Indian Oil Corporation Limited (IOCL)

Pre-feasibility Report

40/60 MMTPA Integrated Refinery-cum-Petrochemical Complex on West Coast

Submitted by:

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PRE FEASIBILITY REPORT

CLIENT
IOCL/BPCL/HPCL

PREPARED BY
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1.0 Executive Summary

1.1 Introduction

M/s Indian Oil Corporation Limited (IOCL), M/s Hindustan Petroleum Corporation Limited (HPCL) and M/s Bharat Petroleum Corporation Limited (BPCL) intend to jointly set up a 60 MMTPA integrated refinery-cum-petrochemical complex on the West Coast, primarily to cater to the growing fuels and petrochemical requirements of the country-besides addressing the additional objective of selective export of the produce.

As per the projections by various international agencies, the refining capacity required to meet India's demand of petroleum products by year 2030 is expected to be between 300 to 350 MMTPA & close to 500 MMTPA by year 2040. The current refining capacity in the country is 231.5 MMTPA which will go to 241.6 MMTPA with completion of on-going expansions at BPCL-Kochi, BORL-Bina & HMEL-Bathinda within year 2017-18. OMC's also have plans to increase refining capacity through debottlenecking of existing facilities as well as through capacity addition. The cumulative capacity addition for firm projects is 24.85 MMTPA while for projects under planning stage is 23.2 MMTPA. Taking credit of these capacity additions, the domestic refining capacity is expected to reach about 290 MMTPA by the year 2030. Thus, in order to take care of shortfall in the refining capacity, there is a clear case for setting up a Greenfield 60 MMTPA refinery to meet the domestic demand.

The project shall be located at Babulwadi in Ratnagiri district of Maharashtra, site location map attached as annexure.

1.2 Objectives

The major objectives of the capacity expansion project are to:

a. Meet the projected increase in domestic demand of fuels & petrochemicals.

b. Maximize value addition and return on investment through:

- ✓ Production of Petrochemicals
- ✓ Minimize production of Naphtha and Heavies
- ✓ Production of LOBS (600 KTPA, total max) and Paraffin/MC Wax (50 KTPA, max)

- ✓ Displace naphtha / fuel gas by Pet coke as fuel for captive consumption in CPP for steam and power generation

c. Minimize Capex through integration of processing facilities

d. Minimize Opex by heat integration & hardware selection

e. Fuel products to conform to BS-VI specifications

f. Limit LPG production to 1.0 MMTPA, max. Balance LPG to be considered as feed to Cracker

g. Cap on Gasoline production commensurate with demand (~10 MMTPA). Out of this, 50% of MS shall be premium grade while balance shall be regular grade.

h. Rationalise diesel production taking into account current demand trends. Flexibility to swing between Diesel and Gasoline production to be incorporated in design

i. Bitumen and Bunker Fuel shall not be considered on account of economics.

k. LNG shall be used as fuel for the complex as well as for Hydrogen generation.

1.3 Basis of Configuration Study

1.3.1 Refinery Throughput

60 MMTPA (proposed to be implemented in two phases)
Phase-1: 40 MMTPA
Phase-2: 60 MMTPA

1.3.2 Crude Mix

The configuration study has been carried out for the representative crude basket with the following Crude mix

Table 1.3.2: Crude Mix

Crude	Crude Quality		Phase-1	Phase-2
	API	S (wt %)	Quantity' KTPA (wt %)	
Basrah Light	29.7	3.2	12,840 (32.1%)	19,260 (32.1%)
Basrah Heavy	24.7	4.0	9,920 (24.8%)	14,880 (24.8%)
Castilla	18.8	1.5	8,080 (20.2%)	12,120 (20.2%)
Oman export	32.7	1.4	9,160 (22.9%)	13,740 (22.9%)

Crude blend	27	2.7	40,000	60,000

1.3.3 Refinery On-Stream Hours

8000 hrs/annum.

1.3.4 Product Specifications

The Refinery Fuel products shall comply with BS-VI specifications while the Aromatics/Petrochemical products shall be industrial/polymer grade.

