Prefeasibility Report for Proposed Floating LNG Terminals in Tapi River estuary at Hazira, Gujarat

ESSAR ENERGY SERVICES LIMITED

JUNE 2016

ESSAR
PORTS

ESSAR ENERGY SERVICES LIMITED

Prefeasibility Report for Proposed Floating LNG Terminal at Hazira

This report is prepared for the use of Essar Energy Services Limited, Hazira, Regulators and relevant stakeholders solely as part of the subject project's Environmental Clearance process. Information provided (unless attributed to referenced third parties) is otherwise copyrighted and shall not be used for any other purpose without the written consent of Essar Energy Services Limited (EESL).

Report Details			
Proposal No.	EESL/EIA/LNG TERMINAL	**Release Date:**	June 13, 2016
Report No.	1	**Version**	1
Prepared By	Ashutosh Mathur		
Reviewed By	V.Vaidyanathan		
Approved By	Capt. S. Das , CEO		

Office:

27 KM Surat Hazira Road, Surat -394270;

E-mail: lngterminal@essar.com T:+91-261-668-2171; F:+91-261-668-2296

CONTENTS

1 LIST OF KEY ABBREVIATIONS

Item	Description
ALARP	As low as reasonable practicable
BOG	Boil Off Gas
DRI	Direct Reduced Iron
FSRU	Floating Storage and Regasification Unit
FSU	Floating Storage Unit
GAIL	Gas Authority of India Limited
LNG	Liquefied Natural Gas
LNGC	Liquefied Natural Gas Carrier
MMSCFD	Million Metric Standard Cubic Feet Per Day
MMSCMD	Million Metric Standard Cubic Meter Per Day
MTPA	Million Tonnes Per Annum
MoEF	Ministry of Environment and Forests
MW	Mega Watt
ONGC	Oil and Natural Gas Corporation
PNG	Piped Natural Gas
PIANC	Permanent International Association of Navigation Congresses
RLNG	Regasified Liquefied Natural Gas
SIGGTO	The Society of International Gas Tanker and Terminal Operators
SCM	Standard Cubic Metre

2 EXECUTIVE SUMMARY

2.1 BACKGROUND

Essar Energy Services Limited (EESL) is a wholly owned subsidiary of Essar Bulk Terminal Limited (EBTL), a company under Ports business division of Essar Group which operates a port facility at Hazira in the mouth of the Tapi estuary. EBTL primarily handles cargo such as Iron Ore, Coal, Limestone etc. to meet the raw material requirements of Essar Steel and Essar Power plant at Hazira. EBTL also handles finished Steel Products of Essar Steel for Export/Coastal movement and Commercial cargo to cater to the requirement of the industries in the hinterland.

EBTL is presently operating a 550m long Deep Draught Berth and 1100m berth is under construction at Hazira, Surat under Magdalla group of ports of Gujarat Maritime Board (GMB).

For the expansion and development of various port facilities, EBTL received the Environment & CRZ clearance from MoEF&CC by letter dated 6th May 2014 which includes handling up of Petroleum and Chemical products in the reclaimed area.

2.2 PROJECT BRIEF

Essar Steel has set up a 10.0 MTPA steel plant at Hazira of which 6.8 MTPA steel capacity (~70 %) is dependent on gas. Further 1015 MW power plant capacity at Hazira is gas based both of which has remained idle due to high prices of LNG in the past.

Due to the current policy of the Government of India gas is not available for steel as it is not a priority sector. For economic viability of the steel and power plants it is essential that the plant operates with LNG sourced from various places outside the country. The current fall in prices of LNG has made LNG imports viable in India. LNG can be imported at an economical cost to cater to the demand of Essar Steel and Essar Power plants as well as third party customers which are connected to the grid via pipeline.

To meet the high demand of Natural Gas (NG) by Essar Steel and Essar Power and also to cater to the gas demand of nearby industries , EESL proposes to develop an LNG import, storage, regasification and bulk natural gas supply terminal at Hazira.

