1.0 EXECUTIVE SUMMARY

1.1 Introduction

Indian Oil Corporation Limited (IOCL) operates one of its largest oil refineries at Koyali (near Vadodara) in Gujarat, Western India. The refinery was commissioned in the year 1965 with a nameplate capacity of 3.0 MMTPA. Over the years, the capacity of the refinery has gradually been increased to 13.7 MMTPA with augmentation of old primary Atmospheric Units (AU-I, AU-II and AU-III) and addition of new primary units viz. Atmospheric Unit-IV in 1978 and AU-V in 1999 as well as augmentation of AU-IV in 2000.

Secondary processing facilities viz. Fluidized Catalytic Cracking Unit (FCCU)and Hydro-cracking Unit (HCU) were added in the years 1982 and 1993 respectively to improve the distillate yield. Diesel Hydro-desulphurization Unit (DHDS) and Hydrogen Generation Unit (HGU) were added in 1999 to meet BS-2000/BS-II quality of HSD. MS Quality Improvement Project comprising of Continuous Catalytic Reforming Unit (CCRU) and revamp of DHDS were carried out in the years 2006 and 2007 respectively to meet BS-II/BS-III MS and HSD quality respectively.

Further, under the Residue Upgradation Project (RUP) and MS/HSD quality improvement Project Delayed Coking Unit (DCU), Vacuum Gas oil Hydro-Treater Unit (VGO-HDT), Diesel HydrotreaterUnit (DHDT), Hydrogen Generation Unit-III (HGU-III), Sulphur Recovery Unit(SRU), Isomerisation Unit (ISOM), ATF & LPG Merox units were commissioned in 2010-11.

At present, Gujarat Refinery has capacity to process 13.7 MMTPA of crude oil, with crude basket comprising of 55% high sulphur crude (7.6 MMTPA) and 45% low sulphur indigenous crude (6.1 MMTPA).In addition to BS-III/BS-IV fuel products, the refinery also has the capability to produce a wide range of specialty products such as benzene, toluene, MTBE, MTO, Food Grade Hexane & LAB.

In current refinery operations, refinery produces Gasoline and Diesel conforming to BS-III & BS-IV specifications. Currently refinery is executing projects to upgrade the entire gasoline and diesel to BS-IV specification by revamp of existing DHDT, DHDS and VGO hydrotreater units.

With objective of meeting the guidelines established in Auto Fuel Policy 2025, wherein refinery would be required to manufacture 100% BS-V fuels. IOCL has entrusted M/s Engineers India Limited to carry out the job of assessment of the configuration and modification/additional facilities required to comply to BS-V auto fuel specification for the existing crude processing capacity of 13.7 MMTPA and preparation of feasibility report with a cost estimate of ± 30%. This report documents the results of the study.

1.2 Objectives

The major objectives of the study are to:

- Develop refinery configuration for the production of 100% BS-V products at the existing refining capacity of 13.7 MMTPA.

- Assessment of additional facilities required to comply to BS V auto fuel specification for 13.7 MMTPA crude processing capacity.
- Estimate capital cost with an accuracy of ± 30%.

1.3 Basis of Configuration Study

1.3.1 Refinery Throughput

13.7 MMTPA

1.3.2 Crude Mix

The configuration study has been carried out for the design crude mix as per the table below:

Table 1.3.1: Crude Mix

CRUDE TYPE	MMTPA
North Gujarat (NG)	3.7
South Gujarat (SG)	1.7
Rajasthan Crude	0.8
Kuwait	7.5

1.3.3 Crude Assay

The crude assays utilized for the study are attached in Annexure-1.

1.3.4 Refinery On-Stream Hours

8000 hrs/annum.

1.3.5 Feed and Product Prices

The feed and product prices considered for base case and 100% BS-V case with MSQU and ISOM unit revamp is provided below in table 1.3.2A & B. The prices are based on average prices during FY 2011-14.

Table 1.3.2A Feed Prices (Rs/MT)

CRUDE	3 YEAR AVERAGE
North Gujarat (NG)	41373
South Gujarat (SG)	46327
Rajasthan Crude	40266
Kuwait	42089
LNG/RLNG	44524

Methanol	29557
Benzene	57859

Table 1.3.2B Product Prices (Rs/MT)

PRODUCT	3 YEAR AVERAGE
LPG	50059
Naphtha Export	50595
Food Grade Hexane	73277
MS BS-V (Normal grade)	58510
HY. REFORMATE TO IOCL GR	50595
SKO	54866
PCK	NA
ATF	54955
LAB	61025
HSDBS-V	53826
Bitumen 60/70	32962
HS Coke	5050
Fuel Oil -Regular	37737
Fuel Oil –Low Sulphur	37617
Fuel Oil - High Sulphur	37737
Sulphur	8835

1.3.6 Product Specifications

The diesel and gasoline fuels produced from refinery after implementation of the project shall conform to BS-V specifications. The major specifications of products shall be:

- Regular grade BS-V Gasoline (91 RON)**-10ppmw sulphur*
- Premium grade BS-V Gasoline (95 RON)***- 10ppmw sulphur*
- Diesel BS-V: 10 ppmw Sulfur*

* Manufacturing spec. of 8 ppm has been considered.

