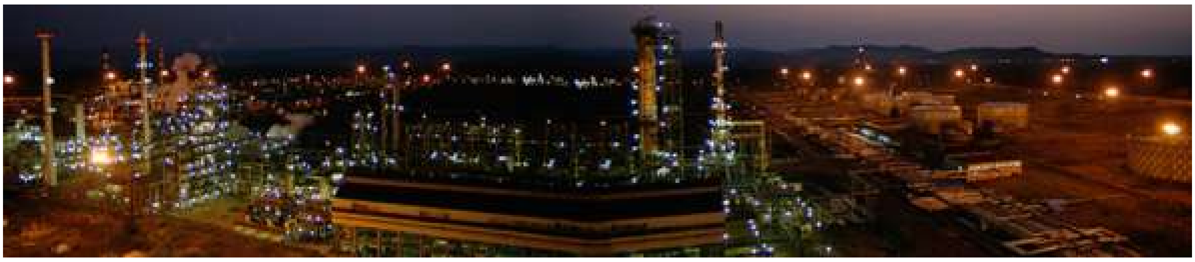
DETAILED FEASIBILITY REPORT

FOR

COMPLETE EURO-IV HSD PROJECT

NUMALIGARH REFINERY LIMITED, ASSAM

NRL



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इंजीनियर्स इंडिया लिमिटेड
(भारत सरकार का उपक्रम)

ई.आई.एल

ENGINEERS INDIA LIMITED
(A Govt. of India Undertaking)

DETAILED FEASIBILITY REPORT

FOR

COMPLETE EURO-IV HSD PROJECT

CLIENT
NUMALIGARH REFINERY LIMITED
ASSAM

PREPARED BY
ENGINEERS INDIA LIMITED
NEW DELHI

EIL JOB No.: A195

REPORT No. A195-RP-0241-0001
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JUNE 2013

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Chapter 1.0
EXECUTIVE SUMMARY

1.0 Executive Summary

1.1 Background

Numaligarh Refineries Limited, (NRL) a subsidiary of Bharat Petroleum Corporation Limited (BPCL) presently operates a 3.0 MMTPA refinery at Golaghat, Assam. The Refinery presently produces e Euro-III and part Euro-IV grade HSD.

NRL has retained EIL as consultant to carry out a Detailed Feasibility Study, based on the findings of the Prefeasibility earlier carried out for Complete Euro-IV HSD production at Numaligarh Refinery.

1.2 Basis and Objectives of Configuration Study:

1.2.1 Basis

The Basis of configuration study are as follows:

- **Refinery Capacity**: Present refining capacity: 3 MMTPA.
  No Capacity expansion is envisaged in this study.
- **Design Crudes** : 100% Assam mix crude.
- **Check Crudes:** None
- **On-stream factor**: 8000 hours/annum
- **Feed and Product prices** : Based on 3 year average (April 09 to March 2012)

1.2.2 Objectives of the Study

The major objectives of the study are:

- Refinery to produce Complete Euro-IV and Part Euro-V grade HSD. All Euro-III HSD to be converted to Euro-IV HSD and actual amount of Euro V HSD that can be produced to be reported.
- Excess Naphtha after meeting MS requirement & Cracker Feed shall be considered for merchant sale.
- Revamped Hydrocracker yields to be utilized to maximize distillates.
- Existing NHT / SRR / ISOM yields to be utilized for MS Block.
- Existing Delayed Coker unit yields to be utilized.
- Revamped SRU (19.3 TPD) Capacity yields to be utilized for Sulphur Block.

1.3 Optimum Case finalized for the DFR:

The optimum case was finalized based on the findings of the Prefeasibility study carried out by EIL.

Case A1: Production of Euro-IV and Euro-V HSD as per the agreed Design Basis

1.4 Results of Configuration study

1.4.1 Product slate

The estimated product slate of the refinery at crude throughput of 3 MMTPA for the optimum case studied for the design crude is summarized in table 1.4.1.1 below.

Table 1.4.1.1 Product Slate (@ 3 MMTPA crude throughput)

CASES	BASE CASE	DESIGN CASE A1: Production of Euro-IV and Euro-V HSD
	'000 KTPA	'000 KTPA
LPG	0.1036	0.104
NAPHTHA SALES	0.192	0.239
NAPHTHA PETROCHEM	0.160	0.160
EURO-III GASOLINE (REGULAR)	0.173	0.173
EURO-IV GASOLINE (REGULAR)	0.048	0.048
KEROSENE	0.492	0.048
ATF	0.060	0.105
EURO-III HSD	1.566	0
EURO-IV HSD	0	1.582
EURO-V HSD	0	0.36
SULFUR	19.4 TPD	21.22 TPD
COKE	0.085	0.085
WAX	50000 TPA	50000 TPA

1.4.2 Unit Capacities

The capacities of major units for 3 MMTPA crude throughput for each design case are summarized in the table 1.4.2.1 below.

Table 1.4.2.1: Unit capacities

UNIT CAPACITIES			
	Unit Name	Base Case	Design case-A1
		Present Capacity	Capacity (MMTPA)
1	Crude Unit	3.0 MMTPA	Same as Nameplate capacity
2	Naphtha Hydrotreater	271 KTTPA	Same as Nameplate capacity
3	Naphtha Splitter	160 KTPA	Same as Nameplate capacity

UNIT CAPACITIES			
	Unit Name	Base Case	Design case-A1
		Present Capacity	Capacity (MMTPA)
4	Isomerisation	55.5 KTPA	Same as Nameplate capacity
5	SRR	168 KTPA	Same as Nameplate capacity
6	HCU	1.45 MMTPA	Same as Nameplate capacity
7	Delayed Coker unit	0.306 MMTPA	Same as Nameplate capacity
8	CCU	0.115 MMTPA	Same as Nameplate capacity
9	HGU (EXISTING)	48600 TPA	Same as Nameplate capacity
10	SRU (in TPD)	19.3 TPD	19.3+7.5
11	FGSU	7.92 TPH	7.92+6.5 TPH
12	SWS	20.3 M3/HR	20.3 +15 M3/HR
13	ARU	26.8 TPH	26.8+25 TPH
14	NEW HGU	--	8000 TPA
15	NEW DHT	--	1 MMTPA

1.5 Modification in Existing Process units

Table below details the modification required in the existing refinery Units.

Table 1.5.1: Summary of modifications required in process units to achieve Complete Euro-IV HSD

UNIT	Modifications Required for Critical Equipment
CDU/VDU	No major modifications envisaged
NHT/ NSU/ SRR/ ISOM	No major modification envisaged
HCU	No major modifications envisaged.
DCU	No major modifications envisaged
CCU	No major modifications envisaged
HGU	No major modifications. Existing Hydrogen plant will be fully based on Natural gas Feed.
SRU	No major modifications envisaged
FGSU	No major modifications envisaged.
SWS	No major modifications envisaged
ARU	No major modifications envisaged

1.5.1 Utility Systems

A summary of findings of adequacy check on utility systems is summarized in the table below

Table 1.5.1.1: Modifications envisaged in existing Utility systems to achieve Complete Euro-IV HSD

System	Modifications required
Steam and Power	1 Gas engine generator (8 MW) and UB (50 TPH)
Cooling Water System	1 additional (1000 m3/hr) Cooling Tower cell with circulation pumps (1+1) in the New cooling water system
Nitrogen System	Existing facility is adequate.
Raw Water System	Additional Cooling water make up pumps (1+1)
Compressed Air System	Existing facility is adequate
DM plant	1 additional DM chain of 65 m3/hr with deaerator.
Fuel gas	Existing facility is adequate
Fuel oil	Existing facility is adequate

The utilities required for the new units are to be availed from the existing Utility systems of the NRL complex where no augmentation is envisaged. Suitable tapping from the existing headers will be taken.

For Utilities such as Cooling water, Steam, Compressed air, Nitrogen, Fuel gas, flare etc independent headers will be provided for the new units. Hookups for connection of steam headers with the existing system will be provided at the execution stage.

1.5.2 Offsite Storage system

A New DHT Feed Tank with pumps (1+1) is considered for the study. No additional Storage requirement considered for Product storage as confirmed with NRL.
The existing Euro-III diesel storage tanks and pumping facilities shall be utilized for the additional feed and storage requirements.
OSBL lines shall be provided to route the feed & product streams to and fro units and Offsite area.

1.5.3 Flare System:

As the existing flare would be inadequate to cater to the additional flare loads from the proposed new units, cost for the new flare system has been considered in the DFR.

1.5.4 Effluent Treatment System

Liquid effluents are intermittent and small in quantity with respect to present capacity of ETP for NRL complex. Stripped water is normally recycled back to the existing HCU, DCU and CDU desalter. In case there is no recycle, this will be routed to ETP.

SOX Emissions: Contribution to SOX emissions due to firing of Natural Gas in the GTG's and Heaters of the New units is very small and estimated to be less than 250 Kg /day.

1.5.5 Control Room

Existing Central control room will be used, however SRR concept has been considered for the DFR.

1.5.6 Plot Plan Studies

A detailed study of the existing Plot plan of the NRL Refinery were carried out as part of the Plot Plan studies, keeping in view to meet all statutory norms, OISD guidelines, existing Pipe Rack locations, necessary space requirements for approach, Crane movements, minimum utilization of Greenfield area and other strategic advantages.

The vacant space identified adjacent to the existing ETP and the Flare has been identified for the New DHT and additional units as shown in the Plot Plan.

Inhouse information from prospective licensors has been considered for the Plot plan study, as licensor evaluation has not been carried out for the new units.

The Plot areas required for Unit/ facilities envisaged in E-IV HSD Project are as under

- DHDT Unit 140M x 130M
- HGU Unit 60M x 50M
- Sulphur Block 75M x 40M
- Satellite Rack Room 1 40M x 15M
- Satellite Rack Room 2 40M x 20M
- Sub-Station 50M x 25M
- Cooling Tower 35M x 16M
- Utility Boiler 40M x 22M
- GEG 48M x 25M

1.6 Capital Cost estimate

The costing indicated in the table below is based on the following:

- The above cost estimates have an accuracy of ± `10%.
- Validity of Cost estimate is as of 2nd Quarter 2013 price basis.
- The project has been assumed to be executed on conventional mode.

Table 1.6.1: Estimated capital cost (In Rs Crores)

Category	Estimated capital cost
Total Project cost	1444.45 Crore's/ Annun

1.7 Financial Analysis

The operating cost, sales revenue and financial analysis have been carried out for calculating internal rate of return (IRR) with a view to establish profitability of the project. The basis of financial analysis is as under:

1	Construction Period	48 months
2	Project Life	15 years
3	Debt / Equity Ratio	2 : 1
4	Expenditure Pattern	Equity Before Debt
5	Loan Repayment period	5 year Term Loan
6	Moratorium Period	1 Year after Project completion
7	Interest on Long Term Debt	12.0%
8	Capital Phasing (Total Capital)	
	1 Year	5.0%
	2 Year	40.0%
	3 Year	45.0%
	4 Year	10.0%
9	Corporate Tax	33.99%
10	MAT	20.96%
11	Capacity Utilization during Operation	
	1year	80%
	2year	90%
	3year	100%
	4year	100%

Financing charges (IDC) has been worked out as per above details.

Annual operating cost has been computed considering costs towards crude price, Natural Gas, Raw water and fixed operating cost. Repair & Maintenance @ 1% of Plant & Machinery, Administrative expenses@ 0.5% of plant & machinery and Insurance & taxes @ 0.5% of the capital cost has been considered under fixed operating cost. Salary & wages has been considered for additional 24 Nos Management Staff: @ Rs. 18 Lakhs/ Annum and 30 Nos Non Management Staff: @ Rs. 9 Lakhs / Annum.

Based on above, Capital cost estimate, operating cost, Sales revenue and financial results are tabulated below:

Table 1.7.1: Financial Analysis

	Cost in Rs Lakhs
Case	
Capital Cost	1444 45
Variable Operating Cost	10268 61
Fixed Operating Cost	28 40
Total Operating Cost	10297 01
Sales Revenue	10573 30
IRR (Pre Tax) on Total Capital	14.67%
IRR (Post Tax) on Total Capital	11.81%
IRR (Pre Tax) on Equity	15.47%
IRR (Post Tax) on Equity	11.13%
Pay Back period (Post tax) on total capital- Years	6.2

1.8 Conclusion

The optimum Case A1 selected meets the objective to produce Complete Euro-IV and Part Euro-V grade HSD.

With implementation of the New DHT units, Present production of 1566 KTPA Euro III HSD will be completely upgraded to Euro-IV along with additional 360 KTPA of Euro-V HSD product.

All technologies envisaged has proven record and are operating satisfactorily.

Chapter 2.0
INTRODUCTION

2.0 Introduction

Numaligarh Refineries Limited, (NRL) a subsidiary of Bharat Petroleum Corporation Limited (BPCL) presently operates a 3.0 MMTPA refinery at Golaghat, Assam. The refinery presently produces Euro-III and part Euro-IV grade HSD.

NRL has retained EIL as consultant to carry out a Detailed Feasibility Study for Complete Euro-IV & part EURO – V HSD production at the Numaligarh Refinery.

The design basis presented in section 4.0 will be the basis for carrying out configuration study followed by preparation of detailed feasibility report based on the selected configuration for the Numaligarh Refinery.

Chapter 3.0
SCOPE

3.0 Scope of the DFR

The Detailed Feasibility study has been carried out corresponding to complete conversion of presently produced EURO – III grade HSD to EURO IV grade HSD and part EURO V grade HSD.

A key consideration for the study was based on the following:

- Refinery to produce Complete Euro-IV and Part Euro-V grade HSD.
- Excess Naphtha after meeting MS requirement & Cracker Feed shall be considered for merchant sale.
- Revamped Hydrocracker yields to be utilized to maximize distillates.
- Existing NHT / SRR / ISOM yields to be utilized for MS Block.
- Existing Delayed Coker unit yields to be utilized.
- Revamped SRU (19.3 TPD) Capacity yields to be utilized for Sulphur Block.
- All Euro-III HSD to be converted to Euro-IV HSD and actual amount of Euro V HSD that can be produced shall be reported. Diesel to conform to Euro IV and Euro V specifications.

The Detailed Feasibility report addresses following facts -

- Evaluation and estimation of Project cost for the Optimum Case
- Identifying suitable integration needs for feed, products, intermediate products and utilities
- Optimization of space use and identifying proper space for new facilities
- Product Quality, material balance and Utility consumption details.
- Project Implementation schedule & Bar chart

Chapter 4.0
DESIGN BASIS

4.0 Introduction

Numaligarh Refineries Limited, (NRL) a subsidiary of Bharat Petroleum Corporation Limited (BPCL) presently operates a 3.0 MMTPA refinery at Golaghat, Assam. The refinery presently produces Euro-III and part Euro-IV grade HSD.

NRL has retained EIL as consultant to carry out a Detailed Feasibility Study for Complete Euro-IV & part EURO – V HSD production at the Numaligarh Refinery.

4.1 Basic Design parameters

4.1.1 Refinery Capacity: The DFR shall be based on minimum crude processing capacity of 3.0 MMTPA.

4.1.2 Crude Processed:

4.1.2.1 **Design Crude**: The Detailed Feasibility Study shall be carried out for the original design Crudes i.e. 100% Assam mix crude

4.1.2.2 **Check Crude:** NONE

4.1.3 **Refinery on-stream hours:** 8000 hrs/annum.

4.1.4 Basis of Configuration study

The capacity of the existing CDU of 3.0 MMTPA will be considered for the Refinery. There is no capacity expansion or addition of any CDU unit.

4.1.5 Configuration study Product demand Price basis:

The product demand & prices given in section 4.3 & 4.4 will be used.

4.2 Objectives of the study:

The major objectives of the Feasibility study are:

- Refinery to produce Complete Euro-IV and Part Euro-V grade HSD.
- Excess Naphtha after meeting MS requirement & Cracker Feed shall be considered for merchant sale.
- Revamped Hydrocracker yields to be utilized to maximize distillates.
- Existing NHT / SRR / ISOM yields to be utilized for MS Block.
- Existing Delayed Coker unit yields to be utilized.
- Revamped SRU (19.3 TPD) Capacity yields to be utilized for Sulphur Block.
- All Euro-III HSD to be converted to Euro-IV HSD and actual amount of Euro V HSD that can be produced shall be reported. Diesel to conform to Euro IV and Euro V specifications.

4.2.1 Configurations to be considered for DFR Study:

Secondary Processing options shall be considered to arrive at the most optimum Refinery configuration is with a New Diesel Hydrotreater (DHT)

4.3 Product demand

The production of the following products has to be limited to the values indicated against each.

S NO.	Product	Present Product slate (MTPA) (Note 1)	Target Production (MTPA)
1.	Liquefied Petroleum Gas (LPG)	103700	Float
2.	Naphtha Domestic sales	192700	Float
3.	Petrochemical Naphtha Export	160000	160000 min
4.	Regular Gasoline (Euro III) Domestic	172670	171000 min
5.	Regular Gasoline (Euro IV) Domestic	48000	48000
6.	ATF Domestic	60000	60000
7.	Kerosene Domestic	492300	48000 (min)
8.	Diesel, (Euro III) Domestic	1566700	0
9.	Diesel, (Euro IV) Domestic	-	to be reported.
10.	Diesel, (Euro V) Domestic	-	To be reported
11.	Sulfur	4500	To be reported.
12.	Coke	85333	85333
13.	Wax	50000	50000

Note 1. Base case estimated considering 1600 Sulphur in LGO and 500 ppm Sulphur in Kerosene as reported in the PGTR for CDU unit.

4.4 Feed, Product & Utility Prices

- **Crude price**: The crude prices are provided by NRL as 3 year average price (Refer Table 4.4.1)
- **Product price**: The product prices are provided by NRL as 3 year average price (Refer Table 4.4.1)
- **Utility price:** The prices of utilities are provided by NRL (Refer Table 4.4.2)

Table-4.4.1: Feed & Product Prices

Feed	Price (Rs/MT)
Assam Crude	33,299.60
Natural Gas	13,762.28
Products	**Price (Rs/MT) Domestic**
Liquefied Petroleum Gas (LPG)	34,702.34
Sales Naphtha	31,471.65
Petrochemical Naphtha	31,471.65
Regular Gasoline (Euro III)	48, 816.01
Regular Gasoline (Euro IV)	48, 841.25
ATF	39,152.47
Kerosene	36,764.54
Diesel (Euro III)	36,990.59
Diesel (Euro IV)	37,183.40
Diesel (Euro V)	37.183.40
Raw Coke	12,103.97
Sulphur	4781.80
Wax	65,000.00

3 year average prices for the period April'09 to March'12 for the crude & products furnished by NRL will be considered for the study.

