the feed gas and to burn as much H₂S as required to obtain desired concentration.

In the first (non-catalytic) reaction furnace section, ammonia is converted to nitrogen and water, and a portion of the H₂S is converted to SO₂ and water. The acid gas then flows through two catalyst beds in series where the Claus reaction occurs (H₂S and SO₂ partially react to form sulfur). The sulfur in the vapors from the thermal section and each of the three catalyst beds is condensed and flows through seal legs to a covered tank termed the "Sulfur Pit". The vapor from the last sulfur condenser then flows to the TGTU.

Upstream of the 1st Claus reactor, the process stream from waste heat boiler is heated in 1st steam preheater to obtain optimum temperature for the catalytic conversion. The effluent gases from 1st reactor pass onto 2nd sulfur condenser where sulfur vapor is condensed and uncondensed process gases pass to the 2nd steam preheater. Heated vapors are again subjected to conversion in the 2nd Claus reactor followed by cooling in the 3rd sulfur condenser. Then the process gas passes to the 3rd steam preheater and the 3rd Claus reactor. To obtain a high sulfur recovery the process gas is passed to the 4th and last catalytic stage indicated as the Super Claus stage. The process gas is heated in the 4th steam preheater, and mixed with preheated air. Proper mixing is achieved in a static mixer. In Super Claus stage, H₂S is selectively oxidized into sulfur. The gas then passes to the 4th and last condenser.

Sulfur condensed in condensers is routed via sulfur locks to cooler and drained into sulfur degasification vessel. Stripping air is supplied to the spargers located at the bottom side of the vessel. This strips off H₂S from liquid sulfur and oxidizes the major part of H₂S to sulfur. Air leaving the stripping columns, together with H₂S released from sulfur degasification vessel is routed to TGT Unit.

Liquid sulfur in the Sulfur Pit is loaded into tank trucks or tank cards for sale. A steam-powered ejector draws sweep-air through the headspace of the Sulfur Pit tank to capture vapors containing reduced sulfur compounds. This sweep-air stream is routed to the inlet of the Claus SRU trains for recovery of the sulfur.

The TGTU removes the remaining sulfur from SRU tail gases by a combination of chemical reaction and absorption. The process involves:

1. Converting all remaining sulfur in SRU tail gas to H₂S.
2. Selectively absorbing the H₂S from rest of the tail gas constituents.
3. Stripping the H₂S from the solvent and returning it to the SRU for subsequent sulfur recovery.

Tail gas exiting the last stage of Claus SRU is combined with hydrogen or methane (natural gas) and passed through the TGTU Reducing Reactor and a catalytic Hydrogenation Reactor to convert the residual sulfur dioxide back to H₂S. Downstream of these reactors, additional recovery of reduced sulfur is accomplished in an amine absorber column that uses an aqueous methyl diethanolamine (MDEA) solvent to scrub H₂S from the TGTU tail gas. The overhead stream from this contactor, containing very low sulfur levels, is sent to the tail gas thermal oxidizer for disposal. The rich MDEA solvent is regenerated in the TGTU amine stripper and H₂S is returned to the inlet of the Claus SRU trains to be recovered. Regenerated MDEA solvent is recirculated back to the TGTU amine absorber column.

Tail gas from TGU is routed to the incinerator where residual sulfur is converted to SO₂ and discharged into the atmosphere.

2.5.12 CRACKER AND ASSOCIATED UNITS

Cracker unit is the heart of the total complex, which gives feed to all the downstream end product units.

❑ Furnace section:

Cracking furnace or often know as brain behind the steam cracker unit, is the most important and complex section of the plant. In this section preheated feed stock is getting mixed with process steam and then sent to convection coils for further heating against flue gases generated in radiant zone of the furnace. Feed stock is then sent to radiant

section coil where main reaction takes place. Heat of furnace effluents is recovered in the transfer line exchangers in which very high pressure steam is getting produced and being utilized for various purposes.

❑ **Oil separation and Cracked gas quenching:**

Cracking effluent (Cracked gas) is combined from all the furnaces and sent to Primary/Gasoline Fractionator. Typically in gas cracker (Ethane), Gasoline Fractionator can be avoided as there is very less quantity of heavy material (C9+) present in the cracked gas stream. In Primary/Gasoline fractionation, Oil which is present in cracked gas is separated and utilized for providing heat duty to several users. Separated oil is sent to battery limit as slop oil/ PFO product.

Temperature of Cracked gas coming from Gasoline Fractionator is typically 102-105 °C. Cracked gas is further cooled in Quench water column with the quench water. Cracked gas leaving the Quench water column is typically at 42-45 deg c. In quench water column, Process water and gasoline fraction is separated from cracked gas. Process water is again utilized for generating process steam for steam cracking.

❑ **Cracked gas compression and drying:**

This is often referred as heart of the steam cracker unit. Cooled cracked is now compressed in Cracked gas compressor. Cracked gas compressor typically compresses cracked gas to the level of ~33-36 kg/cm²g in a 5stage machine. New low pressure technologies are also utilizing cracked gas compressor pressure level of as low as ~ 23 kg/cm²g in 3 stage machine. Pressure level of compressed cracked gas is solely depending on the configuration of separation section. Cracked gas compressor section caustic scrubbing of cracked is also given which removes CO₂ and H₂S from the cracked gas as low as 100 ppm CO₂ and H₂S. Typically Caustic scrubber is placed at the pressure level of 7-18 Kg/cm²g depending upon the cracked gas compressor stages.

In this section, cracked gas and cracked gas condensate which being generated in liquid knockouts are sent to cracked gas dryer and cracked gas condensate dryer. Dryer is removing moisture from the cracked gas and condensate to the level of as low as 1 mol ppm. Drying of cracked gas is required for avoiding hydrate (ice) formation in the chilling sections of steam cracker unit.

❑ Front end Separation of cracked gas:

This system derives which front end separation is to be configured based on the processing objective and economics of the steam cracker. Front end systems are Depropaniser, Deethaniser and demethaniser. Every licensor tries to optimize their plant by keeping them at best suitable place.

❑ Acetylene Convertor:

Acetylene convertor is provided for converting acetylene in to ethylene. CO present in the feed enhances the selectivity towards ethylene over ethane. In the front end depropaniser and Deethaniser scheme, Hydrogen and CO are present in the feed but in Front end demethaniser, hydrogen is supplied externally. Typical spec of Acetylene in polymer grade ethylene is 1 ppm (vol).

❑ Hydrogen & Methane Separation:

Hydrogen and methane present in the cracked gas are separated in the coldest section of the steam cracker unit. Hydrogen rich gas is recovered in the series of chilling and knockout while methane rich fraction is recovered from demethaniser top.

❑ Ethylene fractionation and Propylene fractionation:

C2 fraction from DeEthaniser top goes to Ethylene Fractionator from where, Ethylene is recovered and ethane is recycled back to furnaces. C3 fraction from Depropanizer top or DeEthaniser bottoms is sent to propylene Fractionator from where propylene is recovered and propane is recycled back to furnaces. Propylene fractionator depending upon the technology licensor can be one or two columns.

❑ Refrigeration system:

Typically in the Cracker unit, two main refrigeration systems are present, ethylene refrigeration and propylene refrigeration. The two types ethylene refrigeration cycles are provided one is open loop (heat pump configuration) other is closed loop (conventional cycle). Propylene refrigeration is typically closed loop cycle. Licensor now a days also provide multi component refrigeration system, with the combination of methane, ethylene and propylene.

❑ **Debutanizer and C4 hydrogenation:**

From debutanizer, C4 and C5 are separated. C5+ fraction is sent to PGHU unit and mixed C4 fraction is sent to C4 hydrogenation unit. In configuration-1, as the quantity of C6+ component is very less. C4/C5 can be separated together and sent C4/C5 hydrogenation. In C4 or C4/C5 hydrogenation, total hydrogenation of feed stream is taking place and hydrogenated stream is sent to furnace as a recycle feed.

2.5.13 PYROLYSIS GASOLINE HYDROGENATION UNIT (PGHU) AND AROMATIC EXTRACTION UNIT

Feed to this unit is coming from the cracker unit, which is C5+ fraction.

In first stage hydrogenation, dienes and styrenes present in the feed are selectively hydrogenated and converted to olefins and ethyl benzene. Hydrogenated feed is sent to dehexanizer, which is then separated into C5/C6 fraction and C7 + fraction. C7/C8 fraction is further separated from C9+ fraction in deoctanizer. C7/C8 which are coming from top are cooled and condensed and then sent to Battery limit as Hydrogenated Pyrolysis gasoline. C9+ fraction which is a bottom product is cooled and sent to battery limit. C9+ fraction is also used as wash oil in cracker unit. Separated C5/C6 fraction, is further Hydrogenated in 2nd stage gasoline hydrogenation for removing Dienes and olefins which are still present in the C5/C6 fraction and desulphurization. Hydrogenated C5/C6 fraction is separated into C5 fraction and C6 fraction in Depentanizer. C5 Fraction is recycled back to cracker unit and C6 fraction is used as a feed to Benzene extraction unit.

C6 fraction is used as a feed, from which benzene is extracted. Extraction is done By N-Methyl- Pyrrolidone(NMP) solvent.

C6 fraction is fed to Extractive distillation/ raffinate column. Top section is the raffinate section and the bottom section is the extractive distillation column. Feed and solvent are washed counter currently by which benzene is completely absorbed in the solvent. Toluene and other heavy hydrocarbons are vaporized due to reboiling. Vaporized components go to raffinate column in which, they are further separated from the solvent component. Raffinate column overhead is then cooled and condensed. Part of the condensed overhead is sent back to column and other is sent to cracker unit as a

raffinate product. Benzene + solvent stream is then fed to benzene stripper, in which benzene is separated from solvent and sent to battery limit storage.

2.5.14 BUTENE-1 UNIT

The dimerization reaction is activated by the mixing of two specific catalysts. The first one is an alkyl-aluminium compound and the second is a proprietary catalyst made of a titanium compound and a promoter.

Both catalysts are separately stored in a separate storage drum, filtered and then pumped by metering pumps to the Reactor.

The diluted alkyl-aluminium catalyst (T.E.A) and the diluted second catalyst are fed to the reactor through the pumparound loops.

In case hexane is used (during start-up), it can be dried before using via Hexane Dryer, before being sent to Washing Hexane Drum. The regeneration of the dryer is carried out with hot nitrogen heated up in Nitrogen Heater. Effluents from regeneration are then sent to flare. Nitrogen Heater ensures also the drying of Pumparound Loops after maintenance with hot nitrogen.

❑ Reaction / Catalyst removal sections

The ethylene feedstock coming from Polymer Unit downstream of purification section or directly from cracker is mixed with the unconverted ethylene which is recycled from the recycle column reflux drum. The ethylene stream enters the reactor through a distributor, which improves the dispersion of the ethylene in the liquid.

The reaction is exothermic: the heat of reaction is removed by the pumparound coolers installed on recirculation lines around the reactor. The recirculation is maintained by pumparound pumps. The liquid reactor effluent withdrawn from bottom of reactor must be vaporized to remove all the traces of catalysts. Part of the vaporization occurs in the vaporizers by steam condensation; the vapor and liquid phases are separated in the flash drum. The last step of vaporization is achieved through the thin film evaporator which is fed under flow-control reset by the level of the flash drum.