** Manufacturing spec. of 91.2 has been considered.

***Manufacturing spec. of 95.5 has been considered.

1.3.7 Production Limits

The limits on various products have been considered as per Table 1.3.3 below:

Table 1.3.3: Production Limits (KTPA)

PRODUCT	MAXIMUM QUANTITY (KTPA)	FIXED QUANTITY (KTPA)
Naphtha	(As produced)	-
Total Gasoline	1600	-
SKO	500 Max	-
ATF	400 Max	-
MTO	Nil	-
LDO	Nil	-
Bitumen	630	-
Fuel Oil Sales - High Sulphur		30
Fuel Oil Sales - Low Sulphur		210
Fuel Oil Sales- Regular grade		160

1.3.8 Other Constraints & Considerations

- The base case shall be considered with BS-IV auto fuel compliance considering the revamp of existing DHDT, DHDS and VGO-HDT units.
- In a separate study carried out internally by IOCL, it has been established that the existing CCR and ISOM units can be revamped by 30% and 20% respectively. Thus higher gasoline potential to be considered with revamp as advised by IOCL. This will increase the production of gasoline beyond 1600 KTPA meeting BS-V specification.
- With the revamp of existing MSQU and ISOM units the potential of producing premium grade gasoline from the refinery has been considered.
- Kerosene production to be reduced by upgrading kero streams to diesel product

1.3.9 Plant Fuel System

RLNG has been considered as fuel for the following facilities in the 100% BS-V configuration.

- Existing GT's+HRSG.
- Feed/Fuel to existing HGU-III and new HGU.
- Fuel to Existing HGU-1

Internally generated Fuel Oil (Sul<0.5 wt %) and fuel gas have been considered as fuel for refinery furnaces.

1.4 Configuration study approach

- Development of Base LP model of refinery to produce 100% BS-IV products for the existing capacity of 13.7 MMTPA based on the IOCL input data.
- While going for production of BS-V gasoline and diesel production from BS-IV products, the main objective is the reduction of sulphur specification in the blend components. Hence a new DHDT unit has been considered for treating BS-IV diesel components having high sulphur specification.
- Carry out further analysis to blend maximum possible kero components into diesel product by reducing their sulphur spec in the new DHDT unit considered.
- Similarly for meeting BS-V sulphur specification in gasoline product pool, consider a FCC gasoline desulphurization unit for treating high sulphur FCC gasoline components from FCC.
- As advised by IOCL consideration of revamp of MSQU, and ISOM units to maximize the gasoline production meeting BS-V specification and also producing 240 KTPA of premium grade gasoline.

1.5 Configuration results for 100% BS-V with MSQU and ISOM revamp

- A new DHDT unit of capacity 1500 KTPA is considered to produce 100% BS-V Diesel.
- A FCC gasoline desulphurization unit is required to remove sulphur from FCC gasoline stream to meet BS-V spec. The unit shall be designed for a capacity of 700 KTPA.
- An incremental Hydrogen Generation capacity of 40 KTPA is required to meet the additional consumption in the refinery. However as advised by IOCL a Hydrogen Generation Unit of capacity 72.5 KTPA shall be considered, which may also meet any future requirements of expansion.
- In addition to 100% BS-V gasoline and diesel production, 30% revamp of MSQU and 20% revamp of ISOM units have been considered as part of the study to upgrade naphtha product to gasoline meeting BS-V specification. This also gives opportunity to produce 240 KTPA of premium grade gasoline.
- Additionally following auxiliary units have been considered as part of this project:
    a) A new SWS unit of capacity 55 TPH to process incremental sour water produced in new/ revamped process units.
    b) A new Amine Recovery unit of 190 TPH capacity, considering that the new DHDT unit under BS-V project may process high sulphur feed in future.

c) Since there is no substantial increase in overall sulphur production in refinery after BS-V project, no new SRU is envisaged.

1.6 Material Balance

Table 1.5.1 below provides the material balance for both cases considered for 100% BS-V production with MSQU and ISOM unit revamp. Base case values have been provided for comparison.