Table-4.4.2: Utility Prices

Utility	Unit	Price Rs./ unit
Treated effluent water	Per MT	3.23
DM water	Per MT	11.35
Steam	Per MT	2400
Natural Gas	Per MT	11739.67
Fuel Oil	Per MT	20 683
Naphtha	Per MT	33,077.92
Power (with Naphtha as Fuel)	Per KWh	6.5
Cooling water	Per m3	5

4.5 Product specifications

The product specifications adopted for this study are tabulated below.

Table-4.5.1: Product Specifications

Product	Unit	Specification	Specification
LPG		**(IS 14861 - 2000)**	**(IS 14861 - 2000)**
Vapor pressure at 40 °C, max	Kpa	1050	1050
Odor,min		2	2
C2 minus content, max	Wt%	0.2	0.2
C5 plus, max	Wt%	2	2
Total volatile sulfur, max	Wtppm	200	200
Copper strip corrosion, max		No. 1	No. 1
Hydrogen sulfide	Wtppm	Nil	Nil
Mercaptans	Wtppm	Nil	Nil
Free water		Nil	Nil
Evaporation temperature for 95 vol%,max	°C	2	2
Naphtha (Petrochemical)			
Colour	Saybolt	+25	+25
Density@15 °C	Gm/ml	689	689
Sulfur, max	Wtppm	500	500
Olefins, max	Vol%	0.5	0.5
PARAFFINS,min	Vol%	70.5	70.5
AROMATIC,max	Vol%	6	6
Iso/Normal Paraffins		1.95	1.95
RVP,max	PSIA	10	10
Chlorides,max	PPMW	1	1
Lead	PPBW	5	5
Mercury,max	PPBW	30	30
Naphtha (domestic)			
Specific gravity			
min		0.65	0.65
max		0.74	0.74
Sulfur, max	Wtppm	500	500
Paraffins, min	vol%	65	65
Olefins, max	vol%	0.5	0.5
Aromatics, max	vol%	6	6
Euro-IV gasoline (Regular)			
Specific gravity			
min		0.72	0.72
max		0.775	0.775
Sulfur, max	Wtppm	50	50
RON, min		91	91.5
MON, min		81	81.5
FBP, max	°C	210	210
Aromatics, max	vol%	35	34.5
Benzene, max	vol%	1	0.9
Olefins, max	vol%	18	18
Oxygen content,max	wt%	2.7	2.7
Oxygenates content,max			
Methanol	vol%	Nil	Nil
Ethanol	vol%	5	5

Product	Unit	Specification	Specification
Iso-propyl alcohol	vol%	10	10
Iso-butyl alcohol	vol%	10	10
Tertiary butyl alcohol	vol%	7	7
Ethers with 5 or more carbon atoms	vol%	15	15
Other oxygenates	vol%	8	8
RVP	KPA	60	60
Euro-III gasoline (Regular)			
Specific gravity			
min		0.72	0.72
max		0.775	0.775
Sulfur, max	Wtppm	150	150
RON, min		91	91.5
MON, min		81	81.5
FBP, max	°C	210	210
Aromatics, max	vol%	42	41.5
Benzene, max	vol%	1	0.9
Olefins, max	vol%	21	21
RVP	KPA	60	60
Oxygen content,max	wt%	2.7	2.7
Oxygenates content,max			
Methanol	vol%	Nil	Nil
Ethanol	vol%	5	5
Iso-propyl alcohol	vol%	10	10
Iso-butyl alcohol	vol%	10	10
Tertiary butyl alcohol	vol%	7	7
Ethers with 5 or more carbon atoms	vol%	15	15
Other oxygenates	vol%	8	8
ATF			
Specific gravity			
min		0.775	0.775
max		0.84	0.84
Sulfur total , max	Wt%	0.25	0.25
FBP, max	°C	210	210
Aromatics, max	vol%	22	22
Olefins, max	vol%	5	5
Flash point (Abel), min	°C	38	38
Freeze point,max	°C	(-) 47	(-) 47
Smoke point	mm	21	21
10% recovery,max	°C	205	205
Kerosene			
Specific gravity		0.775	0.775
Min	Vol%	0.84	0.84
max	Vol%	22	22
Aromatics, max	Wt%	5	5
Olefins, max	°C	0.25	0.25
Sulfur total, max	°C	210	210
FBP, max	mm	38	38

Product	Unit	Specification	Specification
Flash point (Abel), min Smoke point 10% recovery,max		21 205	21 205
<u>Euro-IV Diesel</u> Specific gravity Min max Sulfur, max Viscosity at 40 °C Min max 95% recovery, max Flash point (Abel), min Cetane number, min Cetane index, min Poly aromatic hydrocarbon, max Cold filter plugging point,max Summer Winter Lubricity corrected wear scar diameter(wsd 1.4) at 60°C	Wtppm CSt CSt °C °C wt% °C °C Microns (Max)	0.82 0.845 50 2 4.5 360 35 51 46 11 18 6 460	0.82 0.845 45 2 4.5 360 35 51.5 46 11 18 6 460
<u>Euro-V Diesel (Domestic)</u> Specific gravity Min max Sulfur, max Viscosity at 40 °C Min max 95% recovery, max Flash point (Abel), min Cetane number, min Cetane index, min Poly aromatic hydrocarbon, max Cold filter plugging point,max Summer Winter Lubricity corrected wear scar diameter(wsd 1.4) at 60°C	Wtppm CSt CSt °C °C wt% °C °C Microns (Max)	Euro – V 0.82 0.845 10 2 4.5 360 35 51 46 11 18 6 460	Euro – V 0.82 0.845 10 2 4.5 360 35 51.5 46 11 18 6 460

4.6 Data for study

4.6.1 Crude Assay

Refer annexure - VII

4.6.2 Yield data for various conversion units in Refinery Complex to be considered for Feasibility study

Yield and utility data for all the existing units in the Refinery will be based on the data as received from NRL.

The yield data to be considered is on the following basis :

a. CDU / VDU unit : Yields % as per Revised Design (Refer Annexure -V Table 1 in Report on PGTR Run of CDU / VDU as provide by NRL) (LPG yield is 0.9 wt% and Fuel Gas is 0.1 wt% in the reported Unstabilized Naphtha yield of 15.15 wt% to be considered).
b. Revamped Hydrocracker yields as per the Chevron Package Design Case Yield data. (Refer Annexure- VI, Table I, II and III)
c. Delayed Coker yields as per the Process Package Design data
d. MS BLOCK yields to be based on the PGTR Yields (refer Annexure-VII, Axens PGTR report Section 2 Material Balance for NHT, SRR and ISOM).
e. NSU yields as per the Process Package design yields. Annexure-VIII
f. Existing Hydrogen Plant design yields
g. WAX Plant Yield data as per the EIL-IIP Process Package

Yield and utility data for new units if required in the Refinery Complex as part of the optimized configuration shall be based on EIL in-house data.

Crude & vacuum distillation units

Unit Capacity: 3 MM TPA
Design Crude: Assam crude. Crude Assay data

The TBP cut points & yields that will be used in the study are as shown below:

(Reference PGTR report)

Stream	TBP Cut Points (°C)	Wt%
Gas	C2-	0.1
LPG	C3+C4	0.9
Light Naphtha	C5-120	14.15
Heavy Naphtha	120 -140	1.2
Kerosene	140-270	20.27
Light Gas Oil (note 1)	270-300	11.94
Heavy Gas Oil	300-360	12.65
Vacuum Diesel	360-400	1.98
LVGO	400-440	3.48
MVGO	440-460	16.71
HVGO	460-550	6.06
Vacuum Residue	550.+	10.14
Vacuum Offgas		0.42
Total		100

Note 1: LGO stream includes 0.66 wt% of Slop.

Full Conversion hydrocracker unit

Unit Capacity: 1.45 MM TPA

Design Feed: Feed to the Hydrocracker are the following feeds.
VG0 : 61.5 wt%, Heavy Gas Oil (Ex CDU) : 23.1 wt%, Coker Naphtha : 1.6 wt%, Coker Kerosene : 1.9 wt% , Coker Gas oil : 11.9 wt%.

The TBP cut points & yields that will be used in the study are as shown below:

Stream	**TBP Cut Points (°C)**	**Wt%**
H2S		**0.41**
Fuel Gas	C2-	0.64
Treated LPG	C3+C4	3.38
Light Naphtha	C5-105	10.24
Heavy Naphtha	105 -135	2.5
Kerosene	135-270	40.95
Diesel	270-370	44.52
Total		102.64

Delayed Coker unit

Unit Capacity: 0.306 MM TPA

Design Feed: Short Residue 550 deg C + derived from Assam Mix crude.

The TBP cut points & yields that will be used in the study are as shown below:

Stream	**TBP Cut Points (oC)**	**Wt%**
Fuel Gas	C2-	10.7
Coker LPG	C3+C4	4.94
Coker Naphtha	C5-140	7.84
Coker Kero I	140 -230	9.47
Coker Kero –II	230 -320	10.0
Coker Gas Oil	320 - 400	11.73
Coker Heavy Gas oil	400+	17.32
Pet Coke		28.0
Total		100

Design Yields and Product Property data as confirmed by NRL.

MS-Block

The MS Block comprises of an existing Naphtha Hydrotreater unit, A semi Regenerative Reformer unit and an Isomerisation Unit.

Unit Capacities:

ISOM UNIT : 55,500 MTPA
NHT UNIT : 271,000 MTPA
SRR UNIT : 168,000 MTPA

NHT Unit Capacity: 271,000 M TPA

Design Feed : Straight Run Naphtha

The yields that will be used in the study are as shown below:
(refer Annexure-5, Axens PGTR report Section 2 Material Balance for NHT Unit)

Stream	Wt%
Hydrotreated Naphtha	99.7
Stripper Off gas	0.3
Total	100

SRR Unit Capacity: 168,000 M TPA
Design Feed: Hydro treated Heavy Naphtha

The yields that will be used in the study are as shown below:
(refer Axens PGTR report Section 2 Material Balance for SRR Unit)

Stream	Wt%
Reformate	85.1
Hydrogen Rich Gas	5.84
LPG	6.57
Fuel Gas	0.32
Loss	2.20
Total	100

ISOM Unit Capacity: 55,500 M TPA
Design Feed: Hydro treated Light Naphtha

The yields that will be used in the study are as shown below:
(refer Axens PGTR report Section 2 Material Balance for ISOM Unit)

Stream	Wt%
LPG Yield	3.4
Isomerate	96.1
Gas + Loss	0.5
Total	100

Naphtha splitter Unit (NSU)

Unit Capacity: 160,000 M TPA of Petrochemical Naphtha Feed To BCPL Cracker

Design Feed: 91,000 TPA of SR Naphtha, 152,000 TPA of HC Light Naphtha and 46,000 TPA of Hydro treated Light Naphtha.
Surplus naphtha produced in the Unit is routed to Pool Naphtha as Product sales.

The yields that will be used in the study are as shown below:
(Refer, Process Package for NSU unit)

Stream	Wt%
Petrochemical Naphtha	55.77
Naphtha to Pool	44.23
Total	100

4.6.3 Utility systems:

Basis: The DQUP Utility & OFFSITES Package shall be considered for inputs of the existing Utility systems in the Configuration study for the Refinery. The utility requirements for the Individual Process units shall be considered from the Process Packages available. Additional Utility requirement for NSU and WAX unit shall be taken from the Process Packages.

Any additional data / information required on the Utility systems shall be provided by NRL.

4.6.4 Catalyst & Chemicals data for various units considered for screening study

Basis: NRL provided the Catalyst and Chemical requirements and prices for all the existing Process units. Balance data shall be based on the EIL in-house data.

4.7 Other considerations for study:

1) The design of the new units capacity should ensure the products are matching Euro IV specs for Diesel. The entire production of HSD shall meet Euro IV / Euro V specs taking into account the demand for these fuels and the necessary optimization during finalization of the configuration.

2) Expansion and centralization of existing Utilities & Offsite will be considered in the DFR based on the space availability in the existing system. If it is found infeasible due to space constraints, new utility generation facility will be added at new location to cater to expansion refinery units.

3) No additional Light end processing section (ISOM / SRR) is envisaged. Therefore the objective should be to revamp the existing Light end processing section to maximize naphtha and balance naphtha shall be for merchant sale.

4) Addition of any New crude / intermediate and product storage tanks shall not be considered for the study

4.8 Emission norms

Total S0x emission from the refinery is to be limited to 6.1 TPD (As provided by NRL)

CPCB March-2008 guidelines to be followed.

4.9 Broad scope of Work

EIL shall carryout the of the Study for Phase – II which is the Detailed Feasibility report for Complete Euro-IV HSD production. The scope of work shall comprise of the following:

- The configuration study shall be carried out for 3 MMTPA throughput.
- The configuration is based on the finalized option in the PFR study.
- Evolve inputs for Cost Estimates
- Preparation of +/- 10% accuracy level cost estimates for Detailed Feasibility.
- Compilation of DFR

4.10 Key Considerations for the DFR

1) The design of the new unit's capacity should ensure the products are matching Euro IV specs for Diesel.
2) New Gas Engine Generator to be considered to meet additional Power demand.
3) Existing and New Hydrogen Plants shall be on Natural Gas Feed.
4) New Hydrogen unit Capacity will be based on DHT unit Hydrogen demand.
5) Expansion and centralization of existing Utilities & Offsite will be considered in the DFR based on the space availability in the existing system. If it is found infeasible due to space constraints, new utility generation facility will be added at new location to cater to expansion refinery units.

4.11 Contents of Detailed Feasibility Report (DFR)

The Reports will be prepared for the selected configuration and shall include the following:

- Executive summary
- Introduction
- Basis of Study
- Description of Existing Facilities
- Cases Studied for the Feasibility Study & Summary of Results
- Modification in the Existing units
- Hydrogen & Sulphur Balance
- Overall plot plan
- Capital Cost Estimates
- Financial analysis

4.12 Deliverables

The deliverables against the subject job shall comprise following:

- Design Basis
- Draft DFR
- Final DFR

4.13 Exclusions:

The following items are excluded from the Scope of Current DFR.:

a. Market Study
b. Project Implementation Schedule
c. Detailed design including P&ID's, data sheets.
d. Flare Adequacy.
e. Evaluation, design of Utilities and Offsite facility, Tankages.
f. Health Checks and conditional assessment of existing hardware
g. Financial analysis of Existing hardware.

Environmental impact Assessment Study for the Refinery.

4.14 Concurrent obligations of NRL:

NRL shall provide timely the following inputs for carrying out the Study and preparation of PFR & DFR at no cost to EIL:

1. Crude assay for design crudes for the study.
2. Prices of Crude, Product and Utilities.
3. Demand / supply scenario of petroleum products.
4. Existing refinery yield pattern, utilities consumption, effluent and flare load summary.
5. Hydrogen & Sulphur balance of the existing refinery.
6. Any other design data / drawing required.
7. Review of and finalization of the design basis for the configuration study.
8. Statutory / Environmental requirements to be met.
9. Selection of Configuration for DFR.
10. Inputs for carrying out financial analysis based on EIL's requirement.

Chapter 5.0
PROJECT LOCATION AND PLOT PLAN STUDIES

5.0 Project Location and Plot Plan Studies

5.1 Project Location

Details of plant location are as given below.

Site Location Distance

- Plant Location: Numaligarh
- State: Assam
- Nearest Important Town : Golaghat 28 KMs
- Nearest Railway: Numaligarh Station 09 KMs
- Nearest Port: Haldia (West Bengal) 1445 KMs
- Nearest Airport: Jorhat 70 KMs
- Nearest National Highway: NH – 39

Source of Water: - River water (treatment at refinery site) River Dhansiri
- Recycled Treated Effluent Water

Rainy season (Monsoon) : Jun to Aug

Annual Rainfall: 1898.8 MM

5.2 Plot Plan Studies

A detailed study of the existing Plot plan of the NRL Refinery were carried out as part of the Plot Plan studies, keeping in view to meet all statutory norms, OISD guidelines, existing Pipe Rack locations, necessary space requirements for approach, Crane movements, minimum utilization of Greenfield area and other strategic advantages.

The major thrust has been provided on

- Lowering the CAPEX/OPEX.
- Constructability issue
- Optimum utilization of Brownfield area

Studies have been carried out based on information available on as built NRL plot plan superimposing the under new units covered in the TEFR study.

5.2.1 Analysis of the study:

It is proposed completely convert currently produce Euro III HSD to Euro IV & part Euro V HSD at Numaligarh. The plot is to be located within the existing refinery complex of NRL. This would provide the advantage of infrastructure already existing in the refinery for the proposed project.

5.2.2 Overall Plot Plan

- The project is envisaged to be located on a plot of land around **5.6 hectares** area. The Plot Plan prepared is showing all proposed Units, Utilities & Offsites. Refer enclosed Plot Plan No. A195-000-16-47-0001, Rev.0

- The new facilities proposed under the project have been located keeping in view the process sequence, safety & operation requirements & space available & need for future expansion.
- All the proposed facilities are laid out in accordance with safety distances as per OISD:118 and Petroleum Rules 2002 of PESO, Nagpur.

5.2.3 New Units

- DHDT Unit
- HGU Unit
- Sulphur Block

5.2.4 Utilities

- Cooling Water System: A new Cooling Tower of two cells will be provided east of DM Plant in this project.
- Satellite Rack Room: 2 new 2 SRR buildings of size (40x20m & 40x15m) will be provided for proposed units.
- Sub-Station: A new Sub-Station (50m X 25m) will be provided south of Proposed DHDT Unit.
- GEG - Gas Engine generator (48m X25m) with a new Utility Boiler.

5.2.5 Plot Area Requirement

Plot areas required for Unit/facilities envisaged in E-IV HSD Project are as under

- DHDT Unit	140M x 130M
- HGU Unit	60M x 50M
- Sulphur Block	75M x 40M
- Satellite Rack Room 1	40M x 15M
- Satellite Rack Room 2	40M x 20M
- Sub-Station	50M x 25M
- Cooling Tower	35M x 16M (aprox.)
- Utility Boiler	40M x 22M
- GEG	48m x 25m

Chapter 6.0
PROJECT DESCRIPTION

6.0 Project Description

6.1 Description of Existing Facilities

The existing Refinery has the capacity to refine 3.0 MMTPA of Assam Mix Crude. The Refinery is primarily designed to process 100% Assam mix crude.