The residual liquid is collected in the evaporator receiver drum and feeds under level control the spent catalyst drums which are connected to the flare and steam traced to remove the remaining light compounds. The remaining liquid is either sent to

isocontainers and then to incinerator or sent to Fuel Oil. The vapors from the thin film evaporator flow through the evaporator K.O. drum which traps any liquid carry-over. The vapors are then mixed to those got from the flash drum and to the vapor flow from the reactor top. The product, currently stripped from the catalysts, is condensed through the recycle column feed condenser and feeds the recycle column feed surge drum.

To stabilize the product before vaporizing it, pure amine is injected to the reactant effluents filters. This prevents any detrimental isomerization of butene-1 into isobutene and butene-2, which could be promoted by temperature downstream, during the vaporization step, without amine injection.

The amine, unloaded from drums by the amine unloading pump, is stored in the amine storage drum, and sent to the process by the amine pumps.

□ Distillation section

The liquid phase from recycle column feed surge drum is pumped to the recycle column.

A partial condensation of its overhead vapors takes place in the recycle column condenser. Due to the presence of methane and ethane in the feedstock, a slight venting to Naphtha Cracker is necessary to prevent from any incondensable vapor accumulation. The vapour (mainly ethylene) is recycled back under pressure control to the reactor feed line.

The reboiling of the column is ensured in the recycle column reboiler under temperature control resetting the steam flow rate to the reboiler. The bottom product of the column is routed under flow-control, reset by level, to the butene-1 column.

The butene-1 column duty is to provide the specification in heavy components of butene-1 product. The butene-1 product is withdrawn as liquid distillate from the column overhead by means of the butene-1 column reflux pumps under level control of the butene-1 column reflux drum.

The C6+ cut is withdrawn, at the butene-1 column bottom. The C6+ cut is routed, after cooling through the C6+ product cooler, to the C6+ storage drum.

❑ Product drums storage

The butene-1 leaving the distillation section can be routed to any of the storage drums "onspec" drum or an "off-spec" drum after has been cooled down at 40 deg. C in the butene-1 cooler.

The butene-1 on-spec product is routed to OSBL storage tank after analysis, by means of the pump. The off-spec product is routed to C4 mix storage, but can also be recycled in the butene-1 column, if it's content in C6 and heavier is too high. A part of this butene-1 product is used for flushing pumparound pumps, reactor effluent pumps, passivation pumps and ethylene distributor by means of flushing pumps. Another part of this butene-1 is used as carrier of catalysts to the reactor.

The Membrane Cell process is proposed to be adopted wherein the electrolysis of NaCl takes place forming Chlorine and Sodium which further forms Sodium Hydroxide and Chlorine.

2.5.15 POLYETHYLENE UNIT- HDPE

❑ Catalyst preparation

Ziegler Catalyst: High activity Ziegler catalyst is used for the production of narrow molecular weight distribution products. This catalyst is supplied ready-to-use.

❑ Polymerisation: Reaction Loop

The reactor is designed to ensure good mixing and a uniform temperature within the fluidised bed. Polymer particles grow within the fluidised bed over a residence time of several hours. Operating conditions within the reactor are mild. The reactor is made from carbon steel and has three main sections:

A bottom section with a gas distributor to ensure homogeneous fluidisation. A cylindrical section containing the fluidised bed and equipped with catalyst injection and polymer withdrawal facilities. A conical bulb top section where gas velocity reduces, returning entrained polymer powder particles to the fluidised bed.

The gas leaving the reactor contains unreacted monomer, co monomers, hydrogen and inerts (primarily nitrogen and ethane). Conversion of monomers per pass is proximately 3%. Any fine particles leaving the reactor with the exit gas are collected by cyclones and recycled to the reactor. This greatly reduces fouling in the reactor loop and also prevents

product contamination caused by particles formed in the loop, which may have different properties to the target grade. This is one of the reasons why the Innovene process makes such consistently high quality, gel-free products.

The gas then enters the first heat exchanger where the heat of polymerisation is removed before passing to the Enhanced High Productivity Separator. This specially designed vessel separates the condensed liquid, typically up to 15% by weight of the stream, from the loop gas, which is fed to the main fluidisation gas compressor. This provides the volumetric flow necessary to achieve the required fluidisation velocity in the reactor. The separated liquid is then pumped into the reactor via proprietary liquid injection nozzles into the heat of the fluidised bed.

In the reactor, pressure and gas composition are controlled continuously by varying the flow of feedstock into the reaction loop. The relative proportions of the feedstock are adjusted to meet the specification of the required polymer product. This is achieved using on-line analysers for hydrogen, ethylene and co monomers. A purge is provided to prevent accumulation of inerts.

❑ Polymer Withdrawal and Degassing

The polymer powder is withdrawn from the reactor by simple, robust proprietary lateral discharge system and passed on to the primary degasser, where a part of the gas is flashed off, filtered and recycled to the main loop via the recycle compressor.

The polymer powder is transferred to the secondary degasser, where most part of the residual hydrocarbon is removed and separated in the cryogenic Vent Recovery Unit. The degassed powder collected in the secondary degasser passes to a purge column, where trace hydrocarbons are removed and any residual catalyst activity is killed. Powder is then transferred to the extruder via an intermediate surge bin, mounted directly above the extruder, which allows for routine extruder maintenance.

❑ Grade Changes

On-line DCS transition control ensures consistently rapid and reliable grade changes. Changes of grade are made quickly and easily, with the minimum loss of throughput and the minimum generation of wide-specification product.

□ **Finishing: Product Blending and Extrusion (Pelletising)**

Polyethylene powder is transferred pneumatically to the product powder silo. Powder master batch incorporating additives is prepared in mixers or may alternatively be supplied in flexible intermediate bulk containers. The additives are commercially available but the formulations, which are part of Innovene technology, will be disclosed when a licence agreement has been signed. Virgin powder and additives are weigh-fed into the extruder. Pellets are extruded under water and are then dried before being conveyed by air to storage. The pellets conveyed from the pelletising section are homogenised in static homogenisation silos. After homogenisation, the pellets are transferred to storage silos.

2.5.16 MEG UNIT AND EO DERIVATIVES

The plant consists of two water cooled Ethylene oxide (EO) reactors system plus recovery facilities, ethylene oxide purification and storage facilities, glycol reaction, evaporation and purification facilities. This Plant will produce Mono- ethylene Glycol (MEG). There will be two by products – Di-Ethylene Glycol (DEG) and Tri Ethylene Glycol (TEG). This plant is designed in single production line based on 8000 operating hours. This plant is divided into two major sections:

- Ethylene Oxide section.
- Ethylene Glycol Section

Fresh ethylene, recycle gas and oxygen are thoroughly mixed, preheated and passed through EO reactor consisting of large number of tubes filled with silver containing catalyst, where ethylene is converted by partial oxidation into Ethylene Oxide at elevated temperature and pressure.

The reaction product gas is scrubbed with neutralising liquid to remove acidic compounds and further cooled in EO absorber by counter current contact with water, which absorbs Ethylene Oxide and forms a dilute aqueous solution of Ethylene Oxide.

The gas after scrubbing and absorption of Ethylene Oxide is recycled back to the reactor via a recycle gas compressor. A slip stream is taken to CO₂ removal section for removal of carbon dioxide formed in the reactor. This is achieved by absorption in hot potassium carbonate solution, which is regenerated in CO₂ stripper. Dilute aqueous solution of

Ethylene Oxide in water enters Ethylene Oxide stripper where Ethylene Oxide is stripped off. The lean solution after stripping of Ethylene Oxide is cooled and returned to Ethylene Oxide absorber. Ethylene Oxide from stripper are cooled, condensed and purified by passing through lights ends columns which removes lighter fractions. Purified Ethylene Oxide mixture is heated, mixed with additional water and passed through tubular Glycol reactor. The reaction takes place in liquid phase under elevated temperatures and pressure. The conversion is almost complete and the glycol water mixture is sent for evaporation.

In evaporation section, water is separated from glycol mixture in a triple effect evaporator with subsequent vacuum column.

Crude glycol mixture evaporation section is separated into various fractions viz. Mono Ethylene Glycol, Di Ethylene Glycol, Tri Ethylene Glycol & Tetra Ethylene glycols in a series of distillation columns. These products are cooled, stored and subsequently sent to offsite tankages.

Pure EO is distilled from Aq. EO to produce high purity EO which is stored in refrigerated vessels for dispatch. Raw materials are received from the associated tank farm.

2.5.17 STYRENE UNIT

The Styrene Unit comprises of both an ethylbenzene and a styrene section.

□ Ethylbenzene Section:

The fresh benzene feeds a pre-treatment section, where a guard bed is used to remove harmful impurities (catalyst poisons). This treated benzene enters in the distillation section where it is pumped to the reaction sections with recycled benzene.

In the alkylation section, the reaction of ethylene with benzene takes place in liquid phase in one or more fixed bed reactors with multi-bed arrangement. Due to reaction exothermicity, external intra-bed refrigerators are required, with complete heat recovery. The alkylation effluent, which consists mainly of unconverted benzene, ethylbenzene, diethylbenzene and other by products feeds the distillation section.

In the transalkylation section, the diethylbenzene produced in the alkylation and separated in the distillation section reacts with excess benzene to produce additional EB.

The benzene /diethyl benzene mixture is first preheated and then sent to a dedicated fixed bed reactor, where the isothermal reaction takes place in liquid phase.

The transalkylation effluent, which consists mainly of ethylbenzene, unreacted benzene and diethyl benzenes, and by-products such as diphenylethanes, feeds the distillation section.

The distillation consists of a 3 columns train. From the first one, the benzene is removed from the top to be recycled back to reaction sections. From the top of the second column is separated pure EB. In the third column, operated under vacuum, is carried out the separation of heavier by-products. Transalkylable polyethyl benzenes (mainly diethylbenzene) are removed from the top of the column, while high boiling by-products (flux oil) are extracted from the bottom.

❑ **Styrene Section:**

Reaction (Hot Zone):

The gas phase ethylbenzene dehydrogenation occurs in two or three reactors used in series with interstage re-heater. The heat is provided by superheated steam, which, at the end of the cycle, will enter in the first reactor together with ethylbenzene. The main reaction by-products are toluene and benzene; hydrogen rich off-gas is normally recycled in the steam superheater as fuel gas. Due to high operative temperature a small amount of heavy components are formed.

Condensation (Cold Zone):

The reaction effluent, after heat recovery, is sent to the following section, where organic and steam are condensed and separated from off gases (hydrogen, carbon dioxide, methane, ethylene, etc). Off gas is removed by a compressor that assures the sub-atmospheric pressure in the reactors. Water is purified and normally reused, whereas organic phase is sent to distillation section.