PHASE-1 :- Development of FSRU based LNG Terminal-1

In the Phase-1, EESL proposes to develop a Floating Storage Re-gasification Unit (FSRU) based LNG terminal (Project) within a 1.7 km waterfront stretch starting at 550 m from the end of the existing 550 m berth up to the end of the North Reclamation (as per layout). Exact location of FSRU will be finalized after completion of necessary risk assessment, environment impact assessment and other related studies.

.

The FSRU based terminal, located at the mouth of Tapi river where the parent company M/s Essar Bulk Terminal Limited (EBTL) has been granted EC & CRZ clearance for establishment of berths to accommodate various types of cargo and shipping activity along with reclamation of intertidal area for development of Port Back up Facilities.

Conceptual design and flow of operations of the proposed project includes the following:

1. Reception of LNG: LNG will be imported via LNGC carriers and unloaded via flexible hoses to the floating storage and regasification facility (FSU + FSRU of storage capacity ~ 265,000 cbm and regasification capacity of 750 MMSCFD)
2. LNG will be stored in the floating facilities at a temperature of -161 deg C and regasified via LNG vaporizers
3. RLNG will be transferred from the floating facilities (FSU + FSRU) to onshore via unloading arms/gas pipeline which will deliver gas to off takers such as Essar Steel and Essar Power and other third party customers connected to the grid.

The Project broadly comprises of the floating storage and regasification of LNG along with seawater front/marine facilities within the port harbor area, pipeline to transfer RLNG to coast and land based developments. The proposed LNG Terminal-1 shall have a peak handling capacity of up to 6 MTPA.

The project will be implemented with all necessary safety measures in the shortest time period, with an optimum Capital Expenditure.

PHASE-2:- Development of FSRU based LNG Terminal -2

In the Phase-II, EESL plans to develop, another FSRU based terminal south of the Phase 1 location as per layout which will have following facilities. Exact location will be finalized post risk assessment, environment impact assessment and other related studies. .

1. Reception of LNG: LNG will be imported via LNGC carriers and unloaded via flexible hoses to the floating storage and regasification facility (FSU + FSRU of storage capacity ~ 265,000 cbm and regasification capacity of 750 MMSCFD)
2. LNG will be stored in the floating facilities at a temperature of -161 deg C and regasified via LNG vaporizers
3. RLNG will be transferred from the floating facilities to onshore via unloading arms /gas pipeline which will deliver gas to off takers such as Essar Steel and Essar Power and other third party customers connected to the grid.

The Project broadly comprises of the floating storage and regasification of LNG along with seawater front/marine facilities within the port harbor area, pipeline to transfer RLNG to coast and land based developments. The proposed LNG Terminal-2 shall have a peak handling capacity of up to 6 MTPA.

The project will be implemented with all necessary safety measures in the shortest time period, with an optimum Capital Expenditure.

2.3 PROJECT LOCATION

The project will be set up in the water front (Tapi river estuary) & reclaimed area as approved by MoEF vide letter dated 6th May 2016. The project location is 30km from the Surat city and 3.5 km from Hazira Village. EESL at Hazira is along the western shore of the Tapi estuary adjacent to the steel and power complex and the port of Hazira Pvt. Port Limited (HPPL).

Hazira is a notified industrial area with companies such as HPPL (Shell LNG Terminal), Adani Hazira Pvt. Port Ltd. (AHPPL) , Essar Steel, Essar Power, Larsen and Tubro, Reliance industries, NTPC, Kribhcoo, ONGC etc.

There are also 6 villages within 10 km of the proposed project. They are well-developed with facilities such as school, primary health center and public transport.

Since the proposed project will be set-up in the waterfront and partly on the reclaimed area approved as per the Environment Clearance of EBTL, there is no additional land requirement and there are no resettlement and rehabilitation issues.