The product slate of the refinery consists of Regular Gasoline meeting Euro-III and Euro-IV specifications, ATF, kerosene, and Diesel fuels meeting Euro-III and part Euro-IV specifications.

The existing Refinery configuration also has a Delayed Coker Unit which produces petroleum coke, a solid by-product that is sold as a fuel.

Sulphur is also a product from the Oxygen Enrichment process based Sulphur recovery unit.

The major Processing units in the Existing refinery include Crude and Vacuum Distillation Unit, a Delayed Coking Unit, a Hydrocracker unit, a Coke Calcinations Unit, a Naphtha Hydro treating Unit, a Naphtha Splitter Unit, a Semi Regenerative Reforming Unit and an Isomerization Unit.

Supporting process units include a Fuel gas treating unit, a Sulfur Recovery unit, an Amine Regeneration Unit and a Sour Water Stripper. Hydrogen for the above units is generated in a Hydrogen generation unit.

A wax unit and a new Naphtha Splitter unit (NSU) have been added to the refinery post DQUP project.

Each of these process units consists of a number of distinct components such as distillation columns, reactors, fired heaters, heat exchangers, pumps, and compressors to achieve specific refining objectives

The list of existing units along with current capacity & respective licensor is as per Table 6.1.1.1 below

6.1.1 Unit Facilities

The unit capacities for the existing Units which considered for the feasibility study are based on the following:

Table 6.1.1.1: Existing Unit capacity

UNIT	Design Capacity	Licensor
CDU/VDU	3.0 MMTPA	EIL
NHT	271 KTPA	Axens
NSU	160 KTPA	Axens
SRR	168 KTPA	Axens

UNIT	Design Capacity	Licensor
ISOM	55.5 KTPA	Axens
HCU	1.45 MMTPA	Chevron
DCU	0.306 MMTPA	EIL
CCU	0.115 MMTPA	EIL
HGU	48600 TPA	HALDOR TOPSOE
SRU	19.3 TPD	EIL
SWS	20.3 m3/hr	EIL
ARU	23.2 TPH	EIL
FGSU	6.514 TPH	EIL
NEW NSU	160 KTPA	EIL
WAX PLANT	50000 TPA	EIL & Axens

6.1.2 Existing Refinery Feed and Product slate

The feed and product slate for the existing 3 MMTPA refinery for the Design crude case is tabulated below

Table 6.1.2.1: Existing Feed for the Refinery

FEED	CAPACITY
ASSAM MIX CRUDE	3 MMTPA

The Light ends Product slate for the existing Refinery configuration as given by NRL is given in the Table 6,1.2.2

Table 6.1.2.2: Present Product slate

S NO.	Product	Present Product slate (MTPA)
1.	Liquefied Petroleum Gas (LPG)	103700
2.	Naphtha Domestic sales	192700
3.	Petrochemical Naphtha Export	160000
4.	Regular Gasoline (Euro III) Domestic	172670
5.	Regular Gasoline (Euro IV) Domestic	48000
6.	ATF Domestic	60000
7.	Kerosene Domestic	492300
8.	Diesel, (Euro III) Domestic	1566700
9.	Diesel, (Euro IV) Domestic	-
10.	Diesel, (Euro V) Domestic	-
11.	Sulfur	4500
12.	Coke	85333
13.	Wax	50000

6.2 Project Configuration

The cases for the DFR were defined based on the actual desired product slate and various processing options that can be used to meet the project objective.

The Objective is to convert all the EURO III grade HSD produced in the refinery to EURO IV grade HSD and part EURO V grade HSD.

6.2.1 Considerations for the Configuration Study:

A Diesel Hydrotreater was considered as secondary Processing option to arrive at the most optimum Refinery configuration.

Secondary Processing options:

1. Diesel Hydrotreater (DHT)

Based on various options available and the given conditions, following cases were identified for analysis. These cases have been studied for the design case crude.

Case 0: Existing Refinery as the Base Case
Case A: Existing Refinery with a New DHT

Based on the model runs Case A, the case with a new DHT was found to be the optimum case, capable to meet the objective of making Complete Euro-IV grade HSD & part EURO – V grade HSD.

Case A was further studied in detail, for optimum product slate and revenue margins.

6.2.2 Existing Refinery Configuration:

The existing Refinery configuration considered for the Study is as follows:

a. Crude & Vacuum Distillation unit : 3 MMTPA
b. Hydrocracker Unit : 1.45 MMTPA
c. Delayed Coker unit : 0.306 MMTPA
d. Naphtha Hydrotreater unit : 271 KTPA
e. Isomeriation unit : 55 KTPA
f. Semi regenerative reformer unit : 168 KTPA
g. New SRN Splitter Unit : 51 KTPA
h. New HCU LN Naphtha Splitter : 152 KTPA
i. NSU Stabilizer : 87 KTPA

6.3 Various Technology Options considered for the Configuration Study:

Description of Various cases under Case A in the PFR Stage.

Case A1: Production of Euro-IV and Euro-V HSD as per the agreed Design Basis, DHT 10 PPM Sulphur
Case A2: Production of Euro-IV and Euro-V HSD with direct LGO blending into diesel pool. DHT 10 PPM Sulphur.
Case A3: Production of Complete Euro-IV (with LGO direct blending and ATF limited to 105000 TPA). DHT 10 PPM Sulphur.

Case A4: Production of Complete Euro-IV (without LGO direct blending, Maximizing ATF production and with minimum DHT capacity. DHT 10 PPM Sulphur.

Case A5: Production of Complete Euro-IV (without LGO direct blending and HSD limited to 146652 TPA). New DHT considered for 40 PPM Sulphur.

6.3.1 Optimum Case finalized for the DFR:

The optimum case was finalized based on the findings of the Prefeasibility study carried out by EIL.

Case A1: Production of Euro-IV and Euro-V HSD as per the agreed Design Basis

6.3.2 Base Case: Existing refinery as Base Case:

The base case model runs was carried out to match the given Product slate and the agreed Design Basis. The case was run considering the existing Process unit yields & properties as per the data provided by NRL. The properties of the streams were based on the Test Run Data and the Package data as given by NRL.

The base case was to be finalised in order to work out the increment in Revenue generation through Euro-IV / Euro-V Sales with DHT Case. The comparative product slate will be the basis for Revenue estimates.

The properties of the various feed & product streams based on the Test Runs and Data from the Process packages were compared and moderated to obtain the correct estimates.

The Product pattern generated based on the Model Runs are as tabulated below:

PRODUCT SALES	Base case with Crude unit LGO Sulphur 1600 ppm & Kero Sulphur 500 ppm
	KTPA
MIXED LPG'S	103.7
NAPHTHA SALES	192.7
NAPHTHA PETCHEM	160
EURO III REGULAR GAS	172.7
EURO IV REGULAR GASO	48
KEROSENE	492.3
AVIATIONTURBINEFUEL	60
EURO III DIESEL	1566.7
EURO IV DIESEL	0
SULFUR	4.5
COKE PRODUCT	85.4
WAX PRODUCT	50

As per the NRL assay data the Sulfur in the Straight Run Gas oil (LGO) varies in the range of 1400 – 1500 ppm. PGTR data gives Sulfur content of 1525 ppm. The base case for Euro-IV HSD Model was finalised with 1600 ppm sulphur in the LGO Cut.

The base case LP Model Runs were made to match the product slate as in the existing Refinery and also considering the new NSU & WAX units under implementation.

In the above cases, the current Euro--IV diesel production could not be achieved due to high sulfur in the LGO cut. No blending of Oxygenates was considered in the products for any improvement in the product slate.

Based on the above analysis it was apparent that with the given Product properties and the existing capacities it is not possible to make Euro-IV Diesel. Considering that there is no additive blending Euro-III regular gasoline make is only 171000 MTPA. Balance gets dumped into the Naphtha Sales pool.

In addition to the properties, the following were considered to form the Base Case :

a. Wax Unit processing has been considered in the Model.
b. NSU Material Balance as in the existing Process Package
c. Properties as discussed and finalized with NRL as detailed in section –
d. Hydrogen Plant is based on Natural Gas feed.
e. Hydrocracker Unit capacity is 1.45 MMTPA. Make up of Feed is with Straight Run LGO.

6.3.3 Findings of Various Cases studied

Case A1:

CDU, HCU, DCU & MS Block processing at the design capacity. The new NSU and WAX units are also considered. No revamp is considered in these units. A new DHT unit to produce 10ppm Ultra Low Sulphur product of 1.0 MMTPA is considered in this case. Natural Gas has been considered as feed to Hydrogen plant.

Objective of the case is to meet the design Basis product slate ; i.e Up gradation of complete Euro-III HSD to Euro-IV HSD and produce maximum 360 KTPA of Euro-V HSD.

Product slate for Case A1 is given in the following Table: 6.3.5.1

Findings:

Euro-III completely upgraded to Euro-IV HSD and the desired objective is met. Target production of 360 KTPA Euro-V HSD is also achieved.

Total Euro-IV HSD produced is 1582 KTPA. DHT Naphtha could not blended into the Gasoline pool due to limiting RON and aromatics. Total unutilized Naphtha from the refinery stands at 239 KTPA.

Case A2:

CDU, HCU, DCU & MS Block processing at the design capacity. The new NSU and WAX units are also considered. No revamp is considered in these units. A new DHT unit to produce 10ppm Ultra Low Sulphur product of 0.776 MMTPA is considered in this case. Natural Gas has been considered as feed to Hydrogen plant.

Objective of the case is to meet the design Basis product slate ; i.e Upgradation of complete Euro-III HSD to Euro-IV HSD and produce maximum 360 KTPA of Euro-V HSD. Direct Blending of LGO into the HSD pool is considered to the extent possible to minimize the DHT capacity.

Findings:

Euro-III completely upgraded to Euro-IV HSD and the desired objective is met. Target production of 360 KTPA Euro-V HSD is also achieved.

DHT Naphtha could not routed to the Gasoline pool due to limiting RON and aromatics. Total unutilized Naphtha from the refinery stands at 230 KTPA. DHT capacity was lowered from 0.845 MMTPA to 0.776 MMTPA.

Product slate for Case A2 is given in the following Table: 6.3.5.1

Case A3:

CDU, HCU, DCU & MS Block processing at the design capacity. The new NSU and WAX units are also considered. No revamp is considered in these units. A new DHT unit to produce 10ppm Ultra Low Sulphur product of 0.754 MMTPA is considered in this case. Natural Gas has been considered as feed to Hydrogen plant.

Objective of the case is to meet the Production of complete Euro- IV HSD and limiting ATF production to 105 KTPA. Direct Blending of LGO into the HSD pool is considered to the extent possible to minimize the DHT capacity.

Findings:

Euro-III completely upgraded to Euro-IV HSD and the desired objective is met. Maximum production of Euro-IV HSD is 1952.7 KTPA.

DHT Naphtha could not routed to the Gasoline pool due to limiting RON and aromatics. Total unutilized Naphtha from the refinery stands at 228 KTPA. DHT capacity was further lowered from 0.776 MMTPA to 0.754 MMTPA.

Product slate for Case A3 is given in the following Table: 6.3.5.1

Case A4:

CDU, HCU, DCU & MS Block processing at the design capacity. The new NSU and WAX units are also considered. No revamp is considered in these units. A new DHT unit to produce 10ppm Ultra Low Sulphur product of 0.551 MMTPA is considered in this case. Natural Gas has been considered as feed to Hydrogen plant.

Objective of the case is to Production of complete Euro- IV HSD and maximizing ATF production. No Direct Blending of LGO into the HSD pool is considered.

Findings:

Euro-III completely upgraded to Euro-IV HSD and the desired objective is met. Maximum production of Euro-IV HSD is 1592 KTPA.

Maximum ATF production in this case is 494 KTPA. DHT Naphtha could not routed to the Gasoline pool due to limiting RON and aromatics. Total unutilized Naphtha from the refinery was reduced to 201 KTPA. DHT capacity was further lowered from 0.776 MMTPA to 0.551 MMTPA.

Product slate for Case A4 is given in the following Table: 6.3.5.1

Case A5:

CDU, HCU, DCU & MS Block processing at the design capacity. The new NSU and WAX units are also considered. No revamp is considered in these units. A new DHT unit to produce 40ppm Sulphur Diesel product of 0.551 MMTPA is considered in this case. Natural Gas has been considered as feed to Hydrogen plant.

Objective of the case is to Production of complete Euro- IV HSD and maximizing ATF production. No Direct Blending of LGO into the HSD pool is considered.

Findings:

Euro-III completely upgraded to Euro-IV HSD and the desired objective is met. Maximum production of Euro-IV HSD is 1467 KTPA.

Maximum ATF production in this case is 621 KTPA. DHT Naphtha could not routed to the Gasoline pool due to limiting RON and aromatics. Total unutilized Naphtha from the refinery was reduced to 202 KTPA. DHT capacity was further lowered from 0.551 MMTPA to 0.548 MMTPA.

Product slate for Case A5 is given in the following Table: 6.3.5.1

A Summary of comparison with respect to the Feed, Product & Plant Capacities is tabulated in the following tables. Selection of the final case was done based on the analysis of these summary sheets.

The project cost estimates and Utility requirements were worked out for the finalised case of the various options.

6.3.4 Feed stock purchases

The feedstock purchase for each case is summarized in the table below.

Table 6.3.4.1: Feed Purchases, KTPA

FEED	CASE A1	CASE A2	CASE A3	CASE A4	CASE A5
ASSAM MIX CRUDE	3000	3000	3000	3000	3000

6.3.5 Product Sales

The Product slate for each case studied is summarized in the table below:

Table 6.3.5.1: Product sales, KTPA

PRODUCT SLATE	CASE A1	CASE A2	CASE A3	CASE A4	CASE A5
LPG	104	104	104	104	104
NAPHTHA SALES	239	230	228	201	202.4
NAPHTHA PETROCHEM	160	160	160	160	160
EURO-III GASOLINE (REGULAR)	172.7	172.7	172.7	172.7	172.7
EURO-IV GASOLINE (REGULAR)	48	48	48	48	48
ATF	105	105	105	494	621
KEROSENE	48	48	48	48	48
HSD EURO-IV	1582	1591.4	1952.7	1591.7	1466.7
HSD EURO-V	360	360	0	0	0
SULFUR	21.22 TPD	21.22 TPD	21.22 TPD	21.22 TPD	21.22 TPD
COKE	85.33	85.33	85.33	85.33	85.33
WAX	50	50	50	50	50

6.3.6 Unit Capacities

The unit capacities for each case considered in the Study are summarized in the table below.

Table 6.3.6.1 : Unit Capacities

			UNIT CAPACITIES(MMTPA)				
CASE			Case A1	Case A2	Case A3	Case A4	Case A5
S No.	Unit Name	UNITS					
1	CDU/VDU	MMTPA	3	3	3	3	3
2	NHT	MMTPA	0.27	0.27	0.27	0.27	0.27
3	NSU	MMTPA	0.16	0.16	0.16	0.16	0.16
4	SRR	MMTPA	0.168	0.168	0.168	0.168	0.168
5	ISOM	MMTPA	0.0555	0.0555	0.0555	0.0555	0.0555
6	HCU	MMTPA	1.45	1.45	1.45	1.45	1.45
7	DCU	MMTPA	0.306	0.306	0.306	0.306	0.306
8	CCU	MMTPA	0.115	0.115	0.115	0.115	0.115
9	HGU	MMTPA	0.0486	0.0486	0.0486	0.0486	0.0486
10	SRU	TPD	19.3	19.3	19.3	19.3	19.3
11	SWS	M3/hr	20.3	20.3	20.3	20.3	20.3
12	ARU	TPH(RICH AMINE)	26.2	26.2	26.2	26.2	26.2
13	FGSU	TPH	7.92	7.92	7.92	7.92	7.92
14	NEW DHT	MMTPA	0.845	0.775	0.754	0.55	0.548
15	NEW HGU	KTPA	8	8	8	8	8
16	FGSU (NEW)	TPH	6.5	6.5	6.5	6.5	6.5
17	ARU (NEW)	TPH(RICH AMINE)	23.2	23.2	23.2	23.2	23.2
18	SRU (NEW)	TPD	7.5	7.5	7.5	7.5	7.5

6.4 Optimum Case

Case-A1 is considered as the optimum case for the Study. For this case the objective of the configuration to completely upgrade Euro-III HSD to Euro-IV HSD and to produce target of 360 KTPA of Euro-V HSD was achieved.

This case is recommended by NRL for further Utility estimates and Economic Analysis.

6.4.1 Block flow diagram

Refer Annexure: VI

6.5 Modification in the existing units

6.5.1 Process Units

The existing unit which may undergo any modification on a preliminary evaluation is as detailed below:

6.5.1.1 Crude distillation unit & vacuum distillation unit (CDU/VDU):

Since the Crude Processing Capacity is the same as in the existing refinery i.e. 3 MMTPA, no revamp is envisaged in the Crude Distillation and Vacuum Distillation units.

Conclusion: 3 MMTPA crude throughput is achievable without any hardware modifications in the critical equipment.

6.5.1.2 MS block units:

No change in Gasoline Product pool was required and hence no modification is envisaged in the existing MS block.

Conclusion: No modification in MS Block.

6.5.1.3 Hydrocracker unit (HCU)

Hydrocracker unit is considered to be operating at its full capacity. Short fall in the Feed stock to the HCU unit can be made with LGO makeup. Short fall can be due to MVGO routing as feed streams to new WAX units.

Conclusion: No major modification is expected in the HCU unit. .

6.5.1.4 Delayed Coker unit (DCU)

Since the Crude Processing Capacity is the same as in the existing refinery i.e. 3 MMTPA, no revamp is envisaged in the Delayed Coker unit.

Conclusion: No modifications required in DCU unit.

6.5.1.5 Coke Calcination unit (CCU)

Since no change is envisaged in the Coke Production, there will not be any impact on the Coke Calcination unit.
Conclusion: No modification envisaged in Calcination unit.

6.5.1.6 Hydrogen generation unit (HGU)

Based on the hydrogen balance worked out, no capacity augmentation is required in the existing capacity. As per Case A1 the total Hydrogen requirement for the refinery post DHDT is estimated around 46600 TPA. The existing HGU design capacity is 48600 TPA.

As per NRL, though the present HGU capacity is 48600 TPA, the unit has not been able to achieve the rated capacity. The maximum throughput achieved so far in the existing HGU is 42100 TPA owing to limitation in some of the critical equipments of the HGU.