Distillation:

Crude styrene with ethylbenzene, benzene, toluene and some heavy components, is fed to the first column where benzene and toluene are recovered as overhead. Such mixture can be fed to another column where benzene and toluene are separated. Ethylbenzene, styrene and heavies feed another column, where ethylbenzene is separated from styrene

in vacuum conditions. The bottom is fed to the following column, where pure styrene is recovered from the top. The bottom is further processed in a finishing equipment, to recover additional styrene from the residue. In the overhead vapour of the styrene column p-tert-butylcatechol (TBC) is added, to prevent the polymerisation of styrene in the storage.

Although distillation columns work in vacuum, bottoms temperatures can vary from 85 to 110 °C. For this reason it is necessary to add an inhibitor to avoid losses of styrene due to polymerisation. Different substances as inhibitors or retarders can be used for this purpose as nitroderivatives, free radicals, etc; they can be used alone or in combination, to have a possible synergetic effect.

2.5.18 PVC UNIT

Vinyl Chloride Monomer (VCM), which boils at -13.4 C at atmospheric pressure, is polymerised in a batch process by dispersing the monomer in water under its own pressure in a stirred reactor. The reactor contents are heated to the required temperature (typically 56.5°C): the initiator then starts to decompose to give free radicals and the monomer in the droplets starts to polymerise. The reaction is exothermic, and the heat passes into the water and is removed by two methods: circulated cooling water in the jacket and cooling water in a condenser on the reactor top. PVC is insoluble in its monomer and once formed, precipitates out in the monomer droplets as submicron particles.

Polymerisation:

A specified amount of cooled demineralised water being sealed with nitrogen gas in the tank is charged into Reactor through a batch meter. The catalyst solution is fed into Reactor. The specified amount of VCM is also fed into Reactor through a batch meter. The reactor contents are violently stirred in Reactor, keeping the good suspension condition. After charging of VCM, a specified amount of hot demineralised water is charged into Reactor so that temperature of the Reactor contents could reach the set polymerization temperature. Then, cooling water is supplied into Reactor jacket, baffles and Reflux Condenser at high rate. The temperature of the reactor contents is so automatically controlled as to be constant at the set polymerization temperature by adjusting the flow rate of the cooling water. The PVC slurry in Reactor is blown down through Slurry

Discharge Pump into BlowDown Tank, while recovering the un-reacted VCM gas from Reactor and Blow Down Tank into VCM Gas Holder. The slurry in Blow down Tank is fed to the Slurry Stripping section through Stripping Slurry Feed Pump.

Slurry Degassing

The PVC slurry in Reactor is blown down through Slurry Discharge Pump, into Blow Down Tank, while recovering the un-reacted VCM gas from Reactor and Blow Down Tank into VCM Gas Holder. The slurry in Blow Down Tank is fed to the Slurry Stripping section through Stripping Slurry Feed Pump.

Slurry Stripping

After degassing in the Stripper Feed Vessel, the slurry contains 2-3 % of the original VCM charge. In Stripping Column, the slurry passes over a series of trays where it is stripped with a counter current flow of steam from a 4-6 barg supply. VCM passes to the LP Recovery Compressors for recovery. From the base of the column the slurry is pumped through the Spiral Heat Exchanger to preheat the feed and cool the slurry before it goes to the slurry tank. The slurry from the stripping column then passes to the slurry storage tank.

Dryer

Slurry from the Slurry Tank is circulated via a ring main to the centrifuges where it is dewatered to produce a moist PVC powder. The moist PVC powder then passes to the Dryer. There are two options for the Drying Technology to be used: either a two stage Flash/Fluid Bed Dryer, or a Contact Fluid Bed Dryer. The polymer then overflows to the vibrating screens for removal of any oversize material.

VCM Recovery

In this section, the unreacted VCM is recovered and treated for reuse. The unreacted VCM recovered from Polymerization section and Slurry Stripping section into VCM Gas Holder is compressed by VCM Compressors. VCM dissolved in waste water is stripped out by means of steam-stripping by steam fed to the bottom of Column during falling down from top to bottom. Water vapour and VCM leaves from the top of column and water vapour is condensed in Waste Water Condenser and uncondensed VCM is recovered and returned to Gas Holder. VCM stripped waste water is sent from the bottom of Column to

Battery Limit by Waste Water Discharge Pump after being cooled through Waste Water Heat Exchanger.

Product Handling

Screened material from the screens is conveyed to the bagging hoppers. A medium phase blowing system is used, and two bagging hoppers. The filled bags are transferred from Bagging Machine to Palletizer through the conveyor, piled automatically up on the pallet and stored in existing product warehouse.

2.5.19 POLYPROPYLENE UNIT

Fresh propylene from OSBL is fed through propylene dryer to the reactor along with the required catalyst, co-catalyst, hydrogen and stereo-modifier. For production of special grades with small ethylene content, ethylene vapor is also fed to the reactor.

The polymerization reactors each have a stirrer and drive systems. Polymerization itself is carried out in a gas phase stirred reaction. Heat removal is managed by evaporative cooling. Liquid propylene entering the reactor vaporizes and thereby removes the exothermic reaction energy. Reaction gas is continuously removed from the top of the reactor and filtered. Reactor overhead vapor ("Recycle Gas") is condensed and pumped back to the reactor as coolant. Non-condensable gases (mainly H₂ and N₂) in the recycle gas are compressed and also returned to the reactor.

The polypropylene product powder is blown out of the reactor under reactor operation pressure. The carrier gas and powder pass into the powder discharge vessel where powder and gas are separated. The carrier gas is routed through a cyclone and filter to remove residual powder, then scrubbed with white oil and sent to compression.

Powder from the discharge vessel is routed via rotary feeders to the purge vessels which are operating in parallel. Nitrogen is used to purge the powder off residual monomers. The overhead gas from the purge vessels is sent to a common membrane unit for monomer/nitrogen recovery. As refrigerant for the membrane unit fresh Propylene is used. The recovered nitrogen is sent back to the purge vessels for further use. The condensed monomers from the purge gas are combined with the filtered carrier gas, then sent to scrubbing and subsequently to carrier gas compression.

The PP powder from the purge vessels is pneumatically conveyed by a closed loop nitrogen system to the powder silos. The powder product from these silos is fed to the extruder where polymer powder and additives are mixed, melted, homogenized and extruded through a die plate, which is heated by hot oil. The extruding section is electrically/steam heated.

Pelletizing of the final product is carried out in an underwater pelletizer where the extruded polymers - after passing the die plate - are cut by a set of rotating knives. The polymer/water slurry is transported to a centrifugal dryer where polymer and water are separated. Water is recycled to a pellet water tank, for which demineralized water is used as make-up.

The cooled pellets (~60°C) are pneumatically conveyed to the pellet blending silos by an air conveying system. After homogenization in the blending silos the pellets are conveyed to the bagging and palletizing system.

2.5.20 PHENOL UNIT

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. Major Sections involved in production 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:

❑ 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. 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 contained in 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 manner.

❑ Oxidation of Cumene to Cumene Hydroperoxide and subsequent cleavage to produce Phenol and Acetone:

Oxidation: 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.

□ Fractionation to recover and purify Phenol and Acetone:

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, the Hydrocarbon Removal Column, and the Phenol Finishing Column.

AMS Fractionation and Hydrogenation: One of the major by-products of the phenol/acetone process is alpha-methylstyrene (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.

2.5.21 ISO-PROPYL ALCOHOL (IPA) UNIT

The IPA Unit produces Isopropyl Alcohol by the direct hydration of Propylene. Major sections of the unit are as follows:

❑ **Splitter System:**

Refinery grade propylene (RGP) containing 66-95% propylene, 5-35% propane, 0.04% ethane and 0.2% butane + butenes is fed to the C3-splitter system by splitter feed pumps. The overhead product is the refined propylene containing 99% propylene, 0.82% propane and 0.02-0.03% ethane. The bottom product is the propane stream containing 0.16% propylene, 99.2% propane and 0.66% butane / butenes.

The system consists of two distillation columns which operate in series. The RGP and reactor vent gas from the IPA reactor system is fed to the first column and bottoms withdrawn from the 2nd is transferred to Propane storage.

Reboiling is done at the bottom of both the columns from the reactor loop via a closed loop hot water circulation system.

The overhead product flows under gravity as side draw from tray to IPA reactor feed drum. Purified propylene is then pumped to reactor loop.

A small controlled gas stream, relatively rich in C2 content (ethane/ethylene), is continuously vented from overhead condensers and reflux drum to flare. It can also be used as fuel and routed to fuel header. It contains all the C2 content of plant RGP feed, propylene and propane.

❑ Reaction and flash section:

This section consists of the reactor loop and flash section.

Reactor loop:

The reactor loop consists of the IPA reactor, steam heated feed super-heater, reactor feed versus effluent exchangers, trim cooler, main scrubber, recycle compressor, vent gas fractionator and its reboiler.

Purified Propylene and reaction feed process water are the main raw materials. They are fed into a Propylene rich gas stream which is circulating through above mentioned equipment of reactor loop, which is at high pressure. The products formed in the loop are removed from the bottoms of scrubber and vent gas fractionator.

A 20% Caustic soda solution prepared in caustic drum is injected in the reactor outlet stream at effluent exchanger outlet in a controlled flow.

In the main scrubber, the circulating gas is washed with a stream of water, to remove most of the reaction products (alcohol, ketone etc) and small quantities of propylene, propane and ether. The Propylene, propane and ether are recycled back to the reactor loop from the downstream flash section.

A small quantity of the circulating stream at scrubber outlet is vented to the vent gas fractionator operating at a lower pressure. The vent gas is fractionated with reflux as RGP from the main plant feed and steam reboiling. This gives a propylene & ether rich stream, containing some propylene, propane, alcohol and water as the bottoms and propylene rich, ether free top vapor product. The overhead product is fed below appropriate tray in the 1st splitter column. The bottoms from vent gas fractionator are flashed in the flash drum to remove most of the propylene and some ether in the vapor which is routed to the

low pressure in the flash section. The ether rich liquid also contains some alcohol and water which can be used as fuel.

Flash section:

The wash water from bottom of scrubber is flashed in the First Flash Drum at intermediate pressure wherein most of propylene, propane, ether and some alcohol is removed in the vapor phase which is fed to the Flash Gas Fractionator along with the gas from discharge of Flash Gas Compressor.

The liquid from first flash drum, still containing some propylene, propane and ether is flashed to a still lower pressure in Second Flash Drum. The flash gases rich in propylene, propane and ether are cooled in condenser by cooling water to remove most of the alcohol and water, which are sent back to flash drum. The gases at exit of condenser along with flashed gases from the vent gas fractionator bottom flash drum are further cooled by cooling water to make it almost dry. The LP condensate separator separates the gas & liquid at the outlet. The separated gases are compressed to the intermediate pressure and discharged into the First Flash drum. The liquid from LP condensate drum can be pumped to the ether / acetone storage tanks or as feed to second wash column.

The flash gas fractionator receives gas feed from 1st flash drum and operates at the intermediate pressure. It has a CW cooled overhead condenser and steam heated reboiler. It separates the flashed gases in bottoms containing mainly water and alcohol and an overhead liquid containing propylene, propane and ether. The bottoms is sent back to the Second flash drum while overhead liquid is pumped at the reactor effluent outlet effluent exchangers or inlet of the trim cooler.