Table 1.6.1: Overall material balance

Sl. No	Streams	100% BS-V Case (No Premium gasoline)	100% BS-V Case (With Premium gasoline)	Base Case (KTPA)
Feed				
1	North Gujarat crude	3700	3700	3700
2	South Gujarat crude	1700	1700	1700
3	Mangla crude	800	800	800
4	Kuwait crude	7500	7500	7500
	Total Crude	*13700*	*13700*	*13700*
5	Benzene Import	18	18	18
6	Methanol	11	11	11
7	RLNG import	696	696	562
	Total feed	**14425**	**14425**	**14291**
Products				
1	LPG	499.7	499.7	494
2	Export Naphtha	944	971	1169
3	LAB	120	120	120
4	FGH	14	14	14
5	Gasoline- Normal grade (BS-IV)	0	0	1565
6	Gasoline- Normal grade (BS-V)	1899	1631.7	0
7	Gasoline- Premium grade (BS-V)	0	240	0
8	Heavy reformate to IOCL Guwahati refinery	60	60	60
9	Kerosene	500	500	1000
10	ATF	400	400	400
11	PCK	70	70	70

Sl. No	Streams	100% BS-V Case (No Premium gasoline)	100% BS-V Case (With Premium gasoline)	Base Case (KTPA)
12	HSD (BS-IV)	0	0	6434
13	HSD (BS-V)	6827	6827	0
14	Bitumen	430.7	430.7	430
15	Coke	663	663	663
16	Fuel Oil sales- regular grade	160	160	160
17	Fuel Oil sales- Low sulphur	218	218	218
18	Fuel Oil sales - High sulphur	30	30	30
19	Sulphur	102	102	101.4
20	Fuel & loss *(Including FCC coke)*	1487 (10.85 wt% on total crude)	1487 (10.85 wt% on total crude)	1363 (9.95 wt% on total crude)
	Total Products	**14425**	**14425**	**14291**

1.7 Utility Systems

Following new Utility systems shall be implemented along with the new process units. These are after considering integration & centralization with existing utility system.

Table 1.6.2: New Utility systems

UTILITY SYSTEM	DESCRIPTION
Raw water system	The incremental requirement of 140 m3 of raw water from additional facilities shall be made available from the existing facilities.
Recirculating Cooling water	• A new cooling tower cell and cooling water pump of 4000 m3/hr capacity each is to be added with North Block Cooling Tower. • A new cooling tower cell and cooling water pump of 4000 m3/hr capacity each is to be added with South Block Cooling Tower
DM Water	Additional requirement of 65 m3 of DM water shall be made available from the existing facilities.

UTILITY SYSTEM	DESCRIPTION
Steam	Additional net requirement of 20TPH shall be made available from the existing facilities.
Power	Additional requirement of 13.5 MW power shall be made available from the existing facilities.
Condensate handling	A new Condensate Polishing Unit with a capacity of 30 TPH (1W+1S)
Internal Fuel Oil and Fuel gas	Additional requirement of 1500 Nm3/hr of fuel gas shall be made available from the existing facilities.
Compressed Air System	Additional 1500 Nm3/hr of instrument air shall be required for additional facilities envisaged under BS-V project. To meet this requirement a new Instrument Air dryer of 5000 nm3/hr and associated facility is envisaged.
Nitrogen	Additional requirement of 160 Nm3/hr of Nitrogen for additional facilities shall be made available from the existing facilities.

1.8 Offsite System

The offsite facilities of the refinery shall be augmented by adding a new storage tank and pump.

Table 1.8.1A: New storage tanks

Sl. No	Service	No of Tanks	Type	Liquid stored capacity of each tank (kL)
1	New DHDT/FCC Gasoline Desulphurization Unit intermittent feed storage	1	Floating roof	20,000

Table 1.8.1B: New pump

Sl. No	Service	No of pumps	Flow (m^3/hr)	Type
1	New DHDT Unit / FCC Gasoline Desulphurization Unit feed pumps	1W+1S	250	Centrifugal Motor driven

1.9 Flare System

A new flare system is envisaged as a part of this project in place of existing flare as advised by IOCL, to handle the load of existing refinery, incremental load due to revamp of units for 100% BS-IV and incremental loads due to new units for 100% BS-V production. The stack diameter of new flare shall be 84".

1.10 Conclusion

With a new DHDT, FCC gasoline desulphurization unit and a new Hydrogen Generation Unit along with revamps of existing MSQU and Isomerization units, the refinery shall be able to produce all gasoline and diesel products conforming to BS-V specifications at 13.7 MMTPA capacity along with enhanced production of gasoline and diesel while reducing production of naphtha and Kerosene as compared to existing product slate.

The total cost for new facilities under 100% BS-V auto fuel production project has been estimated as 2502.61 Crores.