Therefore based on NRL's recommendation, a separate Hydrogen Plant for new DHDT has been considered.

The capacity of the New Hydrogen plant has been considered as 8000 TPA. Natural Gas has been considered as feed for both Existing and New Hydrogen Plants as recommended by NRL.

6.5.1.7 Sulphur recovery unit (SRU)

Installed SRU capacity is 19.3 TPD. The additional capacity increase of about 68% can be achieved by implementation of new SRU train.

Conclusions: Existing unit with O2 enrichment facility will be inadequate for higher throughput. So a new SRU train of 7.5 TPD capacity has been considered.

6.5.1.8 Sour water stripping unit (SWS)

Increase in Sour Water generation is to the extent of 91% capacity of the installed capacity. This will be achieved by installing a new Sour water stripper unit.

Conclusion: Existing Sour Water Strippers with built-in overdesign margins are inadequate for higher throughput. So a new SWS unit of the same capacity has been considered.

6.5.2 Treating units

6.5.2.1 Fuel Gas Treating Unit (FGTU)

Existing FGSU unit capacity is 7.92 TPH.

Conclusion: Existing Fuel gas sweetening unit with built-in overdesign margins is inadequate for higher throughput. So a new FGSU unit of the same is to be installed.

6.5.2.2 Amine Regeneration Unit (ARU)

Existing ARU capacity is 26.8 TPH

Conclusion: Existing Amine Regeneration unit with built-in overdesign margins is inadequate for higher throughput. So a new ARU unit of the same capacity is to be installed.

6.6 Process Description

6.6.1 Diesel Hydrotreating unit: Refer Annexure – I for PFD.

Reaction section

The feed to the Hydrotreating unit is a blend of straight run gasoil and kerosene. The blend is filtered in automatic backwash Feed Filter 100-T1.

Then the feed is sent to the Feed Surge Drum 100-C1 where it is pumped to the reaction heat exchanger train by Feed Pumps 100-G1 A/B under flow control. The drum pressure is maintained by split range control of nitrogen flow and venting to flare. Antifouling agent is injected at the suction of 100-G1 A/B.

The feed is mixed with a mix of recycle gas and hydrogen make-up gas. The mixture is heated against the reactor effluent in the following way: first in 100-E1 A/B/C/D/E/F and then in 100-E2. A part of the feed can by-pass the exchangers 100-E1 A/B/C/D/E/F and 100-E2 before mixing with the mix of gas in order to adjust the temperature at the heater inlet (to ensure a sufficient duty in the heater for control purposes).

Finally the Reactor Heater 100-F1 is used to adjust the inlet temperature of the reactor to the required value.
The reactor inlet temperature is controlled by acting on fuel gas / fuel oil pressure to the heater burners.

Inside the Reactor 100-R1, the following reactions take place: olefins saturation, desulfurization, denitrogenation and aromatics saturation reactions.

The reactor contains 3 catalytic beds.

As these reactions are highly exothermic and in order to operate the catalyst beds in an optimized temperature range, an injection of cold quench is foreseen between the first and the second beds and the second and the third beds. These injections are performed under flow control reset respectively by the second and the third catalyst bed inlet temperature controller. Equiflow^{TM} mixing trays in 100-R1 ensure a good mixing between quench gas and bed effluents. Equiflow^{TM} distributor trays ensure a good liquid and gas distribution within the catalyst beds of the reactor.

At the outlet of the reactor, the effluent is used to preheat the reactor feed in 100-E2 and 100-E1 A/B/C/D/E/F exchangers. The reactor effluent stream is also preheating the stripper feed in the Reactor Effluent / Stripper Feed Exchangers 100-E3 A/B which is located between 100-E2 and 100-E1 A/B/C/D/E/F.

The effluent is then cooled and partially condensed in the Reactor Effluent Air Cooler 100-E4.
To avoid ammonium salt deposits and risk of corrosion in 100-E4, water is injected at the inlet of the air cooler via Washing Water Pumps 100-G2 A/B. Wash water is a mixture of water from Stripper Reflux Drum 100-C12, Coalescer 100-C22, Stabilizer Reflux Drum 100-C21 and stripped sour water from a sour water stripper unit. The mixture is collected in the Washing Water Drum 100-C6. The drum pressure is maintained by split range control of Fuel gas flow and venting to flare. BFW can also be injected into the washing water drum in case of shutdown of the sour water stripper unit or if the flow from this unit is not sufficient. From this drum the wash water is pumped by the Washing Water Pumps 100-G2 A/B under flow control for injection in the reactor effluent.

The effluent after being cooled down in the Reactor Effluent Air Cooler 100-E4 is collected in the HP Separator 100-C3 where three phases are separated. Pressure of the HP Separator 100-C3, which dictates hydrogen partial pressure at the outlet of the HDS Reactor 100-R1, is controlled by acting first on the spill back control valve of the H_2 Make-up Compressors 100-K1 A/B and second on the HP purge valve located on the overhead line of the HP Amine Absorber 100-C8.

The gas from the HP separator 100-C3 is first routed to the HP Amine Absorber KO Drum 100-C7 and then to the HP Amine Absorber 100-C8 where H_2S is removed by MDEA solution.
Rich amine from the HP Amine Absorber is withdrawn under level control to the LP Amine Absorber 100-C16 in order to increase H2/hydrocarbon recovery.
The sweetened recycle gas is routed to the Recycle Compressor KO Drum 100-C9 and then is compressed in the centrifugal Recycle Compressor 100-K2. This recycle gas is sent to the following destinations:

- quench gas to control the inlet temperature of the second and the third bed (2 different streams).
- recycle gas first mixed with hydrogen make-up and then with the fresh feed upstream 100-E1 A/B/C/D/E/F.

The recycle compressor is driven by a steam turbine.

The hydrogen make-up comes from H2 units and is routed to the Make-up Compressors 1st stage KO Drum 100-C4 and then compressed into the first stage of the alternative Make-up Compressors 100-K1 A/B. At the inter-stage, the gas is routed to the Make-up Compressors Inter-stage Cooler 100-E5 A/B and to the Make-up Compressors 2nd Stage KO Drum 100-C5 A/B. Compressed make-up gas from the second stage of 100-K1 A/B is then mixed with the recycle gas.
The sour water coming from HP Separator 100-C3 is removed under level control, mixed with a part of the water from the Stripper Reflux Drum 100-C12 and routed to the Water Degasser Drum 100-C10. The sour water from 100-C10 is routed to sour water stripper unit under flow control reset by level control and the gas is routed to LP Amine Absorber KO Drum 100-C15 under pressure control.
A part of the hydrocarbon liquid phase from HP Separator (about 15 %wt in normal operation) by-passes the Power Recovery Turbine 100-PRT1 and controls the level of the HP Separator. The other part of the liquid (85 %wt) is routed to a power recovery turbine 100-PRT1 under cascade level/flow control. That means that the flow to the turbine has to be constant but if the control of the level in HP separator is no more possible with the by-pass line, the level controller will reset the set point of the flow controller. Then the 2 parts are mixed and are routed to the stripping section.

Stripping and Drying section

Stripper feed contains H_2S which has to be removed. The hydrocarbon liquid phase from HP Separator 100-C3 is preheated first in the Stripper Feed / Dryer Bottom Exchanger 100-E12, then in the Stripper Feed / Bottom Exchangers 100-E8 A/B/C/D/E and finally in the Reactor Effluent / Stripper Feed Exchanger 100-E3 A/B. Stripper 100-C11 feed inlet temperature is controlled acting on opposite range over the exchanger 100-E3 bypass.
Stripping is ensured by injection of medium pressure steam at the bottom of the column. The steam is first superheated in the convection section of the Reactor Heater 100-F1.
An injection of corrosion inhibitor is provided at the Stripper overhead. The overhead vapor is partially condensed in the Stripper Overhead Air Condenser 100-E6 and in the Stripper Overhead Trim Condenser 100-E7 and then collected in the Stripper Reflux Drum 100-C12.

A part of the condenser liquid hydrocarbon is used as a reflux to the Stripper 100-C11. Flow control of this stream is reset by overhead temperature. The remaining part is sent under flow control reset by reflux drum level control to naphtha stabilizer section.

A part of the sour water from the Stripper Reflux Drum is sent under flow control to the Washing Water Drum 100-C6. The other part is pumped by Stripper Sour Water Pumps 100-G10 A/B to the Water Degasser Drum 100-C10.
Sour gas coming out from the Stripper Reflux Drum is routed to the LP Amine Absorber to be washed.

The stripper bottom is cooled against the stripper feed in 100-E8 A/B/C/D/E and routed to the Coalescer 100-C22. The decanted water from the Coalescer is routed to Washing Water Drum under level control and the liquid hydrocarbon enters in the Vacuum Dryer 100-C13 under flow control reset by level control. The dryer overhead temperature is controlled acting on opposite range over the bypass line of the Stripper Feed / Bottoms Exchangers 100-E8 A/B/C/D/E.

The overhead vapor is sent to the Vacuum Package 100-H1. Vapor is cooled in the Dryer Overhead Precondenser 100-C14 before entering into the vacuum package. The steam condensed in the vacuum package and the entrained hydrocarbons are collected in the Dryer Overhead Receiver 100-C14 where the two liquid phases are separated.

Liquid hydrocarbon phase is pumped by 100-G6 A/B under level control and is recycled back to the Vacuum Dryer 100-C13 inlet. It can also be routed to the inlet of Stripper Feed / Dryer Bottom exchanger 100-E12 (tube side).

The water is pumped by 100-G7 A/B under level control and routed to the Effluent Treatment Plant. It can contain some traces of hydrocarbon.
The uncondensables from the Vacuum Package 100-H1 are sent through the Dryer Seal Pot 100-C24 and then to the Reactor Heater 100-F1. In case of shutdown of the heater, the uncondensables are sent to the atmosphere at safe location.
The bottom of the Vacuum Dryer (the hydrotreated diesel) is pumped by the Diesel Product Pumps 100-G5 A/B and is used to preheat the stripper feed in the 100-E12 exchanger. Before being sent to storage under flow control reset by level control, it is cooled down first in the Diesel Product Air Cooler 100-E13 and afterwards in the Diesel Product Trim Cooler 100-E14.

Lean amine and LP Amine Absorber section

Lean MDEA is coming from Amine Regeneration Unit. A part of the lean amine is preheated in the Lean Amine Preheater 100-E20 and routed to Lean Amine Surge Drum before being pumped by Lean Amine HP Pumps 100-G3 A/B and sent to HP Amine Absorber 100-C8.

A minimum differential temperature between the recycle gas and the lean amine of 10deg.C is necessary in order to ensure absorption and to avoid any foaming in the HP absorber.

Sour gases from Stripper, Naphtha Stabilizer, Water Degasser Drum and NHDT unit are sent to the LP Amine Absorber KO Drum 100-C15 to avoid foaming in the absorber in case of condensate. Rich amine from the bottom of 100-C8 is flashed in the bottom of the LP Amine Absorber 100-C16.

The differential temperature between the sour gas and the lean amine is controlled by acting on the flow of LP steam sent to Lean Amine Preheater 100-E20.

To ensure absorption and to avoid any foaming in the LP Amine Absorber, the differential temperature between the sour gas and the lean amine is controlled acting under opposite range control over the by-pass of the Lean Amine Preheater 100-E20. The target is to maintain a minimum difference of 10deg.C between the sour gas and the lean amine.
The preheated LP lean amine is sent to the LP Amine Absorber 100-C16 under flow control.
Independent antifoaming injections are provided at the suction of 100-G3 A/B and at the top of the LP Amine absorber 100-C16. These injections shall be used only if foaming occurs in Amine Absorbers.
Rich MDEA solution is withdrawn under level control from the bottom of the LP Amine Absorber and sent to the Amine Regeneration Unit.

Vapor from LP Amine Absorber is mixed with gas from Isomerisation Unit and routed to Off-gas Compressor KO Drum 100-C18 before being compressed into the first stage of the alternative Off-gas Compressors 100-K3 A/B. The inter-stage gas is partially condensed in the Off-gas

Compressors Inter-stage Cooler 100-E21 A/B and to the Off-gas Compressors 2nd Stage KO Drum 100-C2. Compressed gas from the second stage of 100-K3 A/B is then cooled in Off-gas Trim Cooler 100-E15 and routed to Off-gas KO Drum 100-C19 before being sent either to PSA Unit in normal operation or to Fuel Gas during stabilisation of the Off-gas Compressors.

Condensed liquid from 100-C2 and 100-C19 are routed under level control to Naphtha Stabilizer section.

Naphtha Stabilizer section

The mixing of naphtha from Stripper and condensed liquid from Off-gas Compressors section is heated in Stabilizer Feed/Bottom Exchangers 100-E16 A/B and then feeds the Naphtha Stabilizer 100-C20 where H_2S is removed.
An injection of corrosion inhibitor is provided at the Naphtha Stabilizer overhead. The overhead vapor is partially condensed in the Stabilizer Overhead Trim Condenser 100-E18 and then collected in the Stabilizer Reflux Drum 100-C21.
The sour gas flow from 100-C21 is sent to LP Amine Absorber KO Drum and controls the stabilizer overhead pressure. The liquid hydrocarbon (total reflux) of 100-C21 is pumped by Stabilizer Reflux Pumps 100-G8 A/B under flow control reset by reflux drum level control to Naphtha Stabilizer 100-C20. The water from 100-C21 is routed under on/off level control to Washing Water Drum 100-C6.
A part of the stabilizer bottom liquid is heated by HP steam in Stabilizer Reboiler 100-E17.
The other part of the bottom liquid is pumped by Naphtha Product / Recycle Pumps 100-G9 A/B and routed to Stabilizer Feed / Bottom Exchangers 100-E16 A/B. The stabilized naphtha is then cooled through Stabilized Naphtha Trim Cooler 100-E19 before being sent to storage under flow control reset by stabilizer level control.
A stabilized naphtha recycle line under flow control is also provided from 100-G9 A/B to the inlet of Naphtha Stabilizer.

6.7 Material Balance

6.7.1 Overall Material Balance for the Optimum Configuration

Table 6.7.1.1: Overall Material Balance for DHT

Sl. No.	Feed Streams / Product Streams	Shortlisted case A1 (KTPA)
Feed Streams		
1	CDU Kerosene	594
2	CDU light gas oil	251
3	Hydrogen	7.68
	TOTAL	**852.68**
Product Streams		
1	H2S	4.67
2	Off Gas	4
3	DHT Naphtha	42.34
4	DHT Diesel	801.67
	TOTAL	**852.68**

6.8 Catalyst and chemicals summary:

6.8.1 Estimated Catalyst quantity:

Unit Name	Estimated Quantity
DHT	
Ceramic inert balls ¾”	6.723 tons
Ceramic inert balls ¼”	10.470 tons
Guard bed 1	1.606 tons
Guard bed 2	1.003 tons
Guard bed 3	2.919 tons
Guard bed 4	7.416 tons
DHT catalyst	229.65 tons
SRU	
SRU reactor catalyst	6 tons
Hydrogen generation unit	
Hydrogen unit reformer catalyst	8.76 m3
Hydrogen unit catalyst	4.49 m3
1” ceramic balls	2.18 m3

The quantity estimated is based on proration of Inhouse data for catalysts in DHT, SRU and HGU Units.

6.8.2 Estimated quantity of chemicals consumed:

Unit Name	Estimated Quantity
DHT	
Corrosion inhibitor	6 tons/annum
DMDS	39 tons/annum
Antifoam agent	3 tons/annum
Antifoul agent	72 tons/annum
Fuel gas sweetening unit	
Lean amine 25wt% solution	15 tons
Amine regeneration unit	
Antifoam injection	15 kg/year
Combination knotol	200 kg/annum

The quantity estimated is based on proration of In house data for chemicals in DHT, FGU and ARU Units.

6.9 Hydrogen & sulphur balance

6.9.1 Hydrogen Balance

Based on the evaluation of cases, Case A1 which is for Production of Euro-IV and part Euro-V HSD has been selected as the optimum case for DFR. The Hydrogen balance has been worked out for this case A1.

The hydrogen plant in the existing refinery is being met, based on Naphtha Feedstock. For the Euro-IV HSD study, Hydrogen requirement of the complex will be met by processing imported natural gas into the Hydrogen generation unit.

6.9.1.1 Hydrogen Quality

Hydrogen generated from the Hydrogen Generation Unit shall meet the following specifications.

Table 6.9.1.1.1 Hydrogen specifications

SNo.	Parameter	
1.	Hydrogen purity, vol %	99.9 minimum
2.	$CO + CO_2$,	15 ppm v, max
3.	Nitrogen,	80 ppm v, max
4.	Water,	50 ppm v,max
5.	Chlorine + chlorides,	1 ppm v, max
6.	Methane, vol %	Balance

The Hydrogen Balance has been worked out to arrive at the Capacity of the New Hydrogen Plant.

Table 6.9.1.1.2 Hydrogen Balance

	BASE CASE		Case A 1	
Process Units with Hydrogen requirement	H2 makeup		H2 makeup	
Hydrogen consumed	TPD	KTPA	TPD	TPA
HCU	115	38333	115	38333
NHT	1	333	1	333
ISOM	1	333	1	333
DHT			24	8000
TOTAL	117	39000	141	47000
Hydrogen produced				
CRU rich off gas (5	29	9667	29	9667
HCU CLPS Gas	24	8000	24	8000
Balance on NG	63	21000	87	29000
	116	38667	140	46667

The hydrogen requirement has been compared for two cases of the study, Base case and case A1. The unit wise hydrogen requirement in KTPA is based on the refinery capacity of 3 MMTPA.

Based on the hydrogen balance worked out, no capacity augmentation is required in the existing capacity. As per Case A1 the total Hydrogen requirement for the refinery post DHDT is estimated around 46667 TPA. The existing HGU design capacity is 48600 MTPA.

As per NRL, though the present HGU capacity is 48600 MTPA, the unit has not been able to achieve the rated capacity. The maximum throughput achieved so far in the existing HGU is 42100 TPA owing to limitation in some of the critical equipments of the HGU. Therefore based on NRL's recommendation, a separate Hydrogen Plant for new DHDT has been considered.