LP Gases from the gas seals of the recycle compressor are routed to the suction of flash gas compressor and ultimately reach the reactor inlet through 1st flash drum, the flash gas fractionator etc.

Liquid in the 2nd flash drum is virtually free of propylene & propane. It contains IPA, water, and small quantities of NPA, ether and acetone. It is pumped to the 1st wash column feed heater, in downstream distillation section. All the distillation columns in this section operate at pressure above atmospheric pressure.

❑ Crude Wash Section

First and second wash columns are placed in series.

First wash column is fed with bottoms from IPA drying column and gives an overhead product that is more concentrated in ether. Washing in 1st wash column is done by a cooled alcohol free water stream which is apart of the bottoms of the downstream Constant Boiling Mixture (CBM) Column.

Overhead product from 2nd wash column is water free and rich in ether which is pumped to ether / acetone storage tank and can be used as fuel. The bottoms is pumped back to appropriate tray in 1st wash column.

The CBM column separates the lean alcohol solution from bottom of 1st wash column into an alcohol / organics free water stream as bottoms and an overhead product with composition of water-IPA azeotrope at the top. The overhead product is a side draw from a suitable tray in the column to the product drum.

The side draw overhead product in product drum is pumped to the drying column for further removal of water from the IPA-azeotrope. It can also be cooled and diverted to the IPA-azeo storage tank.

The bottoms from CBM column is hot water and pumped partly to the distribution header for CBM bottoms. It is further cooled and fed to the top of the 1st wash column. The balance part is pumped to the discharged into the Chemical Effluent Pit from where it is pumped to the new Phosphate treatment section in ETP.

From a suitable tray in CBM column a liquid stream is withdrawn and pumped to the NPA column for removing n-Propyl alcohol. Some of the NPA in CBM feed is removed in this column while the rest appears in CBM column product IPA azeo. The NPA column overhead vapors are condensed in CW cooled condenser. The overhead product in reflux drum is pumped back to a suitable tray in the CBM column. The NPA column bottoms product contains water and NPA and is fed to the IPA recovery column. The overhead product from this column is the recovered IPA which is recycled back to the CBM column. The bottom from this column is NPA rich stream containing about 80% water. It is sent to the effluent treatment section of ZLD plant.

□ IPA Drying:

The IPA drying column can receive feed either directly from the CBM column product drum or from the IPA-azeo storage tank or from the offspec IPA tank. The feed is mixed with the solvent, which is the overhead product of the downstream Solvent recovery column, filtered in filters and fed to the drying column.

The bottoms from the drying column are almost water free and contain NPA. Acetone and solvent is cooled in CW cooled coolers and stored in dry IPA storage tanks. If the product is off-spec it can be diverted to the off-spec storage tank. The column has a steam heated reboiler and a CBM bottoms heated reboiler. The overhead condenser is water cooled and the condensed mixture is sub-cooled to 35 deg C in a cooler. The reflux drum also acts as decanter to separate the solvent rich and water rich phases. The solvent rich phase is refluxed back after filtering. The water rich phase is withdrawn as overhead product and fed to Solvent recovery column after preheating with bottoms of Solvent recovery column.

The drying column reflux drum has a connection from the solvent make-up pump for making up solvent when required which pumps solvent from storage drum to drying column reflux drum. The solvent unloading pump is used to unload solvent from road tankers. The solvent recovery column does not have a reboiler and live steam is introduced at the bottom. The bottom product is almost pure water. It is cooled, discharged to oily water effluent pit and then pumped to the ETP. The overhead product of Solvent recovery column is richer in solvent content than the feed and it is recycled by mixing with CBM column feed.

2.5.22 PROPYLENE OXIDE (PO) UNIT

Propylene oxide (PO), C_3H_6O , is a colourless, low-boiling liquid of high reactivity and is now one of the most important chemical intermediates, especially for the polyurethane and solvents industry. Its polarity and strained three-membered epoxide ring allows it to be opened easily by reaction with a wide variety of substances.

The PO Process consists of following sections:

- Reaction Unit
- Decompressing/ Propene recycling

- PO Purification
- Methanol processing

❑ Reaction Unit:

In the PO reaction process, the catalytic epoxidation of propene, reaction of propene (C₃H₆) and hydrogen peroxide (H₂O₂) takes place in a methanol/water mixture using a fixed-bed reactor with a special titanium silicate catalyst.



The process is characterised by mild process conditions with temperatures below 100°C leading to low formation of by-products. The pressure in the reaction unit is about 30 bar.

Due to the optimised process parameters, a high propene-based PO selectivity of more than 95% can be obtained.

The heat of the highly exothermic reaction is removed by an integrated cooling system. After reaction, the product mixture containing mainly methanol, water, propene and PO is withdrawn from the reactor and depressurised to a pressure slightly above atmospheric pressure.

❑ Propene recycling:

The product mixture leaving the reaction unit is decompressed and heated, resulting in a propene-rich gas phase which is compressed, condensed and returned to the reaction section.

The off-gas, which mainly contains inert compounds and a small quantity of oxygen from the decomposition of the hydrogen peroxide, is withdrawn and delivered to the battery limits.

❑ PO purification:

The depressurised liquid product mixture is then transferred to the pre-separation section where PO and dissolved propene are separated from methanol and water. A C₃ stripper removes the remaining C₃ hydrocarbons from the PO/methanol mixture.

The PO distillate is purified in the PO column and the remaining methanol and water as well as the small quantities of impurities are taken off in the bottom product. The PO distillate meets the highest quality standards.

❑ Methanol processing:

The methanol in the methanol/water mixture withdrawn from the bottom of the pre-separation column and from the bottom of the PO column is separated from the water in the methanol processing section. The emanating overhead methanol stream is returned to the PO reaction section.

The bottom product from the methanol column, which contains water and small amounts of high-boiling by-products, is delivered to the battery limits.

Purification of chemical-grade propene

If polymer-grade propene is used as the feedstock, the recycled propene is fed directly to the reaction section. Where chemical-grade propene is used, considerable amounts of propane are continuously introduced into the process with the fresh propene stream. Propane acts as an inert diluent in the reaction system. In order to keep the propane concentration at a constant level, the surplus propane is removed in the propene purification column.

The column increases the propene concentration in the overhead product while the bottom product accounts for the propane balance. The bottom product is sent to the battery limits while the propene stream is returned to the PO reaction section.

2.5.23 POLYETHER POLYOL UNIT

A polyester polyol is a polyol used in polyurethane production that is saturated and has terminal hydroxyl groups. As flexible foams, they are used as construction materials in products ranging from furniture and bedding, to car interiors, to insulation. As rigid foams, they are found in packaging and refrigeration.

Polyether polyol is the polymeric reaction product of an organic oxide and an initiator (or starting polyol) compound containing one or more active hydrogen atoms. The active hydrogen compound in the presence of a basic catalyst initiates ring opening and oxide addition, which is continued until the desired molecular weight is obtained.

The process consists of the main steps, viz. initiation or activation, PO addition & PO reaction, purification, neutralisation, filtration, drying, and storage and packaging. The activation step allows the glycerin molecules to initiate the polymerization reaction upon PO addition and is accomplished by heating solid KOH with glycerin at 250°F. In this step, a hydrogen atom from the glycerin reacts with the hydroxide anion of KOH, producing water, and the positive potassium cation is attracted to the revealed negative charge on the terminating oxygen of the glycerin molecule. The water produced in this step will be removed using evaporation, since water can prematurely terminate the growing chain during the reaction phase as well as degrade the final polyether.

The addition phase involves adding PO to the activated glycerin. As soon as PO is introduced into the reactor, an exothermic reaction is initiated, resulting in the formation of polyether chains. After the PO addition is complete, the reaction phase occurs, and the concentration of the monomer gradually decreases as it is incorporated into the growing polymer.

Both of the reactors will have their own addition and reaction phases during operation. Due to the exothermic nature of epoxide ring-opening, these steps generate a large amount of heat, and external heat exchangers will be used to control the temperature of the reactor contents.

The purification step consists of removing unreacted PO from the reaction mixture and separating the potassium catalyst from the crude polyether to meet industrial product purity specifications. Separation of PO is performed in the second reactor and is accomplished by decreasing the pressure in the vessel so that liquid PO vaporizes and is removed by opening a pressure relief valve. To this Puron (Sodium Acid Pyrophosphate) and water wash is added which performs the dual function of neutralising the reaction and extracting the potassium ions from the nonpolar polymer product. A gravity decantation process follows where the water, carrying most of the catalyst, is separated from the polyether. The already neutralized polyol passes through a Niaga filter to remove the Puron.

Lastly, auto-oxidation is a phenomenon commonly observed in ethers, in which diatomic oxygen from air is incorporated into the ether as a peroxide or hydroperoxide to form a

highly explosive product. Failure to control ether auto-oxidation can cause several industrial accidents, thus, to avoid this safety hazard, storage step will consist of loading the polyether into a large storage tank and adding 0.05 wt% of Irganox(r)1010, an antioxidant. The polyol here is dried by vacuum and then available to be sent to packaging in bulk, drums or Intermediate Bulk Containers.

2.6 RAW MATERIAL REQUIREMENT

The feedstock requirement for the project is given in the table below:

Table 2.3: Details of Raw Materials

Sl. No	Feed	Quantity, KTA	Source
1.	Crude Oil/Condensate	12,000	Import, Dedicated Pipeline
2.	Naphtha/Ethane ^{Note-1}	5,000	Import, Dedicated Pipeline
3.	Natural Gas	973	Domestically acquired
4.	Hydrogen Peroxide	210	Supply from nearby unit or imports, dedicated pipeline
5.	Chlorine	350	Supply from nearby unit, dedicated pipeline
6.	Coal	2,300	

Note-1: For Operational flexibility and to meet requirements in case of phase-wise implementation. After commissioning of refinery, naphtha import requirement would be reduced to the extent of Naphtha produced from refinery.

2.7 ANCILLARY INFRASTRUCTURE

To support the complex, infrastructure needs to be built to accommodate the requirements. These can be categorized under following sub-categories:

1. OSBL Storage Tanks & Spheres
2. Utility Systems
3. Loading/Unloading Pipelines

2.7.1 OSBL STORAGE TANKS & SPHERES

Adequate storage facility will be built to ensure smooth operation of the complex. Storage requirement for various products have been estimated on the following basis.

- **Crude Storage:** This will be imported mainly from middle-east. Average transit time from Middle-east to Kakinada deep sea port/SBM would be about 10 days. The crude storage has been built to accommodate capacity of one VLCC. On the other hand, the

storage should also be sufficient to maintain refinery operation, in the event of one VLCC fails to deliver on schedule.

- **Intermediate storage:** In order to ensure that the short span operation disruption in one unit does not necessitate shutdown of all the related up-stream and downstream unit of the Refinery, adequate storage capacity of the intermediate products have been kept. Depending on the criticality of the intermediate product, the storage space has been determined that ranges from 2 to 5 days of normal production/consumption volume at steady operation of the refinery.
- **Product Storage:** The refinery product that will be sold in the market will have storage capacity of 10 days. For Paraxylene, adequate storage is there near the consuming unit at Haldia, therefore the storage at Refinery location is built to ensure smooth dispatch through ship loading. Hence, storage capacity should be three tanks each having capacity of one MR ship load. For the solid products, warehouse facility will be created to store 30 days production to ensure smooth product dispatch considering variable demand across the month as well as seasonality across the year.