1.3.5 Production Limits

The limits on various products have been considered as per Table 1.3.5 below:

Table 1.3.5 : Production Limits (KTPA)

S.No	Product Name	Min (KTPA)	Max (KTPA)	Remarks
Products from Refinery Block				
1	LPG	-	1000	
2	Naphtha	-	-	Minimize
3	Gasoline	-	10,000	
4	Kerosene/ATF	-	-	
5	ULSD	-	-	Maximize
6	Paraffin/MC Wax	50	50	
7	LOBS	600	600	
8	FO			Minimize
9	Sulphur			
10	Petcoke			
11	Pitch			Minimize
Products From Aromatics Block				
1	Paraxylene		2400/3600	
2	Benzene			As produced
Products from Petrochemical Block				
1	Polypropylene			Maximize
2	HDPE	-	-	Maximize
3	LLDPE /HDPE	-	-	Maximize
4	LDPE	-	200	
5	MEG		1200	
6	DEG	-	-	
7	Phenol	-	300	
8	Acetone	-	-	

1.4 Refinery-cum-Petrochemical Complex Configuration

Based on the above considerations and constraints, a comprehensive LP model was developed to analyze the various configuration options. Multiple configuration options were studied in detail covering wide spectrum of secondary processing and bottom processing options.

As per the findings of the configuration study, EIL submitted the details of the recommended configuration (referred as the Base case) including Project Capex & IRR in May'2016. Based on the various deliberations held hitherto, the Base case configuration was further modified to improve project profitability. Thus, findings of the following options are included as part of this report :

- **Base Case** configuration with Capex & IRR updated to current prices
- **Modified Case** – Case-2A with additional petrochemical products (Aromatics+Olefins) including Capex & IRR.
- **Modified Case** – Case-2B with additional petrochemical products (Olefins) including Capex & IRR.

The findings for both the above cases are included in the Project Cost Summary attached as part of this report.

1.4.1 Refinery Block

The Refinery block primarily comprises of processing facilities for production of fuel products conforming to BS-VI quality specifications. The major process facilities of the Refinery Block of the selected configuration comprise of the following :

Primary Processing facilities comprising of three parallel trains of Crude & Vacuum Distillation units

Secondary Processing facilities comprising of Feed Hydrotreating coupled with Petro FCC units & Hydrocracker unit.

Bottoms Upgradation facility comprises of Delayed Coking as well as Slurry Hydrocracking units.

Product Treatment facilities comprise of the treatment facilities for LPG, MS, ATF, Diesel besides treatment units for Fuel gas.

1.4.2 Aromatics Block

The typical aromatics complex includes a combination of process units for the production of *para*-xylene, primarily. Para-xylene is used in the production of polyethylene terephthalate (PET), which is used as polyester fiber, film, and resin for a variety of applications.

The processing flow scheme to produce high purity para-xylene and benzene from a naphtha feedstock remains fundamentally same despite minor differences based on process licensors scheme.

The refinery configuration also considers additional aromatic products like benzene and Toluene.

1.4.3 Petrochemical Block

The proposed complex shall consist of dual feed Cracker to produce petrochemical feedstock for various downstream Polymer units. The Dual feed cracker primarily uses C4- Gases and Refinery naphtha as feedstock. Ethylene, Propylene, mixed C4 stream, Raw Pyrolysis Gasoline (RPG), Carbon Black Feed Stock (CBFS), Hydrogen gas and Fuel gas are produced as a result of cracking.

- Generated Ethylene from the cracker will be used within the complex in the separate downstream Butene-1 and polymer units to produce Linear Low Density Polyethylene (LLDPE), High Density Polyethylene (HDPE)
- Ethylene shall also be used to produce ethylene derivatives like LDPE and MEG/DEG
- Generated Propylene from the cracker will be used in the separate downstream polymer units to produce Polypropylene (PP)
- Propylene shall also be used to produce propylene derivative Phenol & Acetone.
- Generated Pyrolysis Gasoline stream from the cracker will be hydrogenated in Pyrolysis Gasoline Hydrogenation unit (PGHU) to produce C6 stream, heavy aromatic C9 stream and Hydrogenated Pyrolysis Gasoline. This Generated Hydrogenated Pyrolysis Gasoline (HPG) and C9 stream will be sold to market for further end uses and generated C6 stream will be sent to

the Benzene Extraction Unit (BzEU) for recovery of Benzene. Fully hydrogenated C5 cut is recycled back to the cracker.