The capacity of the New Hydrogen plant has been considered as 8000 TPA

6.9.2 Sulphur balance

The sulphur balance for Case A1 diagram below:

crude S, %wt	0.27	24.3	
crude throughput, MMTPA	3.00	TPD S IN	

Stream	TPA	% YIELD on crude	% WT S in stream	TPD of S
S emmission from FO &FG	90000	3.00		0.4
LPG	104000	3.47	0.000	0.00
NAPHTHA	399000	13.30	0.002	0.02
MS- EURO-III	172670	5.76	0.005	0.03
MS-EURO-IV	48000	1.60	0.003	0.00
ATF	105000	3.50	0.015	0.05
SKO	48000	1.60	0.020	0.03
HSD-BSII(EURO-II)	0	0.00	0.030	0.00
HSD-EURO-V	360000	12.00	0.001	0.01
HSD-EURO-IV	1582000	52.73	0.005	0.21
RPC	85333	2.84	0.900	2.30
TOTAL WITH PRODUCTS	2994003	99.80		3.1
SULPHUR PLANT				21.22

6.9.2.1 Sulphur balance diagram

Sulphur balance for Case A1 has been worked out based on the actual Sulfur in the Feed (Crude Processed) and the distribution of Sulphur in the entire product slate. Refer the Sulphur Balance diagram shown below.

The existing Sulphur recovery unit is already revamped to its maximum achievable capacity, i.e from 14.6 TPD to 20.5 TPD and based on NRL feedback, the present SR unit is already saturated. Hence a new Sulphur Recovery Unit post Euro-IV HSD project is to be considered.

For cost estimates, a New SRU of 7.5 TPD capacity has been considered.

6.10 Utilities Description

The adequacy of the existing Utility systems has been checked for the recommended case A1.

Case A1 is the case with the Existing Refinery configuration with a new DHT unit.

The utility network for all utility systems will have to be modified to include the utility demand worked out for the new DHT unit in the existing network.

Basis of Data for the existing Utility Systems at the Refinery has been considered based on the following information made available during the study:

a. Original Utility Design Package
b. Actual Design values considered in the DQUP Package
c. Utility Design package prepared POST wax.

6.10.1 Steam and Power

The existing Steam and Power generation facilities in the Refinery consist of the following:

- UB : 1 of 45 TPH each (HP Level)
- STG : 1 X 10 MW each (Extraction/condensing type)
- GTG : 2X30 MW
- HRSG : 2X 130 TPH
- PRDS : 2X 130 TPH (HP to MP)
- Gas Engine Generator : 9.1 MW

The unit wise steam and power consumption for 3.0 MMTPA throughput is tabulated in tables 6.3.1.1, 6.3.1.2, & 6.3.1.3.

6.10.1.1 HP Steam Balance:

The actual Minimum continuous demand and generation data was worked out based on the design book data and verified with the present operating trends given by NRL in the Existing refinery.

The table 6.10.1.1 below gives the design values along with the actual values based on the present trends in the refinery given in brackets.

Table-6.10.1.1: Post Euro-IV HSD HP steam balance

Units	Maximum Continuous demand	Minimum Continuous generation
	TPH	TPH
CDU/VDU	-	-
DCU	-	-
HCU	15.8	-
HGU		20
COKE CALCINATION		30
SRU	0.2	
CPP (HRSG)	-	120
UTILITIES	16	40
OFFSITES	-	-
MSP	13.1	-
WAX		-
New DHT	27.1	-
STG	80	
PRDS	79	
LOSS	5.3	
NET TOTAL	236.5	210.0

Based on the feedback from NRL, 120 TPH can be generated in HRSG's with Auxiliary firing.

The net HP steam requirements are calculated based on the Operating trends in the refinery.

Net HP Steam required = 236.5-210 = 26.5 TPH

6.10.1.2 MP Steam Balance

The actual Minimum continuous demand and generation data for MP Steam was worked out based on the design book data and verified with the present operating trends given by NRL in the Existing refinery.

The table 6.10.1.2 below gives the design values for the refinery

Table-6.10.1.2: Post Euro-IV HSD MP steam balance

Units	Maximum Continuous demand	Minimum Continuous generation
	TPH	TPH
CDU/VDU	10.5	-
DCU	5.1	-
HCU	35.5	24.1
HGU	0.7	-
COKE CALCINATION	0.5	-
SRU	5.3	1
CPP		-
UTILITIES	3.5	-
OFFSITES	6	-
NSU	7.9	
MSP	14.8	-
WAX	30	-
New DHT	16.6	-
STG		40
PRDS	24	79
LOSS	7.2	
NET TOTAL	167.6	144.1

Based on the feedback from NRL, 79 TPH can be generated in the PRDS by letting HP steam to MP steam.

The net MP steam requirements are calculated based on the Operating trends in the refinery.

Net MP Steam required = 167.6-144.1= 23.5 TPH

6.10.1.3 LP Steam Balance

The actual Minimum continuous demand and generation data for LP Steam was worked out based on the design book data and verified with the present operating trends given in NRL in the Existing refinery. The table 6.10.1.3 below gives the design values for the refinery

Table-6.10.1.3: Post Euro-IV HSD LP steam balance

Units	Max Continuous demand	Min Continuous generation
	TPH	TPH
CDU/VDU	20	7.5
DCU	1.7	-
HCU	11.5	35
HGU	0.5	
COKE CALCINATION	0.5	
SRU	6	0.5
CPP	4	9
UTILITIES	-	10
OFFSITES	20	3
MSP	0.5	4
ETP	2.5	
WAX	14.5	1.2
PRDS		24
New DHT	3.2	
LOSS	9.4	
NET TOTAL	94.3	94.2

Based on the feedback from NRL, 24 TPH can be generated in the PRDS by letting MP steam to LP steam.

The net LP steam requirements are also calculated based on the Operating data

Net LP Steam required = 94.3 - 94.2 = 0 TPH

6.10.1.4 Total Steam requirement:

Total Steam requirement was worked out based on the present operating trends in the existing refinery.

Total HP steam required=26.5+23.5 = TPH, i.e. around 50 TPH.

The normal HP, MP & LP steam consumption values are expected to be as under

HP Steam : 236.5 TPH
MP Steam : 167.6 TPH
LP Steam : 94.3 TPH
Total Steam : 498.4 TPH

A Utility boiler of 50 TPH has been considered for Cost estimates.

6.10.2 Power Balance

The continuous & intermittent Power demand in the various units has been worked out for the recommended case Case A1 with DHT.

The table 6.10.2.1 below gives the Continuous & intermittent power demand in KW

Table-6.10.2.1 : Estimated Power Consumption (KWH)

Units	Continuous demand	Intermittent demand
CDU/VDU	3030	
DCU	2000	1680
HCU	17100	
HGU	1025	
COKE CALCINATION	607	
SWS 1 + SWS 2	56	
ARU 1 + ARU 2	20	
SRU 1 + SRU 2	130	
UTILITIES	6740	
OFFSITES (post wax)	4200	1000
DISPATCH	1500	
STG	1000	
AIR CONDITIONING	1300	
TOWNSHIP	3000	
WAX (post Wax)	7350	
MS BLOCK	907	
DHDT	6000	
Total	55965	2680

The present Power scenario is met as per the following basis:

Power generation in the existing refinery is adequate to meet the present refinery requirements with the installed 30 MW GTG and 12 MW STG added during POST DQUP.

Installed capacity: 30 MW + 12 MW = 42 MW.
Peak Power requirement: 55.965 + 2.680 = 58.645 MW.
Additional requirement: 58.645 – 42 = 16.645 MW.

The additional Power requirement estimated post WAX project is 9.1 MW.

As confirmed by NRL, the Power requirement for the refinery Post Wax of 9.1 MW is being arranged at NRL an additional "Gas Engine generator". Hence post wax requirement of 9.1 MW shall not be considered for the Euro-IV HSD study.

The Balance power demand for HSD Study is only 16.645 - 9.1 = 7.545 MW

The break up of Power demand in the New units added the Post DHT case is as follows:

ARU: 10 KW
SWS: 28 KW
SRU : 50 KW
UTILITIES: 300 KW
OFFSITES : 1000 KW

The installed Power systems in the existing refinery is inadequate, hence augmentation is required for the refinery.

The additional power requirement shall be made adequate with a Gas engine generator of 8 MW capacity.

6.10.3 Cooling Water System

The existing cooling water facilities are classified into two systems, namely, Process cooling water and new cooling water system.

The existing facilities for these two cooling water systems are as follows:

- Process Cooling Tower : 13125 m3/hr, with 5 cells
- New Cooling tower : 5250 m3/hr with 4 cells

The total installed in the existing refinery totals to be 18375 m3/hr.

The unit wise cooling water demand for the refinery post Euro-IV is tabulated in Table 6.10.3.1 below:

Table-6.10.3.1: Post Euro-IV HSD Cooling water balance

UNIT	Process Cooling tower Max continuous demand	New Cooling tower Max continuous demand
	M3/hr	M3/hr
CDU/VDU	3105	
DCU	675	
HCU	3787	
HGU	700	
NSU	195	
NHT	93	
ISOM	276	
SRR	198	
COKE CALCINATION	50	
CPP	230	
UTILITIES & OFFSITES	1150	
SRU		1017
STG		2600
ADMIN BUILDING		300
WAX		1798
New DHT		500
TOTAL	10459	6215

Conclusions:

The Refinery cooling tower capacity is adequate and no augmentation is required.

The existing Utility cooling tower will have to be augmented with a new cell of 1000 m3/hr and the cooling water circulation pumps will be required for this new cell.

6.10.4 Nitrogen System

Nitrogen is primarily required during catalyst regeneration, purging, blanketing etc.

Adequacy of the existing system post Euro-IV HSD project is calculated on the following Basis.

The existing Cryogenic Nitrogen plant capacity is as follows:
Gaseous Nitrogen : 1200 Nm3/hr
Liquid Nitrogen : 120 Nm3/hr (Gaseous equivalent)

The unit wise Nitrogen demand for the refinery post Euro-IV HSD is tabulated in Table 6.10.4.1 below:

Table-6.10.4.1.: Post Euro-IV HSD Nitrogen balance

UNIT	Normal continuous demand	Max continuous demand	Intermittent demand
	Nm3/hr	Nm3/hr	Nm3/hr
CDU/VDU	40	50	
HCU	80	90	82000
HGU	128	128	
UTILITIES	25	50	
OFFSITES	150	175	
MSP	50	50	
WAX	251	310	
DHDT	205	1135	1800
TOTAL	929	1988	

As per NRL, in the existing facilities, A New Nitrogen (Package) Plant of 600 NM3/hr is under implementation as part of Wax project. This new N2 plant as part of the Wax project will leave an additional 800 Nm3/hr N2 available for future use by NRL.

Excess Nitrogen after utilization in WAX plant is around 300 NM3/hr.

For Euro –IV HSD DFR study , the excess nitrogen requirement is to be considered only for the New DHT unit i.e. 205 Nm3/hr (normal) and peak of 1135 Nm3/hr.

The normal requirement shall be met by the already proposed New Nitrogen Package as part of the Wax project.

Intermittent peak requirement of Nitrogen for HCU unit is 6200 m3/hr, which is being met with the additional 2 vaporizer's provided each of 2750 m3/hr during DQUP stage. Peak requirements of the units are only during unit start up and shut down. Considering that start up / shut down of HCU & DHT units do not occur simultaneously, the existing vaporizer's shall be considered adequate. NO additional new vaporizer and Nitrogen Storage bullet is envisaged.

The nitrogen demand during peak requirements can be met from the existing vaporizers in the Nitrogen plant. Hence no augmentation is envisaged in Nitrogen system.

6.10.5 Compressed Air System

The capacity of major components in compressed air system is as under:

Plant air capacity : 14780 Nm3/hr (Nor) / 5,046 Nm3/hr (max)
Instrument air capacity : 3320 Nm3/hr (Nor) / 8,705 Nm3/hr (max)
Emergency instrument air : 1 HP storage vessel for 30 minutes for Unit safe shut down

Table-6.10.5,1: Post Euro-IV Plant Air balance

Units	Normal demand	Maximum demand
	Nm3/hr	Nm3/hr
HOSE STATIONS	1020	1020
DCU	720	1800
NITROGEN PLANT FEED	2800	2800
WAX PLANT	2800	2800
DHDT	1005	1391
Total demand	8345	9811

Table-6.10.5.2: Post Euro-IV HSD Instrument Air balance

Units	Normal demand	Maximum demand
	Nm3/hr	Nm3/hr
CDU/VDU	300	360
DCU	150	170
HCU	660	792
HGU	600	720
COKE CALCINATION	250	300
SRU	80	100
UTILITIES & OFFSITES	100	120
WAX	586	686
NSU	170	204
MS-BLOCK	300	360
New DHT	480	600
Total demand	3676	4412

The total installed capacity is estimated as 11780 Nm3/hr considering 2 Air compressors of 5890 Nm3/hr and the new compressor of 3000 Nm3/hr being added during Post Wax to give total installed capacity of 14780 Nm3/hr.

In the post Euro-IV scenario, the Compressed air requirement has increased.

Total Compressed air requirement post Euro-IV HSD Project will be 8345+3676=12021 Nm3/hr

NRL has reported that the capacity of the existing Screw compressor's is capable of operating in the range of 5890 nM3/hr. The adequacy of the screw compressors at the Rated Capacities shall be checked as part of detailing.

The new Air compressor as part of the Nitrogen plant of capacity 3000 Nm3/hr is also under implementation of the Wax Project. This compressor has an excess capacity of 800 NM3/hr of Compressed Air.

The normal requirement of Plant Air of 12021 Nm3/hr can be met considering the additional Air compressor considered as part of WAX project. Peak requirement of around 14223 Nm3/hr can also be met with then existing installed facilities.

Hence the existing compressor system is adequate to meet the additional requirement of Instrument air and Plant air. Hence No compressor capacity augmentation is envisaged.

A new additional Air dryer of 3320 Nm3/hr is also under implementation as part of the WAX project. Hence No additional Air dryer will be required post Euro-IV HSD

6.10.6 DM Water System

The DM water system caters to the requirement of process units and CPP DM water demand.

Table-6.10.6.1: Post Euro-IV HSD DM Water balance

Units	Normal demand	Maximum demand
	M3/hr	M3/hr
CDU/VDU	15	25
DCU	4.2	7.2
HCU	1	2
HGU	78	94.5
COKE CALCINATION	32	38.8
SRU	4.6	6
CPP	171.3	175.3
New UB	52.5	57.7
WAX	-	-
New HGU unit	13	15
DHDT	1	2
Total demand	372.6	423.5

Note 1. As per NRL feedback, the DMW requirement for existing STG is currently being met by the Steam generated from CPP.

The installed capacity for the existing DM water system is 360 m3/hr.

The existing DM water system is inadequate for normal DM water consumption rate. Condensate recovery has been considered to the extent of 12 Tons/hr. Hence augmentation is required post Euro-IV HSD project, which can be achieved by adding 1 new DM water chain of 65 m3/hr capacity.

The existing DM water transfer pumps will be considered adequate to transfer the DM water from the DM water plant to the process users

One new fixed roof type DM water tanks of 12 hrs storage, capacity of 715 m3/h, shall be provided. DM tank shall be nitrogen blanketed. Higher tank capacity is considered to take care of startup / intermittent requirements.

6.10.7 BFW Water System

The BFW water system caters to the requirement of Process units and STG water demand.

Table-6.10.7.1: Post Euro-IV HSD BFW Water balance

Units	Normal demand	Maximum demand
	M3 / Hr	M3/Hr
CDU/VDU	8.8	10.2
DCU	2.2	6.6
HCU	53.3	56.5
HGU	5.2	5.5
COKE CALCINATION	30	31.7
SRU	6.4	8.0
STG	Note 1	Note 1
WAX	1.0	2.0
MS Block	1.0	3.3
NSU	1.0	2.0
DHDT	1.5	9
Total demand	110.4	134.9

Note 1. The BFW requirement for existing STG is currently being met by the Steam generated from CPP.

The installed capacity for the existing BFW water system is two pumps with 120 m3/hr capacity each. The existing BFW water system is adequate for normal BFW water consumption rate.

6.10.8 Raw Water System:

The existing raw water system consists of the following:

Raw water reservoir capacity : 1,100,000 m3 (1 no's- Total capacity)
Treated water Capacity : 30,330 m3
RWTP capacity : 1050 m3/hr.

Table- 6.10.8.1: Post Euro-IV Raw Water balance

Units	Normal demand	Maximum demand
	M3/hr	M3/hr
Cooling Tower makeup	413	484
DM Plant	442	531
Service water	125	150
Drinking water	30	40
Fire water makeup	50	60
Service water to new units	10	10
Total demand	1070	1275

The existing pumping capacities in the refinery are as below:

Cooling Water Makeup Pumps: (2+ 1) No's, each of 180 m3/hr capacity
DM Water Makeup Pumps: (2+ 1) No's, each of 220 m3/hr capacity
Service water pumps: (1+ 1) No's, each of 140 m3/hr capacity

For the New Facility only cooling water make up pumps and DM water feed pumps are considered as additional requirement post Euro-IV HSD project.

New Cooling Water Makeup Pumps: (1+ 1) No's, each of 70 m3/hr capacity
New DM Water Makeup Pumps: (1+ 1) No's, each of 65 m3/hr capacity

6.10.9 Fuel Gas System

The Fuel gas system is designed as follows:

HP Fuel gas demand (100% FG firing)

Table-6.10.9.1: Post Euro-IV HSD Fuel gas balance

Units	Normal demand (A)	Maximum demand
	TPH	TPH
HGU + New HGU	15.5	18.7
CPP(2 GTG)	8.1	9.1
Total demand	23.6	27.8

LP Fuel gas demand (100% FG firing)

Table-6.10.9.2: Post Euro-IV HSD Fuel gas balance

Units	Normal demand (B)	Maximum demand	Normal production ©	Minimum production
	TPH	TPH	TPH	TPH
CDU/VDU	6.5	7.8		
DCU	2.3	2.7	4.6	4.1
HCU	4.4	5.2	2.3	2
HGU	1.5	1.8		
SRU	0.2	0.2		
CCU	1.3	1.6		
CPP(2 HRSG)	3.75	4.5		
CPP(UB)	2.8	3.4		
WAX	0.1	0.12		
NEW UB	3.3	4		
NEW GEG	2.1	2.6		
MSP	0.97	1.28	0.1	-
DHDT	1.2	1.5	2.3	2.1
Total demand	30.42	36.7	9.2	8.2

Net fuel requirement (A+B-C) = (23.6+30.42) - 9.2 = 44.82 (Normal) TPH

Conclusion: For Post Euro-IV, existing Fuel gas system adequacy to be checked during detailing.