Total Storage tanks and spheres required for the complex is enlisted in the table 3.3 below:

Table 2.4: Storage Details

Sl. No.	Chemical	No. of Tanks/Spheres	Working Capacity of Each Tank, (x 1000) m ³	Total Capacity, (x 1000) m ³
Raw Materials				
1.	Crude Tanks	8	113	910
2.	Naphtha Tank	8	55	444
3.	Condensate Tank	2	55	111
4.	MTBE	2	4	8
Finished Products Tanks/Bullets				
5.	ATF	2	31	63
6.	Benzene	3	20	60
7.	MS	3	20	60
8.	PX	7	18	127
9.	Diesel	7	36	253
10.	C9+ Aromatics	2	23	46
11.	MEG	2	23	46
12.	Phenol	2	18	36
13.	Acetone	2	15	30



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Sl. No.	Chemical	No. of Tanks/Spheres	Working Capacity of Each Tank, (x 1000) m ³	Total Capacity, (x 1000) m ³
14.	Isopropanol	2	16	32
15.	Propylene Oxide	3	17	51
16.	Styrene	3	23	69
17.	1-Butene	2	4	8
18.	BUTADIENE	4	4	17
Intermediate Product Tanks/Spheres				
19.	Ethylene	12	6	69
20.	Propylene	12	6	69
21.	LPG to Cracker	8	7	52
22.	CCR Feed	4	14	55
23.	Reformate to PX plant	2	28	57
24.	HCU Feed Tank	3	18	54
25.	ARDS Feed Tank	6	18	109
26.	Feed to Integrated HT	4	18	72
27.	Coker Feed Tank	3	14	42
28.	Coker NHT Feed Tank	2	6	12
29.	Feed to DCC	4	18	72
30.	Feed to Pygas HDT	3	18	54
31.	Extract ex Aromatic Extraction to Benzene Fractionator	3	8	25
32.	Light Slop tank	3	3	10
33.	Heavy Slop tank	3	3	10
34.	n-Butane to Gasoline pool	2	0.3	0.5
35.	C5 ex Depentanizer to Gasoline pool	2	2	5
36.	Aromatic Extraction Raffinate to MS pool	1	3	3
37.	Heavy Reformate to MS pool	2	8	17
Product Dispatch Tanks/Spheres				
38.	ATF	2	5	9
39.	DIESEL	3	5	14
40.	MS	3	5	14
41.	BENZENE	2	8	16
42.	PX	2	15	30
43.	C9+ Aromatics	2	5	9
44.	MEG	2	3	6
45.	Phenol	2	3	6
46.	Acetone	2	3	6
47.	Isopropanol	2	3	6
48.	Propylene Oxide	2	3	6
49.	Styrene	3	12	36

2.7.2 POWER PLANT

In order to meet the steam, power and boiler feed water demands of the complex, dedicated steam, power and BFW system will be installed as part of the captive power plant (CPP). This system should be sized to meet the complex's normal and intermittent steam /power demands only.

The preliminary estimate of steam and power required for the proposed units can be summarized as below:

Table 2.5: Steam and Power Requirements

Units	Total Steam, TPH*	Power, KWh*
Process Plant Requirements	1,530	457
Design Margin (20%)	310	93
Total requirements	1,840	550

**Preliminary estimate, may change during project design*

Considering above steam and power requirements, it is proposed to set-up a 550 MW Captive Cogeneration Power Plant with a capacity to produce about 2,000 TPH of SHP and other level of steams.

❑ CPP Configuration

It is proposed to use internally generated fuel to the extent possible for generation of power and steam. For balance steam and power generation, high calorific value, low ash (<15%) coal would be used.

Based on above considerations, CPP configuration can be summarized as given below:

Table 2.6: CPP Configuration

	Nos.	Capacity		Fuel	Annual Quantity, kTA
		Power	Steam		
GTs with HRSGs	7	40 MW	140	Fuel Gas, Natural Gas	Included in Table 2.3
BPSTGs	2	20 MW	-	-	-
Aux Boilers	4	-	400	Coal, Internally generated FO/CBFS	3 boilers based on coal. Annual requirement in Table 2.3
CSTG	6	40 MW			

2.7.3 UTILITY SYSTEMS

Following utilities system needs to be developed to support operation of the above process units.

A. Raw Water Treatment:

Treated Raw water is required in the plant for cooling water make-up, DM plant feed, potable water in the plant premises, fire water make-up, service water for various units, etc. The tentative capacity of raw water treatment facility for the CTC Complex is estimated to be around 4,750 m³/h.

B. Demineralised Water Treatment:

DM water for the complex is required for the make-up to boiler feed water and as process water for dilution, reaction and washing.

The DM water unit is estimated to be of total capacity 900 m³/h to meet normal and peak requirements.

C. Compressed Air System:

Compressed air is required in the complex as instrument and plant air. Instrument air is required in various process units to operate instruments and purging. Plant air is required for hose stations, generating catalysts, decoking furnaces, etc.

The compressed air system will be designed to meet both the intermittent and continuous demand inside the complex..

The total capacity for air compressors is estimated to be about 40,000 m³/h and that of the air dryers is estimated to be around 25,000 m³/h. Sizing of individual compressors, dryers and air receivers to be finalized during engineering phase.

D. Nitrogen Unit:

Nitrogen is required in the complex for different requirements such as blanketing of surge drums and storage tanks, purging of compressor seals, headers and catalyst regeneration, polymer conveying etc.

The total capacity of the nitrogen system in the complex is estimated to be 25,000 m³/h to meet the both the continuous and intermittent/peak demands.

E. Cooling Tower & Distribution Network:

Cooling water, an essential utility in process and power plants, is required to remove heat from process fluids for cooling or for condensing the exhaust steam. The CW requirements of the complex will be met through re-circulating cooling water systems operating with treated raw water as make-up.

The normal consumption of cooling water in the complex for process cooling is estimated to be 3,50,000 m³/h. Considering design margin and cooling water required for power plant, it is proposed to provide a total of 70 cells of 5,000 m³/h. No of cells in different cooling water blocks would be provided based on detailed design consideration. The system will additionally include suitably sized auxiliaries like formulation dosing system, biocide dosing systems, sulphuric acid dosing system, chlorinator, Polymeric Dispersant dosing system, side stream filter, etc. will be provided in the facility.

F. Effluent Treatment Plant:

The effluent generated from the various units in various units and sanitary waste will be treated in the ETP. The effluent mainly consists of the following streams:

- i. Oily Water
- ii. Waste Water
- iii. Spent DM water, etc.

G. Product Warehouse:

To store polymers for 15 days equivalent inventory, product warehouses would be provided for different polymer products.

H. Flare Unit:

The flare system is required for safe disposal of combustible, toxic gases which, are relieved from various process plants and off sites during start-up, shutdown, normal operation or in case of an emergency such as:

- ✓ Cooling water failure
- ✓ Power failure
- ✓ Combined cooling water and power failure
- ✓ External fire
- ✓ Blocked discharge

- ✓ Any other operational failure

Capacity of the utility units has been decided based on the normal utility consumption rates by various process unit as well as start-up and shutdown consideration. Depending on the selection of the final location, water storage may need to be built at intake point for maintaining adequate supply round the year.

2.7.4 LOADING/UNLOADING PIPELINES

Beside the facilities inside the plant premises, cross country pipelines are required for loading/unloading of feedstock/products from the Jetty or single buoy mooring (SBM).

Following pipelines are envisaged as the part of the complex:

- | | |
|------------------------------|----------------------------------|
| ✓ Crude Unloading Pipeline | ✓ C9+ Aromatics Loading Pipeline |
| ✓ Naphtha Pipeline | ✓ Gasoline Loading Pipeline |
| ✓ Ethane Pipeline | ✓ Diesel Loading Pipeline |
| ✓ LNG Pipeline | ✓ Paraxylene Loading Pipeline |
| ✓ MEG Pipeline | ✓ Phenol Pipeline |
| ✓ Benzene Loading Pipeline | ✓ Acetone Pipeline |
| ✓ Butadiene Loading Pipeline | ✓ Propylene Oxide Pipeline |
| ✓ Butene-1 Loading Pipeline | ✓ CBFS Loading Pipeline |

Besides these feedstock and product pipelines, separate pipelines for raw water supply and effluent disposal would be required.

2.7.5 WATER REQUIREMENT AND SOURCING

The water requirement for the CTC Complex is ~4,750 m³/h (~ 25MGD) on annual average basis. The major water requirement is for cooling water make-up and production of DM water for steam and power generation.

The breakup of water requirement (annualized) can be summarized as below:

Units	Water Requirement (in MGD)	Approx. Water Requirement (in m³/h)
Cooling Water Make-up	18.6	3,525
DM Water	3.4	650
Drinking Water & Sewerage	0.5	100



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Units	Water Requirement (in MGD)	Approx. Water Requirement (in m³/h)
Plant Water/Service Water	0.5	100
Evaporation + Fire Water	2	375
Total	25	4,750

The requirement can be fulfilled from three possible sources in the proximity:

1. Samalkot Canal (66 MLD)
2. Nakkalakhandi Drain (22 MLD)
3. Polavaram Left Canal (116 MLD)

Polavarum left main Canal (AP irrigation) is approximately 12 km from the proposed site and is likely to be main source of supply through a dedicated pipeline. Samalkot is an alternate source of water which is around 28 km from the proposed site.



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CHAPTER 3

SITE ANALYSIS

CHAPTER 3: SITE ANALYSIS

3.1 DETAILS OF ALTERNATIVE SITES

Evaluation of Alternate Location for Proposed Project

Crude to Chemical project of this magnitude requires huge tract of contiguous land and developed infrastructure. While evaluating the proposed location for this project, alternate locations were also identified and evaluated. A brief summary is enclosed below:

Evaluation Parameter	Location -1	Location-2
Location Name	Kakinada, AP	Haldia, WB
Availability of 2,500 Acres of Contiguous Land & Land Acquisition Status	Available with single source in identified industrial zone	Contiguous land parcel of 2,500 acres not available.
Port Infrastructure	Nearby Kakinada Port for equipment movement; A new port having draft of about 15m being set-up	Haldia Port for equipment movement. Existing liquid handling jetties facing congestion and don't have capacity to handle 15-18 mmTPA of inbound and outbound logistics. Draft is about 8 m and is not suitable for handling large sized cargoes
Distance from Port	Sea Port, About 5 KM from proposed site	Riverine port, requires about 10-12 KM pipeline
Water Sourcing (25 MGD)	Available from nearby Polavaram Canal, Dedicated pipeline of about 12 KM required	May require augmentation of Geonkhali Water Works Infrastructure. Pipeline of 20-25 KM required.
Social Infrastructure	Developed social infrastructure available near proposed location	Developed social infrastructure available near proposed location
Distance from Feedstock Source	Feedstock to be sourced from Middle East. Shorter lead time for sourcing compared to location-2	Higher lead time of sourcing feedstock
Distance from Market	Target market is southern India, where petrochemical	Additional freight cost to be incurred to serve Southern



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Evaluation Parameter	Location -1	Location-2
	manufacturing facility is not present. Current demand being met through imports	Indian market.
Availability of Skilled Manpower	Project manpower to be sourced from outside.	Better wrt Location-1 considering existing hydrocarbon industry based and proximity to reputed institutions. However project manpower is to be largely sourced from outside
Awareness about Local Environment	New location	Better wrt Location-1

Considering that alternate location has to incur higher logistics cost for inbound and outbound logistics and land acquisition process requires additional efforts, Kakinada is preferred over alternate location.