3 INTRODUCTION

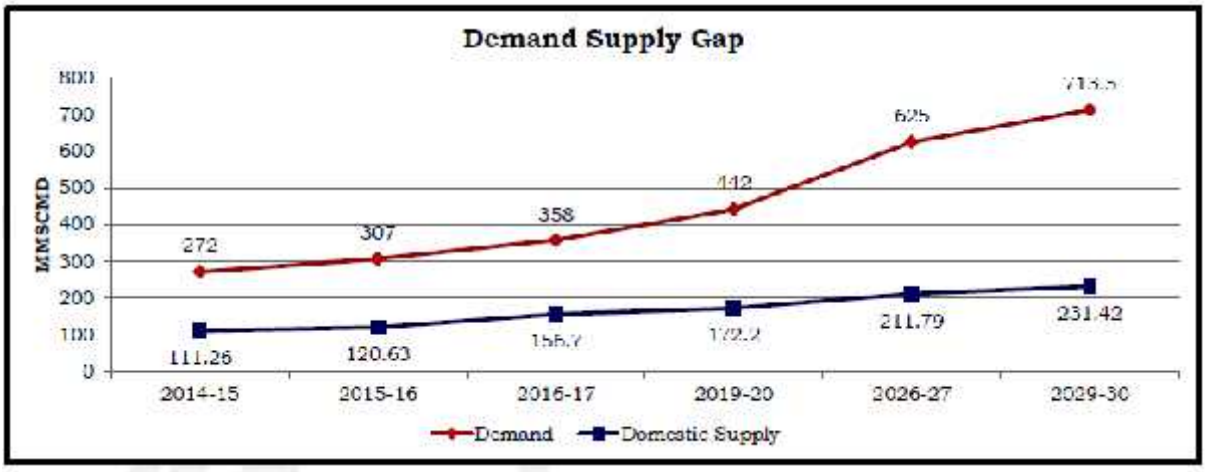
3.1 NEED FOR THE PROJECT

The current fall in LNG prices has resulted in imports of LNG becoming financially viable which is necessary for the survival and operations of the gas based Essar Steel plants (6.8 MMTPA capacity) and idle gas based Essar Power plants (1015 MW) at Hazira towards which approximately Rs. 40,000 Crores has been invested. The development of this project is critical for import of LNG at a competitive rate for the operations of the Essar Steel and Power plants. In addition, the LNG can be supplied to third party companies which are connected to the grid via pipeline.

Indian economy is expected to continue to be amongst the fastest growing economies of the world. Considering the increasing demand for energy in India and the limited domestic availability of fuel resources, the contribution of imported fuels in the country's energy mix is on the rise. In this backdrop, the Natural Gas usage is bound to increase given the growing affordability and rising demand.

Natural gas is a clean and efficient fuel unlike coal which has lower efficiency and high levels of environment concerns. Government of Gujarat in their LNG policy - 2012 have envisioned LNG receiving and regasification terminals along its coast thus making Gujarat as "LNG Gateway" of the country by year 2020. As per the policy GOG plans to develop new capacities for receiving and regasification of LNG of over 20 MTPA along the coast of Gujarat by year 2020.

The government of India in its policy document "Hydrocarbon Vision 2025" outlined India's goal to significantly increase gas usage by 2025. This ambition is mainly an effort to wean the overall Indian economy off its dependence on coal and Liquid fuel for environmental reasons. Currently gas based power generation is around 9% of total power production in India, which is much below world average of 22%.



As per the available industry data, it is observed that the domestic availability and productions are inadequate to meet the existing demand and the ever rising demand of natural gas in the country. Import of gas will be inevitable to meet the growing demand. The proposed project will be developed with the partnership of Govt. of Gujarat, after meeting the captive requirement, Gas will be supplied within the state of Gujarat through the national grid passing through Hazira.

There is substantial gap in demand and supply of Natural Gas (NG) in India. Essar Steel, Hazira has 6.8 MTPA of Steel making capacities through Hot Briquetted Iron (HBI) mode which utilizes NG as the prime source of fuel also Power plants of Essar at Hazira has around 1015 MW of capacity being idle due to non-availability of NG at competitive price. Apart from the above, Natural Gas demand exists from fertilizer and other nearby industries.