6.10.10 Fuel oil System:

Design Capacity : 18.5 TPH

Table-6.10.10.1: Post Euro-IV HSD Fuel Oil balance

Units	Normal demand	Maximum demand
	TPH	TPH
CDU/VDU	5.3	6.2
DCU	1.7	2.1
HCU	3.1	3.4
HGU		
COKE CALCINATION	1.1	1.3
SRU		
CPP(UB)	3.3	3.3
WAX	0.1	-
DHDT	1.2	1.5
Total demand	14.5	16.3

Conclusion: For Post Euro-IV, no augmentation is required for the Fuel Oil system.

As per Feedback from NRL no fuel oil is used for firing in heaters in MS block.

6.11 Off sites Description

6.11.1 Flare System

The Flare study that was carried out during DQUP Project was used as the basis of checking the existing Refinery Flare Loads, and the failure cases.

The total additive General Power failure Load as per DQUP amounted to 162029 Kg/hr, with an average Mol. Wt of 33.6 and relieving temp of 216 deg C. The general power failure load for the Wax project was estimated as 9667 kg/hr with mol wt of 49.4 and relieving temperature of 170 deg C, which is also additive to the DQUP load.

The Flare load estimated for the new DHT and Hydrogen units based on inhouse data is summarized in the Table-6.11.1.1 below

Table-6.11.1.1 : Post Euro-IV HSD Flare Load

Sl No.	**Cases for DHT Unit**	**Flareload (kg/hr)**	**Mol Wt.**	**Temp Deg C**
1.	General Power failure	101319	54	247
2.	Others (gas blow by)	170901	57	185
Sl No.	**Cases for HGU Unit**	**Flareload (kg/hr)**	**Mol Wt.**	**Temp Deg C**
1.	General Power failure	7000	18.9	310

The existing Flare system and header will not be adequate Post EURO IV HSD project. Hence cost of a new flare system is considered in the DFR. The equipments considered in the Flare system includes new flare header, flare stack, flare KOD, Flare Tip and new molecular seals.

6.12 Offsite Facilities

6.12.1 Feed and Product Storage

The Offsite and Storage Facilities which will be utilized as part of the Post EURO IV HSD Project is summarized as follows:

A New DHT Feed Tank with pumps (1+1) is considered for the study. No additional Storage requirement considered for Product storage as confirmed with NRL.
The existing Euro-III diesel storage tanks and pumping facilities shall be utilized for the additional feed and storage requirements.
OSBL lines shall be provided to route the feed & product streams to and fro units and Offsite area.

6.12.2 OSBL Lines

OSBL pipelines will be required to be made for feed, product and intermediate products streams connecting new Process units / offsite area, existing units and New NSU which is under implementation.

1. DHT Feed
2. DHT naphtha
3. Off gas to PSA
4. Lean amine to DHT
5. Diesel product
6. Hydrogen make up
7. Rich amine to ARU

As utilities / flare / effluents will be connected to existing facilities, those are considered to be within ISBL only. These include Cooling water supply / Return, LP condensate, BFW water, Drinking Water, DM water, Service water, Nitrogen, Instrument air, Plant air, flare, fuel gas, fuel oil supply/return, sour water, spent caustic, HP steam, MP steam and LP steam.

6.12.3 Fire Fighting Facilities

Since all new process equipments are to be located in the existing refinery complex at a new identified location, additional fire hydrants (double headed) (without pumper connection), fire water monitors, hoses boxes and hose reels has been considered.

Chapter 7.0
ENVIRONMENTAL CONSIDERATIONS

7.0 Environmental Considerations

7.1 Effluent Details for the New DHT unit:

Figures given hereafter are estimated based on proration of inhouse data.

7.1.1 Spoiled hydrocarbons from backwash feed filter

Spoiled backwashing hydrocarbons is from the backwash filter which shall be sent to slops.

7.1.2 Flue gas from heaters

Flue gas effluent compositions from Reactor Heater 100-F1 has been estimated to 30429 kg/h maximum which shall be confirmed by heater manufacturer.

7.1.3 Sour Water to Sour Water Stripper

In normal operation, sour water from water degasser drum 100-C10 is routed to Sour Water Stripper. Normal flowrate is estimated to be 12198 kg/hr with Maximum ammonium salts concentration: 4 wt%.

7.1.4 HP purge from HP separator

Normally there is no flow and the maximum flowrate has been estimated to 3604 kg/h in normal operation

7.1.5 Oily water

In normal operation, oily water from Dryer overhead receiver 100-C14 is routed to Effluent Treatment Plant (ETP). Normal flowrates is estimated to be around 1300 kg/hr and contains some traces of hydrocarbon in normal operation.

7.1.6 Rich amine

In normal operation, rich amine from LP amine absorber 100-C16 is routed to amine regeneration unit. Flowrates is estimated to be around 105000 kg/hr, with Rich Amine loading of 0.4 mole H_2S / mole MDEA maximum

7.2 Waste effluents during in-situ catalyst regeneration

7.2.1 Spent Caustic to treatment

Estimated composition of spent caustic is as follows:

Component	Composition wt %
N_2	0.04
CO_2	0.03
H_2O	92.59
NaOH	0.91
$(NH4)_2SO_4$	0.05
Na_2CO_3	4.05
Na_2SO_3	2.33
Total	100.00
Flowrate kg/h	8 316

7.2.2 Purge gas

Estimated composition and flowrate of the purge gas are as follows.

Component	Composition mol. %
N_2	94.06
CO_2	4.24
H_2O	0.57
Ar	1.13
Total	100.00
Flowrate kg/h	1 023

7.3 Ex situ regeneration - catalyst unloading

The spent catalyst is pyrophoric and contact with air should be avoided, the catalyst should be unloaded under nitrogen in drums (or bins) and sent to an outside company for regeneration/disposal.

The unloading will be done by a specialized contractor able to work in an inert atmosphere with air masks.

Before unloading, the reactors should be cooled down to 40°C.

Estimated weight of spent catalyst for disposal = 250 t.

7.4 Clean Development Mechanism for DHT unit

The hydrotreating unit shall be compatible with the Clean Development Mechanism (CDM) actually, to illustrate it, some potential areas in the design of the unit that could qualify for CDM benefits are identified hereafter:

- The Reactor Heater will be equipped with low NO_x burners to reduce the atmospheric pollutant emissions.
- The effluent gases from Stripper, Naphtha Stabilizer and Water Degasser Drum are treated in the LP Amine Absorber to remove the maximum H_2S.
- The treated gas at the top of the LP Amine Absorber, instead of being sent to Fuel Gas, is compressed and then routed to PSA unit in order to optimize the recovery of hydrogen.
- The water from Coalescer, Naphtha Stabilizer and a part of the water from the Stripper, are recycled and re-injected in the reaction section.
- A Power Recovery Turbine is provided to recover the energy of the HP Separator high pressure fluid. This energy is used to drive in part the Feed Pumps.
- A Coalescer is also provided to remove a maximum of water in the stream entering Vacuum Dryer to save MP steam in the Vacuum Package.

7.5 Effluent Details for the New Hydrogen unit:

7.5.1 Continuous liquid effluents

Boiler blow down from the blow down drum is continuously flowing to the storm water sewer.

Temperature = 100 Deg C
Pressure = Atm.
Quantity approx normal kg/hr = 600 kg/hr
Intermittent blow-down, 4 sec in each shift, kg/s = 15
Composition ppm wt: = Salts from DMW concentrated up to 150 times
pH = 10 – 11

7.5.2 Continuous Gaseous effluents

7.5.2.1 Flue gas from flue gas stack

Estimated Quantity, Nm3/hr = 27000

Composition (mol %) wet

O_2	=	1.84
N_2	=	58.72
CO_2	=	19.01
Ar	=	0.71
H_2O	=	19.72
Total	=	100

7.5.2.2 Vapor from Deaerator

Estimated quantity Kg/hr = 1500
Composition: Steam with traces of oxygen
Temperature = 100 Deg C
Pressure = Atm

7.5.2.3 Vapor from boiler blow-down drum:

Quantity kg/hr = 100
Composition = Steam with traces of oxygen
Temperature = 100 Deg C
Pressure = Atm

7.6 Effluent Details for the New SRU:

7.6.1. Continuous Gaseous effluents

7.6.1.1 Vent gases from vent stack

Estimated Quantity = 1400 kg/hr

Characteristics:
- H_2S : 10 ppm (Vol.) max
- SO_2: 51 kg/hr (max)

7.6.2. Continuous liquid effluents

7.6.2.1 Blowdown from waste heat boilers and condensers

Estimated quantity = 230 Kg/hr

TDS, ppm : 120 – 155

Hardness as CaCO3, mg/l: Nil

Silica as SiO2, mg/l: 9 – 12

Chlorides, mg/l: 7 -10

pH : 8 – 9

Temperature : 60 Deg C

7.7 Effluent Details for the New SWS:

Stripped sour water s normally recycled back to the existing HCU, DCU or CDU Desalter. If not recycled this will be routed to ETP.

7.8 SOX Emissions:

Contribution to SOX emissions due to firing of Natural Gas in the GTG's and Heaters of the New units is very small and estimated to be less than 250 Kg /day.

7.9 Effluent Treatment Plant

Liquid effluents are intermittent and small in quantity with respect to present capacity of ETP for NRL complex. Stripped water is normally recycled back to the existing HCU, DCU and CDU desalter. In case there is no recycle, this will be routed to ETP.

The effluents from the proposed new units shall be accommodated in the existing ETP facilities. Further detailed estimation shall be done during detailed engineering.

Chapter 8.0
PROJECT IMPLEMENTATION AND SCHEDULE

8.0 Project Implementation and Schedule

8.1 Stipulation of Proposal Schedule

1 Project to be executed in two phases, Phase-I is for pre-project activities as Phase-II is for execution of the project till mechanical completion, pre-commissioning and commissioning.

2 "Following activities has been considered in the pre-project activities:
- Finalisation of the Basis of Design and Design basis.
- Licensor selection
- BDEP licensed processor unit – incl. review and incorporation of comments of consultant by licensor.
- Overall Plot Plan – Preparation and finalization for engineering
- Completion of site grading and enabling activities including construction water and power.
- Survey Soil Investigation"

3 Effective start date of the project is availability of BDEP packages from licensor for Engineering and Environment clearance. BDEP packages for engineering shall be available on effective start date after incorporating consultant comments on process documents.

4 Mode of Project Execution shall be on conventional basis except HGU. HGU shall be executed as EPC contract.

5 "Schedule is based on consideration of following facilities:
a. New DHT unit 1 MMTPA
b. New HGU unit 8 KTPA
c. New SRU train 7.5 TPD
d. Matching SWS & ARU unit (15 CM/Hr & 25 TPH Resp.)
e. FGSU unit - additional train 6.5 TPH
f. New one UB for 50 TPH (adjacent to the Power Plant).
g. One cell cooling towers with new pumps. (1000 CM/Hr) incl make up line from existing RWTP
h. DM Plant - Additional one chain 65 CM/Hr
i. One DGHT feed tank with pump facilities (5000 CM)
j. Other existing utilities including power are sufficient - No addition
k. Hook up with existing utilities & offsite facilities"

5 Process package of the open art units, originally designed by EIL, can be duplicated. The open art process units are FGSU, ARU, SWS.

6 All Statutory approval for establishment of new facilities have been considered in client's scope (e.g CEA, PESO, EIA, AAI etc.). Environment clearance shall be available on effective start date.

7 Land free from encumbrances shall be available by 4th month from Zero date.

8 Piling have been envisaged for construction.

9 Total 3 piping MTOs have been considered for which procurement shall be done on bulk basis.

10 Infrastructure development shall be part of pre-project activities, if any.

11 Monsoon period has been from April to Sept (6 Months) of each year. Adequate monsoon protection shall be in scope of respective contractors.

12 Barricading of units areas & wherever required, Shall be made before commencement of civil/ structural works.

13 Shutdown period shall be decided during detailed Engineering phase.

14 Work permit from client, if required, shall be established to issue from single window.

15 Adequate Labour colony shall be established by respective contractors nearby refinery.

16 Gate entry of labour shall be smooth and no time loss envisaged due to entry of labour and work permit.

17 Format-III completion is considered as Mechanical completion.

8.2 Schedule Bar chart

Refer Annexure - II

Chapter 9.0
Project Cost Estimates

9.0 Capital cost estimate

9.1 Introduction

Numaligarh Refineries Limited, NRL a subsidiary of Bharat Petroleum Corporation Limited is operating a refinery of designed for a capacity of 3.0 MMTPA to process Assam crude and is currently producing both Euro-III & Euro-IV grade HSD. NRL now intends to produce complete Euro-IV HSD from the refinery by putting DHT, Sulphur block, HGU, power generation unit and associated utilities / off-sites facilities.

NRL has entrusted EIL to prepare DFR cost estimate for the above proposed units / facilities.

9.2 Scope

Project Cost estimate has been developed for HSD Up-gradation Project consisting of following units / facilities:

- DHT Unit
- Sulphur Recovery Unit
- FG Sweetening Unit
- Sour Water Stripper Unit
- Amine Regeneration Unit (DEA)
- Hydrogen Generation Unit
- Utilities & Offsites
- Steam & Power system
- Associated facilities.

9.3 Project cost

Capital cost estimate for the identified scope works is Rs 1444.45 Crore

Validity of Cost estimate is as of 2nd Qtr 2013 price basis.

This Capital cost estimate shall be read alongwith Key assumptions and Exclusions listed at para 9.4 & 9.5

9.4 Key assumptions

The basic assumptions made for working out the capital cost estimate are as under:

- Cost estimate is valid as of 2nd Qtr 2013 price basis.
- No provision has been made for any future escalation
- No provision has been made for any exchange rate variation.
- It has been assumed that all units and utilities / off-sites facilities would be implemented on conventional mode.
- It has been assumed that existing Effluent Treatment Plant, infrastructure facilities and Township is adequate for this project.
- It has been assumed that existing land is available for this project.

- All costs are reflected in INR and all foreign costs have been converted into equivalent INR using exchange rate of 1USD=Rs 54.50

9.5 Exclusions

Following costs have been excluded from the Project cost estimate:

- Pipeline, Workshop & Laboratory equipment
- Working capital margin

9.6 Estimation methodology

As indicated in para 1.3, the estimated project cost for the identified scope and technical details for the project works out to be **Rs 1444.45 Crores**

Cost estimate is based on cost information available from EIL's current in-house cost data and Engineering inputs for cost estimation purpose. In-house cost data has been analyzed and adopted for estimation after incorporating specific project conditions. Cost data has been updated to prevailing price level using relevant economic indices.

These Cost estimates are subject to identified scope of work and engineering inputs / technical information, the qualifications, assumptions and exclusions stated herein.

The accuracy of these estimates is targeted at ±10% based on the methodology used and the quality of the information available for cost estimation. Capital cost estimates are enclosed as Annexure.

Process Units

The cost estimate for Process units has been prepared based on analogous reference of similar unit executed by EIL and cost has been adjusted for capacity and updated to the present day price level. Cost Estimate for DHT Unit & Fuel gas Sweetening Unit is based on Equipment list and technical details available for cost estimation purpose. A factored approach has been adopted to estimate the cost for piping, electrical, instrumentation, spares and construction costs.

The factored approach has been adopted for construction works such as Civil & Structural works, Mechanical Works, Electrical Works, Instrumentation Works and Insulation & Painting Works based on realized in-house cost data for similar units

Utilities & Off-sites and Steam & Power System

The cost for various utilities & off-site facilities are based on analogous reference of similar system / facility executed by EIL and cost has been adjusted for capacity and updated to the present day price level. The estimated cost for various utilities & off-site facilities is for following systems / facilities:

- Raw water system (only Pumps)
- Cooling water system

- DM water system
- Associated facilities
- Steam & Power system

The cost estimates for utilities / off sites facilities and Steam & Power system have been prepared based on system capacities and in-house engineering information and recent in-house cost data available for similar facilities implemented in other projects. Piping cost estimate is as per MTO made available. A factored approach has been adopted to estimate the cost for electrical, instrumentation, spares and construction costs.

Scope of Factors

The factors used under Process units / Utilities & off-sites are for the following items:

- Civil and structural items for foundations, technical structures, pipe-racks materials and labour
- Installation of Equipment
- Piping materials supply and installation.
- Electrical & Instrumentation materials supply and installation.
- Insulation, Painting and fireproofing materials supply and installation.

Catalysts & Chemicals

Provision for first fill of catalysts required is based on in-house assessment of quantities and in-house cost database.
Cost provision for chemicals has been made on lump-sum basis.

Indirect Costs, Exchange Rate

The cost estimate is based on following Exchange Rate & Indirect costs:

Exchange Rate	1 US$=Rs.54.50, 1 Euro = Rs 70.00
Ocean Freight	5.0% of FOB cost of imported equipment
rt Handling	2.0% of FOB cost of imported equipment
Inland freight	7.5% of FOB cost of imported equipment and ex-works cost of indigenously sourced equipment
Insurance	1% of total cost

Provision for ocean freight is for supplies by marine transportation / ships only. No provision has been kept for any special transportation means such as Air freighting or usages of barges.

Statutory Taxes and Duties

Provision for statutory taxes & duties has been made as under:

Customs Duty	25.85% of CIF cost of imported equipment (7.5% Basic Customs Duty + 12.36% CVD+ 3% Education Cess and 4% SAD).
Excise Duty	12.36% of ex-works cost of indigenously sourced equipment.
Central Sales Tax/VAT	2% of ex-works cost of indigenously sourced equipment including excise duty.
State Entry Tax	2.0%
Service Tax on Contracts	4.94%
VAT on Contracts	12.5% on 60% of Contract value
Service Tax	12.36% (12% Service Tax + 3% Education Cess)

Royalty, Know-How, Process Design / Basic Engineering Fees

Provision for Royalty, Know-how, Process Design, Licensor's expatriate and Basic Engineering has been made based on in-house information. Cost includes provision for withholding tax and service tax.

Project Management, Detailed Engineering, Procurement Services & Construction Supervision

Cost provision has been made for services of project management, detailed engineering, procurement services & construction supervision assistance with Service Tax. This cost is indicative.

Land and Site Development

Existing land is adequate for expansion project and no cost provision has been made. Cost provision for site development has been made on MTO basis for Pavements, Drains, pipe way Bridges & Road Crossings. Dismantling of pavements has also been considered.

Piling Works

Cost provision has been made for piling works on the basis of in-house information.