3.2 SITE DETAILS

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.

The Khasra No.s of the site as below:

15,16,17/1,17-4,17-7,17-9,17/10,17-11,17-12,17-13,18-1,18-2,18-3,18-4,18-5,18-6,19-1,19-2,21-1,21-2,22,23-5,23-6,23-7,23-8,24-3,24-4,25-1,25-3,26-12,27-1,27-2,27-3,27-4,28-1,28-10,28-11,28-2,28-3,28-4,28-5,28-6,28-7,28-8,28-9,29-1,29-2,29-3,29-4,30-1,30-2,31-1,31-2,31-3,31-4,31-5,31-6,31-7,31-8,31-9,32-1,32-2,32-3,32-4,33-1,33-2,34,35,36-1,36-2,36-3,36-4,37-1,37-2,37-3,37-4,37-5,37-6,38-1,38-2,38-3,39-1,39-2,39-3,39-4,40,41-1,41-2,42,43,44,45,46-1,46-2,46-3,46-4,46-5,47,48,49-1,49-2,49-3,50,51-1,51-2,51-3,52-1,52-2,52-3,54-2,54-3,54-6,54-7,54-8,55-1,55-2,55-3,55-4,55-5,55-6,55-7,56,57,58-1,58-2,59,60,61,62-1,62-2,62-3,62-4,62-5,63-1,63-2,64-1,64-2,64-3,64-4,65-1,65-2,65-3,65-4,65-5,78/1,78/2,78/3,78/4,78/5,81/1,82,83-1,83-2,83-3,83-4,83-5,83-6,83-7,83-8,83-9,84-1,84-2,84-3,84-4,84-5,84-6,84-7,84-8,84-9,85-1,85-2,85-3,86,87-1,87-2,87-3,88-1,88-2,88-3,88-4,88-5,88-6,89,90,91,92-1,92-2,92-3,92-4,93,94,95-1,95-2,95-3,95-4,95-5,95-6,96-1,96-2,96-3,96-4,97-1,97-2,97-3,97-4,97-5,97-6,98,99-1,99-2,99-3,99-4,99-5,99-6,99-7,99-8,99-9,99-10,99-11,100-1,100-2,100-3,100-4,100-5,101-



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1,101-2,101-3,101-4,101-5,102,103,104-1,104-2,104-3,105,106,107,108,109,110,111,112,113,114-1,114-2,115,116,117,118-1,118-2,118-3,215/1,215/2,216/1,216/2,216/3,216/6,217,253p,256/Part,257/Part,263/1,263/2,264/1,264/2,265,267p,268/1,268/2,268/3,268/4,268/5,268/6,268/7,269,270,271/1,271/2,271/3,271/4,272/1,272/2,273/1,273/2,273/3,273/4,273/5,273/6,273/7,274/1,274/2,275/1,275/2,275/3,276/1,276/2,277,278,279,280,281,282/1,282/2,282/3,283,284,285/1,285/2,286,290,291/1,291/2,291/3,291/4,291/5,291/6,291/7,292/1,292/2,292/3,292/4,292/5,292/6,293,294,295/1,295/2,295/3,296/1,296/2,297/1,297/2,297/3,297/4,297/5,297/6,297/7,297/8,297/9,298/1,298/2,298/3,298/4,299,300,301,302,303/1,303/2,303/3,303/4,304/1,304/2,305,306/1,306/2,307,308,309,310/1,310/2,311,312/1,312/2,312/3,312/4,312/5,312/6,313,314,315,316/1,316/2,316/3,316/4,316/5,317,318,319,320,321,322,323/1,323/2,323/3,324,325,326,327,328,329/1,329/2,329/3,329/4,329/5,330,331/1,331/2,331/3,331/4,332,333/1,333/2,333/3,333/4,333/5,333/6,333/7,333/8,333/9,333/10,333/11,334,335/1,335/2,336,337,338,339,340,341/1,341/2,341/3,341/4,342,365/1,365/2A,365/2B,365/2C,365/2D,365/3,365/4,365/5A,365/5B,366,367,375/1,375/2,375/3,376,377/1,377/2,377/3,378,379/1,379/2,379/3,477,478,482,483,484,485,486,487,488,494,495,496,497,502/1,502/2,502/3,503,584,586,587,588/1,588/2,588/3,588/4,588/5,589,590,591,592/1,592/2,592/3,592/4,593,594,595/1,595/2,595/3,595/4,595/5,596,597/1,597/2,598,599,600/1,600/2,600/3,600/4,601,602,603/1,603/2,604,605,606,607/1,607/2,608,609,610,611,612,613,614,615,616,617,618,619,621,622,623,626,627/1,627/2,627/3,627/4,627/5,627/6,627/7,627/8,627/9,627/10,627/11,627/12,627/13,627/14,628,630/4,638/2,639/1,639/2,639/3,640,652,653,654,655,656,660/1,660/2,660/3,660/4,660/5,660/6,660/7,660/8,660/9,660/10,660/11,661/1,661/2,661/3,661/4,661/5,661/6,661/7,661/8,661/9,661/10,662/1,662/2,662/3,662/4,719/1,719/2,719/3,719/4,

3.3 CONNECTIVITY

The plant site is well connected to the proposed NH-16, a 120 metre wide corridor (11 km long) from Kakinada Town through beach road. The corridor is to cross Howrah-Chennai railway line near Ravikampada railway station. NH-214 joins NH-16 at

Kathipudhi. NH-214 is being expanded to 4-lane road and will help logistic support from the existing deep-sea port.

Kolkata-Chennai Railway line is passing at about 11kms from the site. There is a possibility of taking connectivity from Ravikampadu station through the 120 m wide corridor for entering HPL sites. Space from railway siding within plant need be probed.

Kakinada SEZ Limited subsidiary of GMR Infrastructure Limited, is also proposing an all-weather, deep water, multipurpose port in the vicinity of Kakinada SEZ in Kona Village. Capacity of the port envisaged to handle dry bulk and multipurpose cargo to handle upto 120,000 DWT vessels.

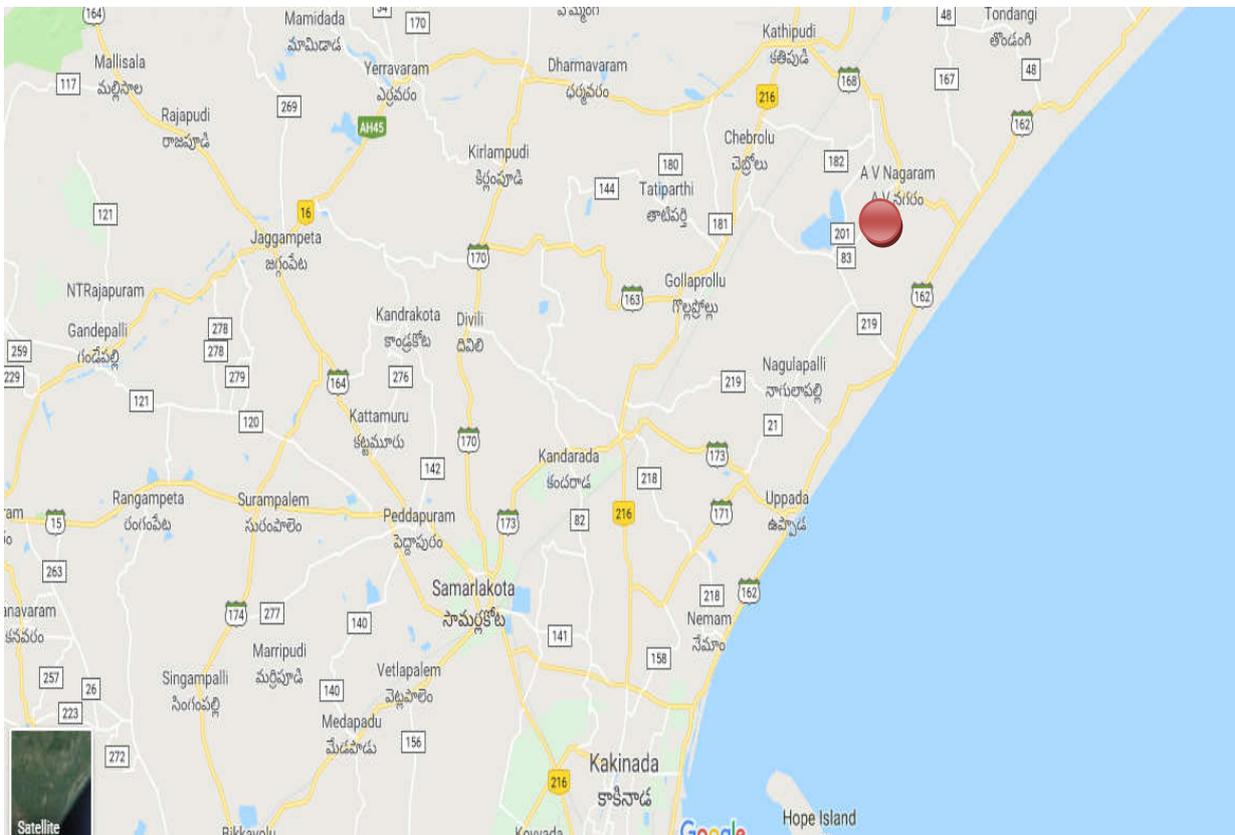


Figure 3.1: Connectivity shows in the map

3.4 LAND FROM LAND USE AND LAND OWNERSHIP

Kakinada SEZ is the owner of the Land. The Land is mostly non-agricultural dryland. Total project area is 2500 Acres which is under the possession of GMR Infrastructure. Land use of the area is already industrial. Topography of the land is almost flat with minor undulation. The elevation of plant area is 6m amsl.

Tentative breakup of area, subject to further refinement during engineering stage, is

Table 3.1: Plant area break up

Particulars	Area (Acres)
Total Project Area	1,923
Greenbelt	637
Total	2,560

3.5 TOPOGRAPHY

The topography of the area is flat. The general drainage is parallel to sub parallel. The drainage in surrounding area is dendritic in nature and the drainage density depicts a low drainage density.