3.2 TRAFFIC STUDY

Gujarat has been one of the earliest oil/ gas producing states in the country with Ankleshwar and Mehsana being amongst the earliest gas field discoveries in the country. The Gujarat region is the second largest gas-producing region in the country with a share of 10% of the overall gas production in the country. The existing gas supply sources in Gujarat are provided in table below:

NATURAL GAS SUPPLY

Table 1: Existing supply sources in Gujarat

S. N	Supplier	Source	Volume (MMSCMD)
1	ONGC	Onshore fields located near Ahmedabad region & Ankleshwar / Surat region and offshore (JV) fields in the Arabian Sea (Western Offshore – including PMT supplies)	20
2	GSPC/ Niko Resources	Hazira gas field	0.6
3	Cairn	CB-OS2 field in the Cambay basin	0.8
4	Petronet LNG Limited (PLL)	LNG from Ras Gas, Qatar	8
5	Shell, Hazira	LNG spot cargo	0
6	RIL	KG D6 Gas	26
	Total Volume (MMSCMD)		**55.4**

*Source: CRISIL Analysis

Reliance Industries Limited is the largest existing gas supplier to the state. ONGC is second largest and is operating gas fields in the Mumbai offshore and the Gujarat onshore regions and supplies natural gas to GAIL who markets it to the final consumers.

The other suppliers include GSPC and Niko resources producing gas from its fields located in Hazira; Cairn Energy supplying gas from its offshore fields -- Lakshmi and Gauri and the Cambay basin. Both GSPC and Cairn directly market the gas produced from their fields to the final consumers in the state.

Gujarat in addition to having access to domestic gas also is the only state in the country to have LNG import facility at two locations viz. Dahej & Hazira.

- Petronet LNG Limited (PLL) commissioned its Dahej terminal in April 2004 with an installed capacity of 7.5 MMTPA. PLL is sourcing its supplies from Qatar (RasGas) through a 25-year long-term contract for 7.5 MMTPA of LNG. PLL sells gas to GAIL, IOCL and BPCL that sell to consumers in Gujarat and other Northern States.
- Shell-Total combine commissioned the LNG regasification terminal at Hazira, Gujarat with an initial capacity of 2.5 MMTPA in April 2005, now expanded to 3.7 MMTPA throughput capacity. Hazira LNG has entered into contracts with both Gujarat State Petronet Limited & GAIL for transporting gas within Gujarat.
- In addition to the imports of LNG and domestic gas in Gujarat is being delivered from new finds in KG Basin, ONGC's recent gas discoveries including Vasai West and NMT-2 in Western Offshore would flow into Gujarat further consolidating the State as a major consumption and transit point.

The exhibit below provides the gas supply projections from FY2009 to FY 2020

Table 2: Supply projections for Gujarat

MMSCMD	2009	2012	2015	2020
ONGC - Onshore	5	4	3	1
PMT / HBJ Volumes	9	6	4	2
PLL	13	18	18	18
Shell	6	8	8	8
RIL	15	30	30	30
GSPC - KG Basin	0	8	8	8
GSPC – LNG	0	0	13	13
Cairn	0	1	0	0
CBM	0	3	3	5
New Gas finds	0	0	6	16
Total	**47**	**78**	**96**	**101**

*Source: CRISIL Analysis

NATURAL GAS DEMAND

Currently, Gujarat accounts for approximately 32% gas consumption in the country. The per capita consumption of natural gas in India is only around 29 SCM as compared to the world average of 363 SCM. There is clear room for growth even accounting for the fact that gas may not be able to displace coal in the power sector to the extent it may have in other developed countries.

Broadly, the following factors are expected to drive the increased consumption of natural gas in India:

- **Macroeconomic setting and policy making**

Overall macroeconomic conditions in the economy will set the demand for energy and the growth of energy demand. India has been enjoying higher growth rates since the early 1990s because of economic reforms. This growth will contribute to greater demand for energy.