- Generated C6 stream from the PGHU will be charged into the Benzene Extraction Unit from where C6 raffinate is recycled back to the cracker

Petrochemical complex product profile is primarily based on production of bulk polymers & select derivatives. The product profile shall be further fine tuned based on the recommendations of the petrochemical products market study for which external consultant is being lined up.

1.4.5 Utilities & Offsite Block

For the Base case estimate, all the utilities generation & offsite facilities are considered to be captive for meeting the internal demand. The major utilities facilities include :

Desalination Plant based on sea water for meeting the raw water demand of the complex.

Captive Power Plant based on Pet coke/ Pitch / Imported coal as fuel for generation of steam & power.

Compressed air & Nitrogen system to meet the total demand of the complex. The Nitrogen system is cryogenic system capable of generating Nitrogen with 99.9% purity.

Offsite Storage capacity provided for feed, intermediate products & finished products is based on the following :

- Crude storage : 15 days equiv. (total including COT & Refinery)
- Intermediate Products : 7 days equiv.
- Finished Products : 15 days equiv.

Crude Receipt facilities comprise of crude receipt through VLCC tankers. The crude receipt & unloading facilities are considered at the following locations :

- **Jaigarh Port** : Facilities available / being developed at Jaigarh port shall be utilized for unloading crude & its transfer to a Crude Oil Terminal (COT). Crude from COT shall be transferred to Complex site through sub-sea pipeline (120-150 km long). The facility shall be designed for receiving one third of the total crude demand of the complex i.e., 20 MMTPA.
- **SPM near Sindhudurg** : Two SPM's are proposed for receiving balance two third crude i.e., 40 MMTPA. A preliminary study of the Wave Rider Buoy Plots of the area indicates that SPM availability throughout the year shall be high (~340 days per year) & shall not be significantly effected by the monsoon weather . The crude unloaded at SPM shall be transferred to the COT terminal at coast from where it will be pumped to the complex.

Product Evacuation facilities envisaged for liquid products comprise of all four modes of product evacuation namely :

i) Rail
ii) Road
iii) Pipeline
iv) Coastal movement

As per the estimates available for the local demand in the region, the product movement by Rail & Road shall be limited (~3 MMTPA). Thus, majority of the product movement shall take place through Pipelines & coastal movement (expected ratio of 40:60).

The facilities for product evacuation through coastal movement comprise of the following :

- Port facilities at Jaigarh
- Jetty facilities at Sindhudurg

The volumes of product evacuation planned at each site is tabulated below :

Jaigarh Port

S.No.	Product	Quantity, MMTPA
1	MS	2.0
2	ATF	3.0
3	HSD	10.0

Sindhudurg Jetty

S.No.	Product	Quantity, MMTPA
1	LPG	0.5
2	MS	1.0
3	ATF	3.0
4	HSD	6.0

A schematic showing connectivity of the Jaigarh Port, COT / POT facility at Jaigarh, SPM, Jetty & COT facility at Sindhudurg with the Processing complex is attached.

1.5 Feed and Product Slate

The feed and product slate Phase-1 and Phase-2 has been provided in table below.