Roads & Buildings

Cost provision has been made for roads on MTO basis. Cost provision has been made for Sub-Station & SRR.

Effluent Treatment Plant

No cost provision has been kept in the cost estimate considering existing ETP is adequate.

Infrastructure facilities

It has been assumed that adequate infrastructure facilities are available at identified site. No cost provision has been made in the estimate.

Construction Site Facilities

Cost provision has been made as a factor of plant & Machinery Cost for construction site facilities such as construction power and construction water.

Township

No cost provision has been made in the cost estimate.

Owners Project Management Expenses

Cost provision for owner's construction period expenses has been made as per in-house norms for items such as project management, salaries & wages, environment clearances, feasibility reports, fund raising, recruitment, Office furniture / equipment, training requirement, legal expenses, vehicles hire / rentals / maintenance, stationary, postage, travel etc. during project construction period.

Start-up & Commissioning

A provision has been made for chemicals & consumables, vendor servicemen, technician & operators required during start-up and commissioning period as factor on plant and machinery cost.

Contingency

Provision for contingency has been made @ 10% of capital cost excluding interest during construction. This provision has been kept to take care of inadequacies in estimate basis definitions (including design and execution) and inadequacies in estimating methods and data elements.

Working Capital Margin

Working capital margin money has been excluded from the cost estimate.

Interest during construction

Interest during construction has been included in the cost estimate.

Based on the above assumptions and exclusions, Project cost summary has been enclosed as Annexure.

9.7 Financial Analysis

The operating cost, sales revenue and financial analysis have been carried out for calculating internal rate of return (IRR) with a view to establish profitability of the project. The basis of financial analysis is as under:

1	Construction Period	48 months
2	Project Life	15 years
3	Debt / Equity Ratio	2 : 1
4	Expenditure Pattern	Equity Before Debt
5	Loan Repayment period	5 year Term Loan
6	Moratorium Period	1 Year after Project completion
7	Interest on Long Term Debt	12.0%
8	Capital Phasing (Total Capital)	
	1 Year	5.0%
	2 Year	40.0%
	3 Year	45.0%
	4 Year	10.0%
9	Corporate Tax	33.99%
10	MAT	20.96%
11	Capacity Utilization during Operation	
	1year	80%
	2year	90%
	3year	100%
	4year	100%

Financing charges (IDC) has been worked out as per above details.

Annual operating cost has been computed considering costs towards crude price, Natural Gas, Raw water and fixed operating cost. Repair & Maintenance @ 1% of Plant & Machinery, Administrative expenses@ 0.5% of plant & machinery and Insurance & taxes @ 0.5% of the capital cost has been considered under fixed operating cost. Salary & wages has been considered for additional 24 Nos Management Staff: @ Rs. 18 Lakhs/ Annum and 30 Nos Non Management Staff: @ Rs. 9 Lakhs / Annum.

Based on above, Capital cost estimate, operating cost, Sales revenue and financial results are tabulated below:

	Cost in Rs Lakhs
Case	
Capital Cost	1444 45
Variable Operating Cost	10268 61
Fixed Operating Cost	28 40
Total Operating Cost	10297 01
Sales Revenue	10573 30
IRR (Pre Tax) on Total Capital	14.67%
IRR (Post Tax) on Total Capital	11.81%
IRR (Pre Tax) on Equity	15.47%
IRR (Post Tax) on Equity	11.13%
Pay Back period (Post tax) on total capital- Years	6.2

9.8 Enclosures

1. Project Cost Summary (1 sheet)
2. Process unit cost summary (5 sheet)
3. Utilities / Off-sites summary (1 sheet)
4. Operating Cost (1 sheet)
5. Sales Revenue (1 Sheet)

ENGINEERS INDIA LIMITED

COST ENGINEERING DEPARTMENT

PROJECT: COMPLETE EURO-IV HSD PROJECT,NRL

PROJECT COST SUMMARY

Sl. No.	DESCRIPTION	CAPACITY	ALL COSTS ARE IN Rs. LAKHS		
			Fc	Ic	Total
1	LAND	Existing			
2	SITE DEVELOPMENT			3 10	3 10
3	ROYALTY / KNOW-HOW / BASIC ENGINEERING		51 83	9 00	60 83
4	EPCM SERVICES			112 27	112 27
	SERVICE TAX ON EPCM SERVICES			13 88	13 88
5	PLANT & MACHINERY				
	DHT	1.0 MMTPA	20 97	453 16	474 13
	SRU-Additional Train	7.5 TPD	16 95	54 09	71 04
	FG Sweetening Unit	6.5 TPH		1 62	1 62
	SWS new train	15 TPH	54	12 16	12 70
	Amine Regeneration Unit (DEA)	25 TPH	52	16 14	16 66
	Hydrogen Genaeration Unit	8 KTPA	21 01	174 20	195 20
	CATALYSTS & CHEMICALS		6 48	4 43	10 92
	SUB-TOTAL (UNITS)		66 46	715 80	782 26
	UTILITIES & OFFSITES		24	80 16	80 41
	CAPTIVE POWER PLANT		36	72 24	72 60
	PILING			8 50	8 50
	SUB-TOTAL (PLANT & MACHINERY)		67 07	876 70	943 77
6	PIPELINE	Not Envisaged			
7	WORKSHOP & LABORATORY EQUIPMENT	Not Envisaged			
8	ROADS & BUILDINGS			8 19	8 19
9	EFFLUENT TREATMENT PLANT	Existing			
10	INFRASTRUCTURE FACILITIES	Existing			
11	CONSTRUCTION SITE FACILITIES			4 72	4 72
12	TOWNSHIP	Existing			
13	OWNER'S CONSTRUCTION PERIOD EXPENSES		2 83	16 04	18 88
14	START UP & COMMISSIONING		2 36	7 08	9 44
	TOTAL (1 to 14)		124 09	1050 96	1175 05
15	CONTINGENCY	@ 10%	12 41	105 10	117 51
16	WORKING CAPITAL MARGIN	Excluded			
	TOTAL (1 to 16)		136 50	1156 06	1292 56
17	INTEREST DURING CONSTRUCTION			151 89	151 89
	TOTAL PROJECT COST		136 50	1307 95	1444 45

JOB NO.	A195
PROJECT	Complete Euro-IV HSD Project
CLIENT	NRL
LOCATION	Numaligarh

TYPE OF ESTIMATE

DFR

ESTIMATE VALIDITY

2nd Qtr 2013

EXECUTION METHODOLOGY

Conventional

EXCHANGE RATES

1 US $ = Rs 54.50

1 EURO = Rs 70.00

CUSTOMS DUTY *	25.85%
EXCISE DUTY	12.36%
CST / VAT	2.00%
STATE ENTRY TAX	2.00%
SERVICE TAX ON CONTRACTS	4.94%
VAT ON CONTRACTS	12.5% on 60% of Contract value
SERVICE TAX ON SERVICES	12.36%

* Basic Duty 7.5% + CVD 12.36% + E. Cess 3% + SAD 4%

PROJECT MANAGER

Ms.Suma Matthews

PREPARED BY	Dhiraj Puri / P Sridhar
REVIEWED BY	S Baishnab
APPROVED BY	Sanjiv Kumar

SUMMARY

PROJECT COST

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ENGINEERS INDIA LIMITED (A Govt of India Undertaking)

COST ENGINEERING DEPARTMENT

PROJECT : COMPLETE EURO-IV HSD PROJECT, NRL

DHT UNIT

ALL COSTS ARE IN RS. LAKHS

NO.	DESCRIPTION	Fc	Ic	Sc.	TOTAL
A	MAJOR ITEMS				
1	COLUMNS & INTERNALS		5 60	62	6 21
2	VESSELS / TANKS		5 59		5 59
3	REACTORS		41 28		41 28
4	HEAT EXCHANGERS		53 81		53 81
5	AIR COOLERS		5 53		5 53
6	PUMPS & DRIVES	3 81	23 39		27 20
7	COMPRESSORS		48 50		48 50
8	FIRED HEATERS	1 13	4 50	16 88	22 50
9	PACKAGES / MISCELLANEOUS	5 67	3 79		9 47
	SUB-TOTAL (A)...	10 61	191 98	17 49	220 08
B	BULK MATERIALS				
	PIPING	6 60	26 41		33 01
	ELECTRICAL		13 20		13 20
	INSTRUMENTATION	2 20	19 81		22 01
	SUB-TOTAL (B)...	8 80	59 42		68 22
C	SPARES	56	13 77		14 33
D	CATALYSTS & CHEMICALS				
	SUB-TOTAL OF P&Mc (A TO D)...	19 97	265 17	17 49	302 63
E	ERECTION				
	MECHANICAL			35 21	35 21
	ELECTRICAL			2 64	2 64
	INSTRUMENTATION			4 40	4 40
	SUB-TOTAL (E)...			42 25	42 25
F	CIVIL WORKS			34 60	34 60
G	INSULATION AND PAINTING			5 06	5 06
	SUB-TOTAL (A TO G)...	19 97	265 17	99 40	384 54
H	INDIRECT COSTS				
1	OCEAN FREIGHT	1 00			1 00
2	CUSTOMS DUTY		5 42		5 42
3	EXCISE DUTY		32 77		32 77
4	CENTRAL SALES TAX / VAT		5 96		5 96
5	PORT HANDLING		40		40
6	INLAND TRANSPORTATION		19 96		19 96
7	STATE ENTRY TAX		7 01		7 01
8	SERVICE TAX			4 91	4 91
9	VAT ON CONTRACTS			7 46	7 46
10	INSURANCE		4 69		4 69
	SUB-TOTAL (H)...	1 00	76 22	12 37	89 59
	SUB-TOTAL (A TO H...	20 97	341 39	111 77	474 13
	TOTAL COST...	20 97	341 39	111 77	474 13

JOB NO.	A195
CLIENT	NRL
PROJECT	Complete Euro-IV HSD Project
LOCATION	Numaligarh
UNIT	DHT
CAPACITY	1.0 MMTPA

TYPE OF ESTIMATE
DFR

EXECUTION METHODOLOGY
CONVENTIONAL

ESTIMATE VALIDITY
2nd Qtr 2013

EXCHANGE RATES
1 US $ = Rs 54.50
1 EURO = Rs 70.00

CUSTOMS DUTY *	25.85%
EXCISE DUTY	12.36%
CST / VAT	2.00%
STATE ENTRY TAX	2.00%
SERVICE TAX ON CONTRACTS	4.94%
VAT ON CONTRACTS	12.5% on 60% of Contract value

* Basic Duty 7.5% + CVD 12.36% + E. Cess 3% + SAD 4%

PROJECT MANAGER

Ms. Suma Mathews

PREPARED	Dhiraj Puri / P Sridhar
REVIEWED	S. Baishnab
APPROVED	Sanjiv Kumar

S U M M A R Y

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COST ENGINEERING DEPARTMENT

PROJECT: COMPLETE EURO-IV HSD PROJECT,NRL

SULPHUR RECOVERY UNIT

SL. NO.	DESCRIPTION	Fc	Ic	Sc	TOTAL
		ALL COST IN RS. LAKHS			
1	**MAJOR ITEMS**				
1.1	COLUMN & INTERNALS				
1.2	VESSELS				
1.3	REACTORS				
1.4	HEAT EXCHANGERS				
1.5	AIR COOLERS				
1.6	HEATERS				
1.7	PUMPS & DRIVES				
1.8	COMPRESSORS				
1.9	PACKAGES				
1.10	MISCELLANEOUS				
	TOTAL EQUIPMENT	13 61	8 11	1 28	23 00
	SUB-TOTAL (1)...	**13 61**	**8 11**	**1 28**	**23 00**
2	**BULK MATERIALS**				
2.1	PIPING	92	3 68		4 60
2.2	ELECTRICAL		1 15		1 15
2.3	INSTRUMENTATION	1 61	6 44		8 05
	SUB-TOTAL (2)...	**2 53**	**11 27**		**13 80**
3	SPARES	Included above			
4	CATALYST & CHEMICALS	Included In Summary			
	SUB-TOTAL (1 TO 4)...	**16 14**	**19 38**	**1 28**	**36 80**
5	**ERECTION**				
5.1	MECHANICAL			6 90	6 90
5.2	ELECTRICAL			29	29
5.3	INSTRUMENTATION			2 01	2 01
	SUB-TOTAL (5)...			**9 20**	**9 20**
6	**CIVIL WORKS**			9 20	9 20
7	**INSULATION AND PAINTING**			83	83
	SUB-TOTAL (1 TO 7)...	**16 14**	**19 38**	**20 50**	**56 03**
8	**INDIRECT COSTS**				
8.1	OCEAN FREIGHT	81			81
8.2	CUSTOMS DUTY		4 38		4 38
8.3	EXCISE DUTY		2 40		2 40
8.4	CENTRAL SALES TAX / VAT		44		44
8.5	PORT HANDLING		32		32
8.6	INLAND TRANSPORTATION		2 49		2 49
8.7	STATE ENTRY TAX		93		93
8.8	SERVICE TAX			1 01	1 01
8.9	VAT ON CONTRACTS			1 54	1 54
8.10	INSURANCE		70		70
	SUB-TOTAL (8)...	**81**	**11 65**	**2 55**	**15 01**
	TOTAL (1 to 8)	**16 95**	**31 04**	**23 05**	**71 04**
9	Piling				
	T O T A L C O S T ...	**16 95**	**31 04**	**23 05**	**71 04**

JOB NO.	**A195**
CLIENT	**NRL**
LOCATION	
CAPACITY	**7.5 TPD**
UNIT	**SRU**
LICENSOR	**EIL**

TYPE OF ESTIMATE

DFR

EXECUTION METHODOLOGY

CONVENTIONAL

ESTIMATE VALIDITY

2nd Qtr 2013

EXCHANGE RATES

1 US $ = Rs 54.50

1 EURO = Rs 70.00

CUSTOMS DUTY *	25.85%
EXCISE DUTY	12.36%
CST / VAT	2.00%
STATE ENTRY TAX	2.00%
SERVICE TAX ON CONTRACTS	4.94%
VAT ON CONTRACTS	12.5% on 60% of Contract value

* Basic Duty 7.5% + CVD 12.36% + E. Cess 3% + SAD 4%

PROJECT MANAGER

Suma Matthews

PREPARED BY	Sheina / Dhiraj Puri / P Sridhar
REVIEWED BY	S Baishnab
APPROVED BY	Sanjiv Kumar

S U M M A R Y

Process Unit (Battery Limit)

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ENGINEERS INDIA LIMITED
(A Govt. of India Undertaking)

COST ENGINEERING DEPARTMENT

PROJECT: COMPLETE EURO-IV HSD PROJECT,NRL

SWS

SL. NO.	DESCRIPTION	Fc	Ic	Sc	TOTAL
		ALL COST IN RS. LAKHS			
1	**MAJOR ITEMS**				
1.1	COLUMN & INTERNALS				
1.2	VESSELS				
1.3	REACTORS				
1.4	HEAT EXCHANGERS				
1.5	AIR COOLERS				
1.6	HEATERS				
1.7	PUMPS & DRIVES				
1.8	COMPRESSORS				
1.9	PACKAGES				
1.10	MISCELLANEOUS				
	TOTAL EQUIPMENT		3 49	3	3 53
	SUB-TOTAL (1)...		**3 49**	**3**	**3 53**
2	**BULK MATERIALS**				
2.1	PIPING	14	56		71
2.2	ELECTRICAL		19		19
2.3	INSTRUMENTATION	35	1 41		1 76
	SUB-TOTAL (2)...	**49**	**2 17**		**2 66**
3	SPARES	2	25		27
4	CATALYST & CHEMICALS	Included In Summary			
	SUB-TOTAL (1 TO 4)...	**51**	**5 92**	**3**	**6 46**
5	**ERECTION**				
5.1	MECHANICAL			2 12	2 12
5.2	ELECTRICAL			5	5
5.3	INSTRUMENTATION			44	44
	SUB-TOTAL (5)...			**2 60**	**2 60**
6	**CIVIL WORKS**			1 24	1 24
7	**INSULATION AND PAINTING**			13	13
	SUB-TOTAL (1 TO 7)...	**51**	**5 92**	**4 00**	**10 43**
8	**INDIRECT COSTS**				
8.1	OCEAN FREIGHT	3			3
8.2	CUSTOMS DUTY		14		14
8.3	EXCISE DUTY		73		73
8.4	CENTRAL SALES TAX / VAT		13		13
8.5	PORT HANDLING		1. 02		1. 02
8.6	INLAND TRANSPORTATION		45		45
8.7	STATE ENTRY TAX		16		16
8.8	SERVICE TAX			20	20
8.9	VAT ON CONTRACTS			30	30
8.10	INSURANCE		13		
	SUB-TOTAL (8)...	3	1 75	50	2 27
	TOTAL (1 to 8)	**54**	**7 66**	**4 50**	**12 70**
	TOTAL COST ...	**54**	**7 66**	**4 50**	**12 70**

JOB NO.	**A195**
CLIENT	**NRL**
LOCATION	
CAPACITY	**15 TPH**
UNIT	**SWS**
LICENSOR	**EIL**

TYPE OF ESTIMATE

DFR

EXECUTION METHODOLOGY

CONVENTIONAL

ESTIMATE VALIDITY

2nd Qtr 2013

EXCHANGE RATES

1 US $ = Rs 54.50

1 EURO = Rs 70.00

CUSTOMS DUTY *	25.85%
EXCISE DUTY	12.36%
CST / VAT	2.00%
STATE ENTRY TAX	2.00%
SERVICE TAX ON CONTRACTS	4.94%
VAT ON CONTRACTS	12.5% on 60% of Contract value

* Basic Duty 7.5% + CVD 12.36% + E. Cess 3% + SAD 4%

PROJECT MANAGER

Suma Matthews

PREPARED BY	Sheina / Dhiraj Puri / P Sridhar
REVIEWED BY	S Baishnab
APPROVED BY	Sanjiv Kumar

S U M M A R Y

Process Unit (Battery Limit)