- **Fall in LNG Prices**

The recent crash in prices of crude oil has led to a reduction in price of LNG as LNG prices follow crude prices with a time lag. Decrease in LNG prices has made LNG imports in India a viable option for operation of gas based power plants which are currently idle. and is likely to spur growth in gas consumption

- **Growth of end-user segments**

The robust growth outlook for the Indian economy and the resultant increase in the end–user consumption of the natural gas is expected to drive the natural gas market in the future. Reduction in gas prices has made supply of PNG more viable for domestic consumption in both urban and rural cities. Recent fall in the natural gas prices will also make gas based power plants able to competitively run on imported LNG. These units are currently shutdown or operating at very low Power Load Factors. Gas based iron making steel units will also benefit from the fall in LNG prices.

- **Regulation**

The PNGRB Act, 2006 is an overarching framework that would attract, enable and sustain much needed capital into the entire sector. It will also take the shape of protecting consumer interests and those of industry participants. With regulatory clarity, it is envisaged that gas sector would develop in a big way with a number of cities being connected with gas pipelines and city gas distribution networks supplying natural gas to consumers.

- **Environmental concerns**

With India becoming a signatory to the Kyoto Protocol, there is an emphasis on reduction of green house gas emissions. Gas is preferred as it has lower carbon emissions per unit of energy generated. The promotion of gas can earn certified emission reduction credits and CDM project developers can gain monetarily from such projects / transactions.

- **New uses of Natural Gas (eg. co-generation)**

Natural gas can be considered as “single fuel solution”, replacing power and fuel for heating and cooling requirements. Use of gas in co-generation of power, refrigeration and heating (CCHP- Combined Cooling, Heating & Power) gives 75% to 90% thermal efficiency. Given the economic advantage in terms of efficiency, industrial and commercial institution are likely to switch to the single fuel application, once natural gas becomes available.

The demand for gas can be categorized as under;

- **Existing gas demand:** The existing gas demand is defined as the present demand for natural gas by the entity based on current supplies from all sources or its gas allocation, whichever is higher.
- **Switching gas demand:** Switching gas demand is defined as the demand resulting from switching of units operating on alternate fuels such as Naphtha/

Fuel Oil/Light Diesel Oil to gas when the same is made available at economical price. This demand is expected to materialize gradually over the forecast period.

- **Gas demand from capacity additions:** This is the gas demand from green field / brown field capacity additions in various sectors and has been estimated on the basis of the demand/ supply outlook for the sector till 2020. This includes demand from capacities that have been announced and are expected to come up to meet the demand / supply gap in the sector.

The projections of the gas demand is depicted in following exhibit.

Table 3: Gas Demand build-up in Gujarat FY2009-2020

Sector	2009	2012	2015	2020
Power	19	32	43	43
Fertilizer	10	12	12	12
Industry	35	49	53	73
Distribution	7	10	14	19
Total (MMSCMD)	**70**	**102**	**122**	**146**

*Source: CRISIL Analysis

3.3 TRAFFIC ESTIMATE FOR ESSAR LNG TERMINAL

Phase-1 Total captive Requirement of LNG from proposed LNG terminal will be around 3.9 Million MTPA and the remaining 2.1 Million MTPA shall be given to the national Gas Grid Passing through Hazira.

Company	Requirement	Quantity (MMSCMD)
EOL- Process	Hydrogenation & Heating	1.6
EOL- Power	Power-220 MW	1
Total EOL		2.6
EStL-Net	Process Unit	6.5
Essar Power and Bhander Power units	Power – 1015 MW	5
Total Essar Group (MMSCMD)		**14.1**
Total Essar Group (MMTPA)		**3.9**
Total Third Party (MMSCMD)		7.5
Total Third Party (MMTPA)		2.1
Total (MMTPA)		**6**

In phase II additional 6 MTPA of LNG is proposed to be completely supplied to the grid for commercial use to meet the future term demand potential of LNG by Power, Steel and other industrial sectors connected on the grid.

3.4 EMPLOYMENT GENERATION

The Proposed LNG Terminal development will generate approximately employment for 100 people directly in phase I and 200 people in phase II. There will be indirect employment generation of around 300 people from the Project.