Table-1.5 : Feed /Product slate for FCHCU+ DCU Option

Case Desc.	405 Refinery + PX+ Dual Cracker + Coke Maximization	905 Refinery + PX+ Dual Cracker +Coke Maximization+ Propylene Derivative	451 1RPD+ Dual Cracker+ PX + Coke Maximization	951 1RPD+ Dual Cracker+ PX + Coke Maximization+ Propylene Derivative	955 1RPD+ Dual Cracker+ Dual Cracker+Coke Maximization+ Propylene Derivative
	40 MMTPA (Phase-1)	40 MMTPA (Phase-1)	60 MMTPA (Phase-2)	60 MMTPA (Phase-2) (Case-2A)	60 MMTPA (Phase-2) (Case-2B)
Case-ID	1RPD	1RPD	1RPD2RPD	1RPD2RPD	1RPD2RDD
BASRAH LIGHT	12840.0	12840.0	19260.0	19260.0	19260.0
BASRAH HEAVY	9920.0	9920.0	14880.0	14880.0	14880.0
CASTILLA	8080.0	8080.0	12120.0	12120.0	12120.0
OMAN EXPORT	9160.0	9160.0	13740.0	13740.0	13740.0
LNG IMPORT	999	1346	1330	1553	892
HI PURITY O2 FOR MEG/PDPP	400	512	741	854	851
COAL IMPORT	1391	1035	3011	2278	1575
BRINE	-	360	-	360	360

Product Slate('000 TPA)

Case Description	405 Refinery + PX+ Dual Cracker	905 Refinery + PX+ Dual Cracker + Propylene Derivatives	451 1RPD+ Dual Cracker+ PX	951 1RPD+ Dual Cracker+ PX + Propylene Derivatives	955 1RPD+ Dual Cracker+ Dual Cracker+ Propylene Derivative
	40 MMTPA (Phase-1)	40 MMTPA (Phase-1)	60 MMTPA (Phase-2)	60 MMTPA (Phase-2) (Case-2A)	60 MMTPA (Phase-2) (Case-2B)
Case-ID	1RPD	1RPD	1RPD2RPD	1RPD2RPD	1RPD2RDD
LPG PRODUCT	1000	1000	1000	1000	1175
NAPHTHA	678	0	0	0	0
MS REG BS-VI	2590	2500	4281	4000	4000
MS PREM BS-VI	2590	2500	4281	4000	4000
ATF	5213	5000	5608	4134	2169
DIESEL BS-VI	16491	17456	25076	26750	26752
LOBS	600	600	600	600	600
Wax	50	50	50	50	50
Bunker Fuel	200	197	200	200	200
BENZENE	166	81	616	87	255
P-XYLENE	1200	1200	2400	2400	1200
STYRENE		-		500	500
HDPE	450	450	900	900	900
LLDPE	1017	712	2049	1413	2417
LDPE			200	200	200
MEG	600	600	1200	1200	1200

Case Description	405 Refinery + PX+ Dual Cracker	905 Refinery + PX+ Dual Cracker + Propylene Derivatives	451 1RPD+ Dual Cracker+ PX	951 1RPD+ Dual Cracker+ PX + Propylene Derivatives	955 1RPD+ Dual Cracker+ Dual Cracker+ Propylene Derivative
	40 MMTPA (Phase-1)	40 MMTPA (Phase-1)	60 MMTPA (Phase-2)	60 MMTPA (Phase-2) (Case-2A)	60 MMTPA (Phase-2) (Case-2B)
Case-ID	1RPD	1RPD	1RPD2RPD	1RPD2RPD	1RPD2RDD
DEG	117	117	233	233	233
POLYPROPYLENE/ Impact PP	1639	1195/133	2929	2427/270	2828/314
EAA	-	47.0	-	47.0	47.0
BA	-	180.0	-	180.0	180.0
2EHA	-	10.0	-	10.0	10.0
nBuOH	-	38.0	-	38.0	38.0
iBuOH	-	7.0	-	7.0	7.0
2EHA	-	48.0	-	48.0	48.0
PHENOL	200	300	200	300	300
ACETONE	123	184	123	184	184
PVC		600		600	600
PET COKE	-	-	-	-	
H2SO4		333		333	333