3.6 ENVIRONMENTAL SETTINGS

Existing land use pattern (agriculture, non-agriculture, forest, water bodies (including area under CRZ)), shortest distances from the periphery of the project to periphery of the forests, national park, wild life sanctuary, eco sensitive areas, water bodies (distance from the HFL of the river), CRZ. In case of notified industrial area, a copy of the Gazette notification should be given

Table 3.2: Environmental Settings of the Area

Particulars	Details
Nearest Town/City	Kakinada – 30 km (SW)
Nearest highway	Kakinada-Tuni Road passing through the proposed project site.
Nearest railhead / Railway station	Nearest Railway Station is Durgada station about 7 km from project site (NW)
Nearest airport	Nearest airport is Visakhapatnam about 105 km from project site (NE)
Defence installations	None
Archaeological important places	None
Wild life sanctuaries	None
Rivers in 10-km radius	Polavaram Main Canal – 9.5 Km (NW)
Hill ranges	None
Seismic zone	The proposed plant-site area falls in Seismic Zone III as per IS 1893:2002 (Part-1), which is a Moderately sensitive seismic zone.

3.7 SOIL CLASSIFICATION

The subsoil condition as revealed from field test data is very much erratic and its profile is found to be undulated too and is as given below:

Table 3.2: Soil Profile

Stratum	Description	Depth of Soil (m)
I	Medium compact yellowish grey / light grey fine grained sand with traces of kankars and mica.	0 – 3
II	Dense to very dense yellowish grey / light grey fine to medium grained sand with traces of silt at lower reaches.	3 – 7
III	Very stiff to hard dark brown / brownish grey clayey silt / silty clay with varying percentage of sand & occasional stone fragments.	7 – 13
IV	Dense to very dense dark brown / brownish grey / yellowish grey silty sand with traces of clay as binder and occasional stone fragment.	13 – 19
V	Dense to very dense brownish grey / yellowish grey / light grey coarse to fine grained sand and varying percentage of stone fragments.	19 – 25

3.8 CLIMATIC CONDITIONS

The project area has a tropical climate with hot, humid weather most of the year. The warmest time of the year is late May and early June, with maximum temperatures around 38–42 °C. January is the coolest month, with minimum temperatures of 18–20 °C. The area gets most of its seasonal rainfall from the southwest monsoon, although considerable rain also falls during the northeast monsoon (from mid-October to mid-December). Cyclones in the Bay of Bengal frequently strike the city. The prevailing winds are from the southwest for most of the year, except from October to January when they are from the northeast. The average annual rainfall is 110–115 cm.

Ambient Temperatures

The mean highest temperature of 41.9 °C is reported for June while mean lowest temperature of 17.0 °C is reported for the months of January and December.

Relative humidity

The average relative humidity values varied from the lowest of 59% in the months of April and June to the highest of 82% in the months of August and September. The humidity is relatively higher in the morning hours than the evening hours.



3.9 WATER TABLE ELEVATION

The ground water level is in between 1.0 to 3.5 m below natural ground level. For design purpose the ground water level to be taken at the formation level.

Site elevation above sea level:

Average Site Elevation above Mean Sea Level: + 4.90 m

Barometric design pressure: 1000 mbar

Barometric Minimum pressure: 960 mbar

Barometric maximum pressure: 1014 mbar

3.10 SOCIAL INFRASTRUCTURE AVAILABLE

Social Infrastructure facilities (both public and private) such as schools, hospitals, community halls, markets, colleges, railway station and religious buildings are located at Kakinada and surrounding area.



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CHAPTER 4

PLANNING BRIEF

CHAPTER 4: ENVIRONMENTAL CONSIDERATIONS

4.1 INTRODUCTION

Industrial development is vital for the growth and betterment of living conditions of the local population and society as a whole. Industrial development, however, is endemic with its effect on the environment. It is important, therefore, that even while the industrial development is required for growth, the environment is conserved and protected. The proposed CTC Complex Project is a step in the direction of spurring industrial activity in Andhra Pradesh. Notwithstanding this fact, it has been considered essential to adopt environmental protection measures and adhere to legislations such that the ecology and the habitat of the area are not disturbed.

Various pollution control measures required to meet the prevailing environmental standards are planned at the different stages of execution of the project, viz., design, construction and operational phases.

4.2 POLLUTION CONTROL MEASURES

Environmental impacts of proposed projects have been described in the management plan broadly included below.

4.2.1 AIR EMISSIONS SOURCES AND MANAGEMENT

Potential emission sources from various process units and management options are –

Process Units	Potential Sources	Management Mechanism	Options/Control
Crude Distillation Unit	CO ₂ , NO _x , SO _x and CO emissions from process furnaces.	Low sulphur fuel used to minimise SO _x in the flue gas. Heaters/furnaces provided with proven Low NO _x burners to reduce NO _x emissions. Vent streams will be directed to flare	
Integrated Hydrotreating Unit	CO ₂ , NO _x , SO _x and CO emissions from furnace stacks. Particulates from intermittent catalyst regeneration.	Low sulphur fuel used to minimise SO _x in the flue gas. Heaters/furnaces provided with proven Low NO _x burners to reduce NO _x emissions. Vent streams will be directed to flare Particulates will be minimized by	

Process Units	Potential Sources	Management Mechanism	Options/Control
		controlled combustion.	
Hydrocracking Unit	CO ₂ , NO _x , SO _x and CO emissions from furnace stacks. Particulates from intermittent catalyst regeneration.	Low sulphur fuel used to minimise SO _x in the flue gas. Heaters/furnaces provided with proven Low NO _x burners to reduce NO _x emissions. Vent streams will be directed to flare to minimise any VOC in the flue gas. Particulates will be minimized by controlled combustion.	
Atmospheric Residue Desulfurisation Unit	CO ₂ , NO _x , SO _x , CO and TSP emissions from furnace stacks.	Low sulphur fuel used to minimise SO _x in the flue gas. Heaters/furnaces provided with proven Low NO _x burners to reduce NO _x emissions. Vent streams will be directed to flare to minimise any VOC in the flue gas.	
Delayed Cracker Unit	CO ₂ , NO _x , SO _x , CO and TSP emissions from furnace stacks. Coke dust from coke yard.	Low sulphur fuel used to minimise SO _x in the flue gas. Heaters/furnaces provided with proven Low NO _x burners to reduce NO _x emissions. Vent streams will be directed to flare to minimise any VOC in the flue gas. Sprinkler system will be used to suppress the suspended dust particles.	
Fluidized Catalytic Cracking Unit	CO ₂ , NO _x , SO _x and CO emissions. Particulates and VOC from regenerators.	Low sulphur fuel used to minimise SO _x in the flue gas. Vent streams will be directed to flare to minimise any VOC in the flue gas. High efficiency cyclonic separators will be used to minimize dust emission from the regenerators.	
Continuous Catalytic Cracking Unit	CO ₂ , NO _x , SO _x and CO emissions.	Low sulphur fuel used to minimise SO _x in the flue gas. Vent streams will be directed to flare to minimise any VOC in the flue gas.	

Process Units	Potential Sources	Management Mechanism	Options/Control
	Particulates and VOC from regenerators.	High efficiency cyclonic separators will be used to minimize dust emission from the regenerators.	
Paraxylene Recovery System	CO ₂ , NO _x , SO _x , CO and TSP emissions.	Low sulphur fuel used to minimise SO _x in the flue gas. Heaters/furnaces provided with proven Low NO _x burners to reduce NO _x emissions. Vent streams will be directed to flare to minimise any VOC in the flue gas.	
Sulfur Recovery unit	CO ₂ , NO _x , SO _x , CO and TSP emissions from stacks.	Sulfur recovery unit with more than 99.0% efficiency will be provided. Incinerator and Thermal oxidizer will be provided to minimize CO and VOC emission to the atmosphere.	
Steam Cracker & Associated Units	CO ₂ , NO _x , SO _x , CO and TSP emissions from furnace stacks in Naphtha Cracker, PGHU and CHU	Low sulphur fuel used to minimise SO _x in the flue gas. Heaters/furnaces provided with proven Low NO _x burners to reduce NO _x emissions.	
Ethyl Benzene & Styrene	Waste gas stream from Benzene drying column, alkylation and trans-alkylation units, benzene recovery and/or benzene drag column Flue gas from steam super-heater furnaces Process off-gas from De-hydrogenation Reactors Off-gas streams from vacuum system	Wet gas scrubbers Process off-gas stream used a fuel in steam super-heater furnace Furnace flue gas is emitted to atmosphere following pollution control norms	
PVC	Emission from EDC Cracking Furnaces Waste vent gases from direct chlorination	Low sulphur fuel used to minimise SO _x in the flue gas. Heaters/furnaces provided with proven Low NO _x burners to reduce NO _x emissions and to be designed suitably to	

Process Units	Potential Sources	Management Mechanism	Options/Control
	<p>process</p> <p>Reaction vent post wash stream from Oxy-chlorination process</p> <p>Waste gases from EDC & VCM Purification, Dryer off gas streams, Emission from Waste Gas/Liquid Incinerator</p>	<p>adhere to emission standards.</p> <p>Wet gas scrubbers</p> <p>Furnace flue gas is emitted to atmosphere following pollution control norms</p>	
EO/EG	<p>Purge of inert from reaction section</p> <p>Air emissions from CO2 removal section</p> <p>Emission from EO Scrubbers, EG Fractionation etc.</p>	<p>Catalytic or thermal oxidizer for VOC destruction followed by release to atmosphere</p>	
Isopropanol	<p>Hydrocarbons from tank and process vents, fugitive release of hydrocarbons</p>	<p>To be directed to flare</p>	
Propylene Oxide, Propylene Glycol and Polyether Polyol	<p>Off-gas from Propylene Recovery Column</p>	<p>To be directed to flare</p>	
CPP Stack	<p>CO₂, NO_x, SO_x, CO and TSP emissions.</p>	<p>Electrostatic Precipitator, Chimney, Limestone dosing and other measures to confirm to emission standards</p>	

Considering above, point source emissions are likely to take place from various process units and stacks of power plant and incinerators.

Management Options

Major options to be exercised while formulating air pollution control measures are –

1. Use of low sulfur fuel in process heaters, furnaces etc.
2. Low NO_x burners

3. Process measures to ensure complete destruction of harmful substances process emissions
4. Routing of process vents to Flare, Blowdown vessels etc.
5. Incinerator for destruction of process vents containing harmful components
6. Double mechanical seal, bellow seal valves etc. to minimize fugitive emissions
7. Regular LDAR
8. Limestone dosing to minimize Sulfur emissions from Power Plant
9. High efficiency Electrostatic Precipitators (ESPs) to capture particulates from flue gases
10. Chimney of adequate height for proper dispersion
11. Regular monitoring and measurement

4.2.2 VOC EMISSIONS AND MANAGEMENT

Fugitive emissions are primarily due to intermittent/continuous leakage or evaporation of Volatile Organic carbons (VOCs) from processing/storage area of the refinery. The major sources of such fugitive emissions of VOCs in the refinery are the main processing area, the storage tank farm area for crude oil & products and the loading/unloading gantry area. These fugitive emissions originate from the static and dynamic compressor joints and seals used in flanges, pumps, valve packings and connection joints to the atmosphere like sampling, relief valves, etc.