This project is critical for the survival of Essar Steel which will directly employ an additional 1000 people and indirectly employ an additional 5,000 people and similarly for Essar Power which will directly employ additional 300 people and indirectly employ additional 1000 people. Moreover, since existing operations of both Steel and Power plants are not sustainable on long term basis, existing employees of Essar Steel and Essar Power may also be impacted if the terminal is not developed.

4 PROJECT DESCRIPTION

EESL proposes to develop LNG import, storage, regasification and bulk natural gas supply terminal at Hazira. The proposed Terminal will have capacity of 6 MTPA in phase I and additional 6 MTPA in Phase II.

Phase I : **LNG Terminal-1 at North Reclamation area**

The project envisages a jetty & Floating Storage and Re-gasification Unit (FSRU) based LNG terminal to be developed in a location within a 1.7 km waterfront stretch starting at 550 m from the end of the existing 550 m berth upto the end of the North Reclamation (as per layout). Exact location of FSRU will be finalized after completion of necessary risk assessment, environment impact assessment and other related studies.

The terminal will be developed to meet the demand of natural gas for idling natural gas based Essar Steel units and Power plants of Essar at Hazira and also for supply to the natural gas grid for catering the nearby industries.

The operations will include the following:

1. Reception of LNG: LNG will be imported via LNGC carriers and unloaded via flexible hoses to the floating storage and regasification facility (FSU + FSRU of storage capacity ~ 265,000 cbm and regasification capacity of 750 MMSCFD)
2. LNG will be stored in the floating facilities at a temperature of -161 deg C and regasified via LNG vaporizers
3. RLNG will be transferred from the floating facilities (FSU + FSRU) to onshore via unloading arms/gas pipeline which will deliver gas to off takers such as Essar Steel and Essar Power and other third party customers connected to the grid.

The Project broadly comprises of floating storage and regasification of LNG along with seawater front/marine facilities within the port harbor area, pipeline to transfer RLNG to coast and land based developments as given below:

- Water front / marine facilities:
- Development of jetty with necessary floating storage and regasification facilities and LNG carrier(LNGC) (adjacent / side-by-side) berthing and mooring on to the jetty ;
- Creation of necessary facilities (through capital dredging) for the movement of FSRU / LNG carrier ships (entry channel, turning circle, berthing / mooring pockets) to and from proposed jetty with required navigational aids;
- Berthing, Mooring and associated structures including the Berthing/Mooring aids and marine furniture's for the safe Berthing/Mooring and operation of FSRU, FSU and LNGC.
- Terminal connectivity with Service road, Area lighting, Adequate Green Belts around the Terminal Boundaries.
- Sea Water Intake (mounted over the FSRU) and outfall/ Discharge system.

Firefighting system, Electrical and other utilities including the required Instrumentation and Automation systems.

- Long term berthing of FSU /FSRU (almost permanent) to import, store, regasify LNG and for sending out RLNG;
- 3 Flexible hoses for transfer of LNG from LNGC to FSU/FSRU
- 6 Flexible hoses/loading arms for transfer of LNG from FSU to FSRU (in case FSU and FSRU are two separate units)
- 3 high pressure (HP) send out hoses for discharge of gas from FSRU into the pipeline ;
- Inland pipeline of about 6 km length to transport RLNG to offtake point within Essar Steel Complex which is also connected to Essar Power units and the gas grid
- Gas metering and pressure regulating system including filters;
- Cold Vent for maintenance works;
- Electrical/ Diesel generator set for emergency backup at shore.

The proposed LNG Terminal-1 shall have a peak handling capacity of up to 6 MTPA. The project will be implemented with all necessary safety measures in the shortest time period, with an optimum Capital Expenditure.

Phase-II : LNG Terminal-2 at South Reclamation area

In Phase-II, EESL plans to develop one more FSRU based terminal south of the Phase 1 location as per layout which will have following facilities:

1. Reception of LNG: LNG will be imported via LNGC carriers and unloaded via flexible hoses to the floating storage and regasification facility (FSU + FSRU of storage capacity ~ 265,000 cbm and regasification capacity of 750 MMSCFD)
2. LNG will be stored in the floating facilities at a temperature of -161 deg C and regasified via LNG vaporizers
3. RLNG will be transferred from the floating facilities to onshore via unloading arms/gas pipeline which will deliver gas to off takers such as Essar Steel and Essar Power and other third party customers connected to the grid.