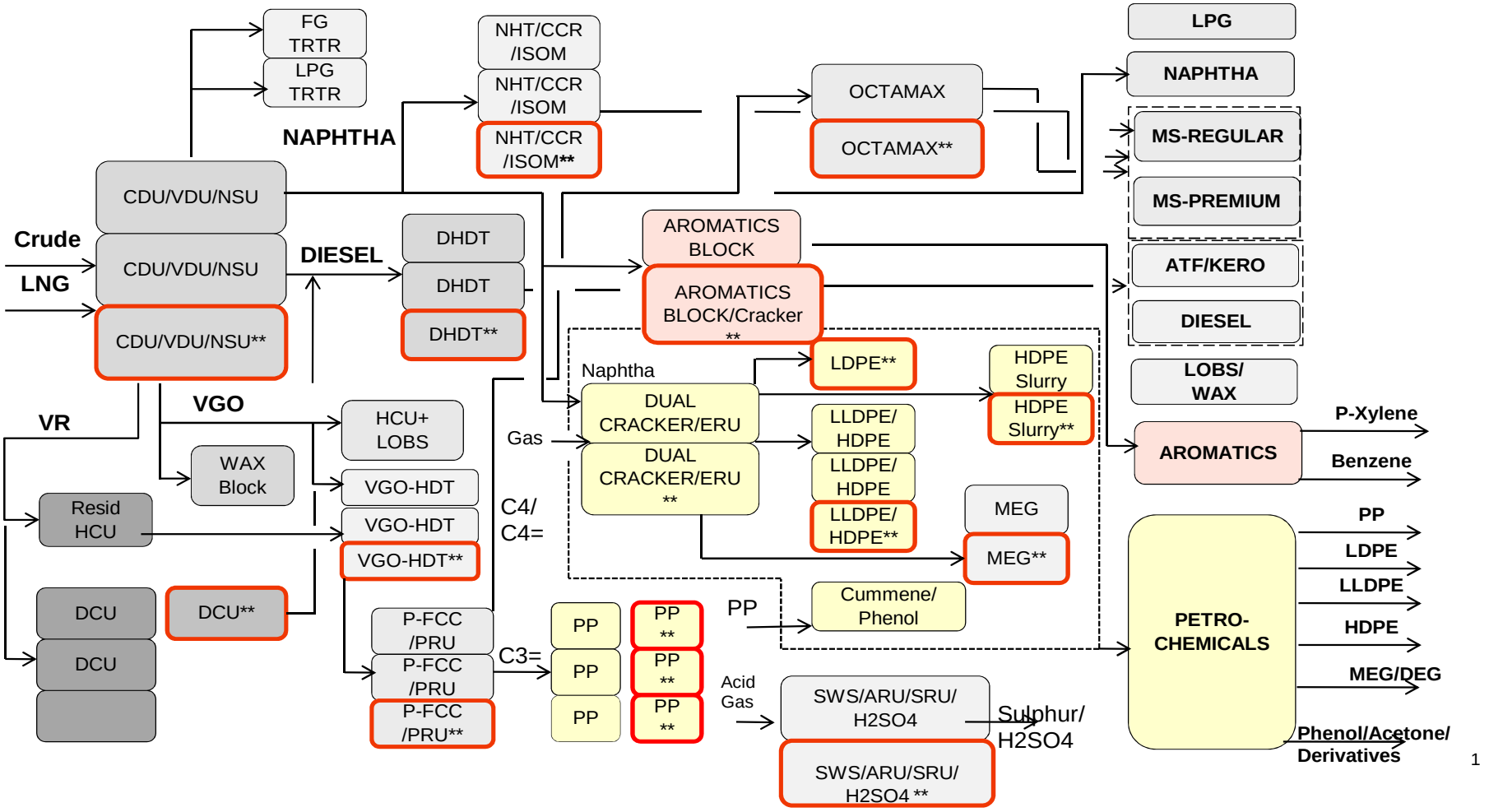
1.6 Block Flow Diagram

The block flow diagram is attached as Annexure to this Report.

1.7 Utility & Offsite Systems

Commensurate utility and Offsite systems were considered.

Phase-1 + Phase-2 Complex



Annexure

Location Map – Babulwadi Site