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COST ENGINEERING DEPARTMENT

PROJECT: COMPLETE EURO-IV HSD PROJECT,NRL

ARU

SL. NO.	DESCRIPTION	Fc	Ic	Sc	TOTAL
			ALL COST IN RS. LAKHS		
1	**MAJOR ITEMS**				
1.1	COLUMN & INTERNALS				
1.2	VESSELS				
1.3	REACTORS				
1.4	HEAT EXCHANGERS				
1.5	AIR COOLERS				
1.6	HEATERS				
1.7	PUMPS & DRIVES				
1.8	COMPRESSORS				
1.9	PACKAGES				
1.10	MISCELLANEOUS				
	TOTAL EQUIPMENT		5 31	2	5 33
	SUB-TOTAL (1)...		**5 31**	**2**	**5 33**
2	**BULK MATERIALS**				
2.1	PIPING	21	85		1 07
2.2	ELECTRICAL		27		27
2.3	INSTRUMENTATION	27	1 07		1 33
	SUB-TOTAL (2)...	**48**	**2 18**		**2 66**
3	SPARES	1	33		35
4	CATALYST & CHEMICALS		Included In Summary		
	SUB-TOTAL (1 TO 4)...	**49**	**7 82**	**2**	**8 34**
5	**ERECTION**				
5.1	MECHANICAL			3 20	3 20
5.2	ELECTRICAL			7	7
5.3	INSTRUMENTATION			33	33
	SUB-TOTAL (5)...			**3 60**	**3 60**
6	**CIVIL WORKS**			1 60	1 60
7	**INSULATION AND PAINTING**			19	19
	SUB-TOTAL (1 TO 7)...	**49**	**7 82**	**5 40**	**13 72**
8	**INDIRECT COSTS**				
8.1	OCEAN FREIGHT	2			2
8.2	CUSTOMS DUTY		13		13
8.3	EXCISE DUTY		97		97
8.4	CENTRAL SALES TAX / VAT		18		18
8.5	PORT HANDLING		1		1
8.6	INLAND TRANSPORTATION		58		58
8.7	STATE ENTRY TAX		20		20
8.8	SERVICE TAX			27	27
8.9	VAT ON CONTRACTS			41	41
8.10	INSURANCE		16		
	SUB-TOTAL (8)...	2	2 24	67	2 93
	TOTAL (1 to 8)	**52**	**10 06**	**6 08**	**16 66**
	TOTAL COST...	**52**	**10 06**	**6 08**	**16 66**

JOB NO.	**A195**
CLIENT	**NRL**
LOCATION	
CAPACITY	**25 TPH**
UNIT	**ARU**
LICENSOR	**EIL**

TYPE OF ESTIMATE

DFR

EXECUTION METHODOLOGY

CONVENTIONAL

ESTIMATE VALIDITY

2nd Qtr 2013

EXCHANGE RATES

1 US $ = Rs 54.50

1 EURO = Rs 70.00

CUSTOMS DUTY *	25.85%
EXCISE DUTY	12.36%
CST / VAT	2.00%
STATE ENTRY TAX	2.00%
SERVICE TAX ON CONTRACTS	4.94%
VAT ON CONTRACTS	12.5% on 60% of Contract value

* Basic Duty 7.5% + CVD 12.36% + E. Cess 3% + SAD 4%

PROJECT MANAGER

Suma Matthews

PREPARED BY	Sheina / Dhiraj Puri / P Sridhar
REVIEWED BY	S Baishnab
APPROVED BY	Sanjiv Kumar

S U M M A R Y

Process Unit (Battery Limit)

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COST ENGINEERING DEPARTMENT

PROJECT: COMPLETE EURO-IV HSD PROJECT,NRL

Hydrogen Generation Unit (HGU)

SL. NO.	DESCRIPTION	ALL COST IN RS. LAKHS Fc	Ic	Sc	TOTAL
1	**MAJOR ITEMS**				
1.1	COLUMN & INTERNALS				
1.2	VESSELS				
1.3	REACTORS				
1.4	HEAT EXCHANGERS				
1.5	AIR COOLERS				
1.6	HEATERS				
1.7	PUMPS & DRIVES				
1.8	COMPRESSORS				
1.9	PACKAGES				
1.10	MISCELLANEOUS				
	TOTAL EQUIPMENT	15 47	39 80	26 51	81 78
	SUB-TOTAL (1)...	**15 47**	**39 80**	**26 51**	**81 78**
2	**BULK MATERIALS**				
2.1	PIPING	2 04	8 18		10 22
2.2	ELECTRICAL		6 54		6 54
2.3	INSTRUMENTATION	1 64	6 54		8 18
	SUB-TOTAL (2)...	**3 68**	**21 26**		**24 94**
3	SPARES	86	2 64		3 50
4	CATALYST & CHEMICALS				
	SUB-TOTAL (1 TO 4)...	**20 01**	**63 71**	**26 51**	**110 23**
5	**ERECTION**				
5.1	MECHANICAL			16 36	16 36
5.2	ELECTRICAL			1 64	1 64
5.3	INSTRUMENTATION			2 04	2 04
	SUB-TOTAL (5)...			**20 04**	**20 04**
6	**CIVIL WORKS**			26 68	26 68
7	**INSULATION AND PAINTING**			2 76	2 76
	SUB-TOTAL (1 TO 7)...	**20 01**	**63 71**	**75 99**	**159 71**
8	**INDIRECT COSTS**				
8.1	OCEAN FREIGHT	1 00			1 00
8.2	CUSTOMS DUTY		5 43		5 43
8.3	EXCISE DUTY		7 87		7 87
8.4	CENTRAL SALES TAX / VAT		1 43		1 43
8.5	PORT HANDLING		40		40
8.6	INLAND TRANSPORTATION		5 86		5 86
8.7	STATE ENTRY TAX		2 11		2 11
8.8	SERVICE TAX			3 75	3 75
8.9	VAT ON CONTRACTS			5 70	5 70
8.10	INSURANCE		1 93		1 93
	SUB-TOTAL (8)...	1 00	25 04	9 45	35 50
	TOTAL (1 to 8)	**21 01**	**88 75**	**85 45**	**195 20**
	T O T A L C O S T ...	**21 01**	**88 75**	**85 45**	**195 20**

JOB NO.	**A195**
CLIENT	**NRL**
LOCATION	
CAPACITY	**8 000 TPA**
UNIT	**HGU**
LICENSOR	**EIL**

TYPE OF ESTIMATE

DFR

EXECUTION METHODOLOGY

CONVENTIONAL

ESTIMATE VALIDITY

2nd Qtr 2013

EXCHANGE RATES

1 US $ = Rs 54.50

1 EURO = Rs 70.00

CUSTOMS DUTY *	25.85%
EXCISE DUTY	12.36%
CST / VAT	2.00%
STATE ENTRY TAX	2.00%
SERVICE TAX ON CONTRACTS	4.94%
VAT ON CONTRACTS	12.5% on 60% of Contract value

* Basic Duty 7.5% + CVD 12.36% + E. Cess 3% + SAD 4%

PROJECT MANAGER

Ms.Suma Matthews

PREPARED BY	Sheina / Dhiraj Puri / P Sridhar
REVIEWED BY	S Baishnab
APPROVED BY	Sanjiv Kumar

S U M M A R Y

Process Unit (Battery Limit)

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COST ENGINEERING DEPARTMENT

PROJECT: COMPLETE EURO-IV HSD PROJECT,NRL

UTILITIES & OFFSITES

NO.	DESCRIPTION	Fc	Ic	Sc.	TOTAL
		ALL COSTS ARE IN RS. LAKHS			
A	**MAJOR ITEMS**				
1	RAW WATER SYSTEM		11		11
2	COOLING WATER SYSTEM		52	3 50	4 02
3	DM WATER SYSTEM		7 80	5 20	13 00
4	COMPRESSED AIR SYSTEM	Not envisaged			
5	STORAGE TANKS, MOUNDED BULLETS & DESPATCH FACILITIES		30	1 88	2 18
6	FLARE SYSTEM		1 37		1 37
7	FUEL OIL SYSTEM	Not envisaged			
8	NITROGEN SYSTEM	Not envisaged			
9	FIRE FIGHTING / PROTECTION SYSTEM		1 07	65	1 72
10	OFFSITE PUMPS	Not envisaged			
11	MISC. EQUIPMENTS		25		25
	SUB-TOTAL (A)...		**11 42**	**11 22**	**22 64**
B	**BULK MATERIALS**				
	PIPING		10 43		10 43
	ELECTRICAL		3 40		3 40
	INSTRUMENTATION	23	5 91		6 13
	SUB-TOTAL (B)...	**23**	**19 73**		**19 95**
C	SPARES	1	62		63
D	CHEMICALS	Incld In Summary			
	SUB-TOTAL (A+B+C+D)...	**23**	**31 77**	**11 22**	**43 22**
E	**ERECTION**				
	MECHANICAL			9 74	9 74
	ELECTRICAL			1 02	1 02
	INSTRUMENTATION			1 84	1 84
	SUB-TOTAL (E)...			**12 60**	**12 60**
F	**CIVIL WORKS**			10 65	10 65
G	**INSULATION AND PAINTING**			99	99
	SUB-TOTAL (A TOG)...	**23**	**31 77**	**35 46**	**67 46**
H	**INDIRECT COSTS**				
1	OCEAN FREIGHT	1			1
2	CUSTOMS DUTY		6		6
3	EXCISE DUTY		3 93		3 93
4	CENTRAL SALES TAX / VAT		71		71
5	PORT HANDLING				
6	INLAND TRANSPORTATION		2 24		2 24
7	STATE ENTRY TAX		78		78
8	SERVICE TAX			1 75	1 75
9	VAT ON CONTRACTS			2 66	2 66
10	INSURANCE		80		80
	SUB-TOTAL (H)...	1	8 52	4 41	12 95
	SUB-TOTAL (A TO H)...	**24**	**40 29**	**39 87**	**80 41**
	TOTAL COST...	**24**	**40 29**	**39 87**	**80 41**

JOB NO.	**A195**
CLIENT	**NRL**
LOCATION	**Numaligarh**
CAPACITY	
UNIT	**UTILITIES & OFFSITES**

TYPE OF ESTIMATE

PFR

EXECUTION METHODOLOGY

CONVENTIONAL

ESTIMATE VALIDITY

2nd Qtr 2013

EXCHANGE RATES

1 US $ = Rs 54.50

1 EURO = Rs 70.00

CUSTOMS DUTY *	25.85%
EXCISE DUTY	12.36%
CST / VAT	2.00%
STATE ENTRY TAX	2.00%
SERVICE TAX ON CONTRACTS	4.94%
VAT ON CONTRACTS	12.5% on 60% of Contract value

* Basic Duty 7.5% + CVD 12.36% + E. Cess 3% + SAD 4%

PROJECT MANAGER

Suma Matthews

PREPARED	Dhiraj Puri / P Sridhar
REVIEWED	S Baishnab
APPROVED	Sanjiv Kumar

S U M M A R Y

DOCUMENT NO.	**A195-FR-6842-0001**
REVISION NO.	**0**
DATE :	**25-Jun-13**
FILE NAME	D:\DP\Refinery\A195_NRL_HSD upgradation_DFR\Final

ENGINEERS INDIA LIMITED (A Govt. of India Undertaking)	JOB NO.: A195	DOCUMENT NO. A195-DR-6842-0001
	PROJECT: EURO IV HSD	REVISION NO. 0
	CLIENT: NRL	DATE 25-Jun-13
COST ENGINEERING DEPARTMENT		PAGE NO. 1 of 1

Cost are in Rs. Lakhs

ANNUAL OPERATING COST

S.No.	DESCRIPTION / CASES	Unit	Prices (RS./MT)	Quantity in '000	Amount
A	**VARIABLE COST**				
1	***Feed***				
	ASSAM CRUDE	MT	33300	30 00	9989 88
	NATURAL GAS	MT	13762	2 02	277 45
2	**UTILITIES**				
	RAW WATER	m3	20	6 40	1 28
	SUB-TOTAL A				**10268 61**
B	**FIXED OPERATING COST**				
1	**SALARIES & WAGES**	Nos.	24 Nos Management Staff: @ Rs. 18 Lakhs/ Annum 30 Nos Non Management Staff: @ Rs. 9 Lakhs / Annum		7 02
2	**REPAIR & MAINTENANCE**	1.0%	of Plant & Machinery		9 44
3	**GENERAL ADMINISTRATION**	0.5%	of Plant & Machinery		4 72
4	**INSURANCE & TAXES**	0.5%	of Total Capital Cost		7 22
	SUB-TOTAL B				**28 40**
	TOTAL				**10297 01**

Format no. 5-6842-2000-F5 Rev.4

इंजीनियर्स इंडिया लिमिटेड (भारत सरकार का उपक्रम) ENGINEERS INDIA LIMITED (A Govt. of India Undertaking)

COST ENGINEERING DEPARTMENT

JOB NO.:	**A195**	**DOCUMENT NO.**	A195-DR-6842-0001
PROJECT:	**EURO IV HSD**	**REVISION NO.**	0
CLIENT:	**NRL**	**DATE**	25-Jun-13
		PAGE NO.	1 of 1

Cost are in Rs. Lakhs

SALES REVENUE

S.No.	DESCRIPTION / CASES	Unit	Prices (Rs /Unit)	Quantity in '000	Amount
	REFINERY PRODUCT				
	LPG	MT	34 702	104.00	360 90
	NAPHTHA	MT	31 472	239.00	752 17
	PETROCHEMICAL NAPHTHA	MT	31 472	160.00	503 55
	Euo-III Reg GASOLINE	MT	48 816	172.67	842 89
	Euro-IV Reg GASOLINE	MT	48 841	48.00	234 44
	ATF	MT	39 152	105.00	411 10
	KEROSENE	MT	36 765	48.00	176 47
	Euro-IV DIESEL	MT	37 183	1582.00	5882 41
	Euro-V DIESEL	MT	37 183	360.00	1338 60
	COKE	MT	12 104	85.33	103 29
	SULPHUR	MT	4 782	7.07	3 38
	WAX	MT	65 000	50.00	325 00
	SUB-TOTAL A				**10573 30**
B	**SALES OF BY-PRODUCT**				
	SUB-TOTAL B				
	TOTAL				**10573 30**

Format no. 5-6842-2000-F6 Rev.4

IRR (Bef Tax)	14.67%
IRR (After Tax)	11.81%

Job No. : A195

Project : NRL

Client : NRL

CASHFLOW STATEMENT

S NO.	DESCRIPTION	CONSTRUCTION PERIOD				OPERATING PERIOD															
		1	2	3	4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	22
	CASH INFLOW																				
A	EQUITY	6463	41686																		
B.	DEBT		10317	63182	351440																
C.	OPERATING REVENUE					845864	951597	1057330	1057330	1057330	1057330	1057330	1057330	1057330	1057330	1057330	1057330	1057330	1057330	1057330	
D.	SALVAGE VALUE																			35134	
	CASH OUTFLOW																				
E.	MAIN INVESTMENT	6463	51702	58165	12926																
F.	FINANCING CHARGES		301	5017	9872																
	TOTAL INVESTMENT	**6463**	**52003**	**63182**	**22797**																
G.	OPERATING COST																				
H.	ANNUAL FIXED COST					2840	2840	2840	2840	2840	2840	2840	2840	2840	2840	2840	2840	2840	2840	2840	
I.	ANNUAL VARIABLE COST					821489	924175	1026861	1026861	1026861	1026861	1026861	1026861	1026861	1026861	1026861	1026861	1026861	1026861	1026861	
J.	INTT. ON SHORT TERM LOAN																				
	CATALYST AND CHEMICALS					549	673	560	684	553	684	549	684	560	756	549	695	549	673	563	
K.	**TOTAL COST**					**824878**	**927687**	**1030261**	**1030385**	**1030253**	**1030384**	**1030250**	**1030385**	**1030261**	**1030457**	**1030250**	**1030395**	**1030250**	**1030373**	**1030264**	
L.	**GROSS MARGIN(C+D-H-I-J)**					**20986**	**23910**	**27069**	**26946**	**27077**	**26946**	**27080**	**26946**	**27069**	**26874**	**27080**	**26935**	**27080**	**26957**	**62200**	
M.	DEPRICIATION (AS PER C.A.)					7118	7118	7118	7118	7118	7118	7118	7118	7118	7118	7118	7118	7118	7118	7118	
N.	AMMORTIZATION (SEC. 35D)					160	160	160	160	160											
O.	**NET MARGIN(L-M-N)**					**13708**	**16632**	**19791**	**19668**	**19799**	**19829**	**19963**	**19828**	**19952**	**19756**	**19963**	**19817**	**19963**	**19839**	**55082**	
P.	INTT. ON LONG TERM DEBT					11556	10978	8667	6356	4044	1733										
Q.	**PROFIT BEFORE TAX(O-P)**					**2153**	**5654**	**11125**	**13312**	**15755**	**18095**	**19963**	**19828**	**19952**	**19756**	**19963**	**19817**	**19963**	**19839**	**55082**	
R.	TAX					566	1326	2449	2934	3418	3936	4299	7782	8184	8486	8712	8882	9009	9105	21118	
S.	**PROFIT AFTER TAX(Q-R)**					**1586**	**4328**	**8676**	**10378**	**12337**	**14159**	**15663**	**12046**	**11768**	**11270**	**11250**	**10935**	**10953**	**10735**	**33964**	
T.	NET CASH FLOW					8704	11446	15793	17496	19454											
U.	LONG TERM DEBT REPAYMT						19259	19259	19259	19259	19259										
	ON TOTAL CAPITAL																				
	BEFORE TAX	**-6463**	**-51702**	**-58165**	**-12926**	**20986**	**23910**	**27069**	**26946**	**27077**	**26946**	**27080**	**26946**	**27069**	**26874**	**27080**	**26935**	**27080**	**26957**	**62200**	
	AFTER TAX	**-6463**	**-51702**	**-58165**	**-12926**	**20420**	**22584**	**24620**	**24012**	**23659**	**23010**	**22781**	**19164**	**18885**	**18388**	**18368**	**18053**	**18071**	**17852**	**41081**	
	ON EQUITY																				
	BEFORE TAX	**-6463**	**-41686**			**9431**	**-6327**	**-857**	**1331**	**3773**	**5953**	**27080**	**26946**	**27069**	**26874**	**27080**	**26935**	**27080**	**26957**	**62200**	
	AFTER TAX	**-6463**	**-41686**			**8864**	**-7653**	**-3306**	**-1603**	**355**	**2017**	**22781**	**19164**	**18885**	**18388**	**18368**	**18053**	**18071**	**17852**	**41081**	

Chapter 10.0
Annexure

Annexure- I	Schematic Process Flow Diagrams
Annexure – II	Project Schedule
Annexure – III	Utility Summary sheet
Annexure – IV	Description of existing 3.0 MMTPA facilities
Annexure-V	Equipment list
Annexure – VI	Block Flow Diagram
Annexure – VII	Crude Assay
Annexure – VIII	Overall plot plan

Annexure – I