❑ Management Options

1. Minimum number of flanges, valves, etc.
2. High grade gasket material for packing
3. Usage of state-of-the-art low leakage valves preferably with bellow seals
4. Usage of pumps with Double Mechanical seals for light hydrocarbon services
5. Provisions of floating roof storage tanks
6. Provisions of double seal in some of storage tanks
7. Leak Detection and Repair (LDAR) Program

4.2.3 LIQUID WASTE SOURCES AND MANAGEMENT

The main process units primarily generate oily wastewater from pump leakages, equipment drains, Sour condensate from O/H drums etc. Oily water is also generated from Desalter unit on a continuous basis and from Intermediate/finished Product tanks

on an intermittent but regular basis. Similarly oily water stream, which is high in TDS and oil content, is also produced from the draining of the crude tanks. The floor wash of the contaminated process paved area during dry weather and rainwater from the same area during wet weather shall also constitute source of oily wastewater. Besides the oily water, certain specific waste streams are also produced, viz., sour condensate from the reflux drum of CDU, NHT, HCU, ARDS, DCU etc., and spent caustic waste stream from CCR.

The sour condensate streams are primarily contaminated with Oil, Sulphides, Ammonia, Cyanides and Phenols. The spent caustic streams are primarily contaminated with very high sulphides, mercaptans, acid oils and some phenols complexed with caustic. These streams are prime contributors of Biological oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

Besides these process wastes, there shall be certain blow down streams from utility generation units. The Cooling Tower Blow Down streams primarily contain dissolved solids and suspended solids and occasionally traces of oil. Boiler Blowdown stream is also a regular effluent. This is relatively a cleaner effluent. There will be wastewater generation from the DM Plant in the form of neutralized regeneration water containing high concentration of dissolved solids.

There are certain waste streams, which occur only once in a year or so during plant shut down, etc. The spent caustic stream from DHDT falls under this category. These waste streams shall be primarily contaminated with very high concentration of Sodium carbonate, Sodium Sulphite and Ammonia.

The potential waste generation sources from various process plants and likely control mechanism can be summarized as below:

Process Units	Potential Sources	Management Options/Control Mechanism
Crude Distillation Unit	Waste Water streams from Desalter. Spent Caustic from Caustic Scrubber. Floor wash streams.	Waste water, spent caustic and floor wash water are treated in wastewater treatment plant before disposal.
Integrated	Spent Caustic from Caustic Scrubber	Spent caustic is treated



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Process Units	Potential Sources	Management Options/Control Mechanism
Hydrotreating Unit		in wastewater treatment plant before disposal.
Delayed Cracker Unit	Waste Water streams from decoking drums	Liquid waste is treated in Wastewater Treatment Plant before disposal
Hydrocracking Unit	Spent Caustic from Caustic Scrubber.	Spent caustic is treated in wastewater treatment plant before disposal. Spent caustic will be routed to an oxidation plant with aeration by air in the presence of catalyst to oxidize the sulfites in to sulfates.
Fluidized Catalytic Cracking Unit	Waste Water streams. Spent Caustic from Caustic Scrubber. Floor wash streams.	Liquid waste is treated in Wastewater Treatment Plant before disposal
Continuous Catalytic Cracking Unit	Waste Water streams from catalyst regeneration.	Liquid waste is treated in Wastewater Treatment Plant before disposal
Amine Regeneration Unit	Intermittent Waste Water streams.	Liquid waste is treated in Wastewater Treatment Plant before disposal
Sour Water Stripper unit	Treated Sour Water streams	Liquid waste is treated in Wastewater Treatment Plant before disposal
Sulfur Recovery unit	Intermittent Waste Water streams	Liquid waste is treated in Wastewater Treatment Plant before disposal
Ethyl Benzene & Styrene	Oily water streams from Benzene drying and recycling columns	Tar is used as fuel in power plant

Process Units	Potential Sources	Management Options/Control Mechanism
	Aqueous stream from decanter downstream of the condensation system of reactor effluent Aqueous stream from vacuum system of distillation columns Tar from reaction by-product	Liquid waste is treated in Wastewater Treatment Plant before disposal
PVC	Reaction water and quench water from oxy-chlorination section Washing effluent from Direct Chlorination Effluent from waste gas scrubbing	
EO/EG	Purge streams from EO and EG streams. Spent scrubber effluent.	
Isopropanol	Propanol, organic and inorganic phosphates from water wash.	
Propylene Oxide, Propylene Glycol and Polyether Polyol	Water hydrocarbon mixture from Methanol column	

The various process streams shall be brought to the ETP battery limit separately. The estimated generation of process effluent and other streams can be summarized as below:

Sl. No.	STREAM TYPE	FLOW RATE (m ³ /h)
1	Oily Stream From Process Units	800
2	Sanitary Waste	45
3	DM Neutralization Waste	110 (Normal)/200 (Peak)
4	Cooling Water Blowdown	700 (Average)/1,300 (Peak)
5	Contaminated Rain Water	34,000 m ³ (2 hour peak rain over entire complex)

Effluent Treatment Plant (ETP) consisting, physical, physico-chemical, biological and tertiary treatment system will be designed to (i) treat process effluent and sanitary effluent being generated on continuous basis (ii) stabilize Cooling Tower Blowdown and

DM Neutralization Waste before disposal and (iii) process contaminated rain water to meet discharge norms and recycle part of the treated effluent for various applications. Water recycle measures would be taken to the extent possible to minimize fresh water intake.

4.2.4 SOLID AND HAZARDOUS WASTE SOURCES AND MANAGEMENT

During the design stage itself due care will be taken to select the process technologies generating minimum solid wastes so that their handling, treatment and disposal do not cause any serious impact on the existing land environment. Also, efforts will be made to recycle some of the spent catalysts by way of returning to the original supplier for reprocessing.

The solid wastes management plan proposed is briefly described below. The provisions of Hazardous Waste (Management & Handling) Rules, 2000, will be complied with.

There are primarily four types of solid wastes generated in a refinery:

1. Spent Catalysts
2. ETP Sludges
3. General Solid Wastes
4. Tank Bottom Sludge

❑ Spent Catalysts

Patented catalysts are used in various refinery process units. Some of the spent catalysts will be sent back to the original supplier for reprocessing. The other catalysts after proper disposal treatment steps are normally sent to a secured landfill.

❑ ETP Sludges

The sludge separated in different units of ETP, viz., oily & chemical sludge from API / TPI / DAF, will be thickened in a thickener and the thickened sludge will be dewatered in a centrifuge. The dewatered sludge will be sent to secured landfill.

The bio sludge from bio-treatment section will be separately thickened and dewatered in a thickener and centrifuge respectively and sent for land fill/reuse as manure.

❑ General Solid Wastes

Small quantities of non-hazardous, non-recyclable solid waste consisting of waste refractory, spent insulation, decoking solid waste from CDU/VDU,DCU, used filter



cartridges, spent charcoal, spent clay and sand will be generated. These wastes will be disposed off as landfill.

❑ Tank Bottom Sludge

This sludge is generated periodically during the tank cleaning operations. As this sludge is hazardous, after recovery of oil to the maximum extent possible in a melting pit, the residue will be sent to secured landfill. However, the sludge generated from product tanks will be nominal.

The potential waste generation sources can be summarized as below:

Process Units	Potential Sources
Atmospheric Residue Desulfurisation Unit (ARDS)	Spent Catalyst
Fluidised Catalytic Cracking Unit (FCC)	Daily Spent Catalyst from the unit
Continuous Catalytic Reforming unit (CCR)	Daily Spent Catalyst from the unit
Hydrocracking Unit	Spent Catalyst
Integrated Hydrotreating Unit	Spent Catalyst
Coker Naphtha Hydrotreating Unit	Spent Catalyst
PX Unit	Spent Catalyst
Steam Cracker and associated units	Spent Catalyst
Sulfur Recovery unit	Spent Alumina Catalyst Hydrolysis Catalysts
Effluent Treatment Plant (ETP)	Dewatered sludge from the plant.
Ethyl Benzene & Styrene	Zeolite based catalysts in EB Reactors Catalyst used in Ethylbenzene Dehydrogenation
PVC	Spent Oxy-chlorination catalyst Coke from EDC racking Sludge from Wastewater Pre-treatment
EO/EG	Spent EO Catalyst
Isopropanol	Spent catalyst
Propylene Oxide	Spent Titanium Silicate Catalyst
CPP	Fly Ash & Bottom Ash



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Process Units	Potential Sources
ETP	Sludge, Waste Oil
DM Plant	Ion Exchange Resins

Management Options

1. Sale of spent catalysts under buy-back arrangement for recovery of valuable metals or authorized re-processors
2. Secured landfill in a facility duly approved by MoEFCC
3. Incineration of ETP sludge and waste oil in incinerator
4. Disposal of incinerator ash in secured landfill duly approved by MoEFCC
5. Sale of fly ash and bottom ash to cement manufacturers, brick manufacturers, infrastructure companies etc.



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CHAPTER 5

REHABILITATION AND RESETTLEMENT (R & R) PLAN



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CHAPTER 5: REHABILITATION AND RESETTLEMENT (R & R) PLAN

I. Policy to be adopted (Central/State) in respect of the project affected persons including home oustees, land oustees and landless labourers

The land identified for project is already acquired for industrial use and is in the possession of the infrastructure company offering the land to Project Proponent for setting up these proposed units. Therefore, land acquisition and subsequent rehabilitation is not envisaged for the project.



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CHAPTER 6

PROJECT SCHEDULE AND COST

ESTIMATES

CHAPTER 6: PROJECT SCHEDULE AND COST ESTIMATES

6.1 PLANNING OF ACTIVITIES

Careful planning of all the activities is one of the pre-requisite for timely completion of the project. Following activities will be given special attention.

6.2 PRE PROJECT ACTIVITIES

- ✓ Management Approvals.
- ✓ Selection of location
- ✓ Statutory Clearances
- ✓ Financial Approvals
- ✓ Conceptual Design
- ✓ Preparation of main machinery tender
- ✓ Evaluation of tenders

6.3 PROJECT ACTIVITIES (IMPLEMENTATION STAGE)

- ✓ Firm up basic design
- ✓ Main Machinery Order placement
- ✓ Detailed engineering of the project
- ✓ Statutory approvals of Layout Plans.
- ✓ Preparation of tender, evaluation of tenders received and order placement for balance machinery
- ✓ Completion of procurement activities on time
- ✓ Release of civil drawing for civil construction
- ✓ Civil construction
- ✓ Supply of mechanical & electrical equipment
- ✓ Inspection of major machinery at supplier's works
- ✓ Erection of all plant & machinery
- ✓ Commissioning of the plant

6.4 STATUTORY CLEARANCES

The proposed CTC project will require various statutory approvals and clearances from various authorities of the State and Central Government.



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- ✓ Effective project monitoring including project planning schedule and monitoring will be employed in this project. Timely execution and resources will be monitored using computer based project monitoring tools. In case of deviations in project progress, all possible corrective actions such as crashing of network etc. will be carried out.

6.7 PROJECT COST

□ Estimated project cost along with analysis in term of economic viability of the project

The total integrated project cost is estimated to be about ~Rs. 62714 Cr. The project is likely to generate adequate margins to justify investment and generate huge direct and indirect employment opportunities in proposed plant and downstream processing units.

ANNEXURE 1: PRELIMINARY LAYOUT OF THE PLANT