Exact locations of the terminal units will be finalized post risk assessment, environment impact assessment and other related studies.

The Project broadly comprises of the floating storage and regasification of LNG along with seawater front/marine facilities within the port harbor area, pipeline to transfer RLNG to coast and land based developments as given below:

- Water front / marine facilities:
- Development of jetty with necessary floating storage and regasification facilities and LNG carrier(LNGC) (adjacent / side-by-side) berthing and mooring on to the jetty ;
- Creation of necessary facilities (through capital dredging) for the movement of FSRU / LNG carrier ships (entry channel, turning circle, berthing / mooring pockets) to and from proposed jetty with required navigational aids;

- Berthing, Mooring and associated structures including the Berthing/Mooring aids and marine furniture's for the safe Berthing/Mooring and operation of FSRU, FSU and LNGC.
- Terminal connectivity with Service road, Area lighting, Adequate Green Belts around the Terminal Boundaries.
- Sea Water Intake (mounted over the FSRU) and outfall/ Discharge system.

Fire fighting system, Electrical and other utilities including the required Instrumentation and Automation systems.

- Long term berthing of FSU /FSRU (almost permanent) to import, store, regasify LNG and for sending out RLNG;
- 3 Flexible hoses for transfer of LNG from LNGC to FSU/FSRU
- 6 Flexible hoses/loading arms for transfer of LNG from FSU to FSRU (in case FSU and FSRU are two separate units)
- 3 high pressure (HP) send out hoses for discharge of gas from FSRU into the pipeline ;
- Inland pipeline of about 6 km length to transport RLNG to offtake point within Essar Steel Complex which is also connected to Essar Power units and the gas grid
- Gas metering and pressure regulating system including filters;
- Cold Vent for maintenance works;
- Electrical/ Diesel generator set for emergency backup at shore .

The proposed LNG Terminal-2 shall have a peak handling capacity of up to 6 MTPA and the overall capacity will become 12 MMTPA after phase-2.The project will be implemented with all necessary safety measures in the shortest time period, with an optimum Capital Expenditure.

4.1 TYPE OF PROJECT

The Project is linked to the steel plant and power plants of Essar. Project location is on the Tapi estuary & on the land reclaimed from dredging activity for which EC & CRZ Clearance has been granted to the Parent company Viz EBTL in May'2014. The RLNG will be used for both captive and commercial purpose.

4.2 PROJECT PROPONENT

In view of existing shortage in natural gas in the country, the natural gas import is unavoidable to fill up the increasing supply-demand gap. This project shall have priority to supply natural gas within Essar and excess gas will be supplied through the gas grid network of the Gujarat state/central grid.

Table : Brief profile of the Company

Name of the Company	Essar Energy Services Limited
Registered Office	Essar House, 11 K.K.Marg, Mahalaxmi ,Mumbai-400034, Maharashtra, India.

Site Office	27 K.M. Surat Hazira Road, Surat -394270
Date of Incorporation	June 25, 2008
Sector	Ports & Terminals
Constitution	Public Limited Company
Stock Listing	Not Listed
Site Location	Hazira , Surat

4.3 DESIGN CONCEPTS - REGASIFICATION TECHNOLOGY

FSRUs are designed to incorporate certain equipment and processes on board to accomplish the task of offshore LNG vaporization. There exist two distinct types of re-gas concept, with a number of manufacturers for each concept. The two re-gas concepts are either an open loop or a closed loop system. The fundamental difference between the two systems is on the medium used to heat the LNG and convert it from a cold liquid to an ambient temperature gas is fully contained within the FSRU (closed loop) or is brought in from outside (in this case seawater) and sent out again to outside of the FSRU (open loop).

VAPORIZATION OF LNG

To accomplish the task of offshore LNG vaporization FSRUs may be operated in one of the three ways:

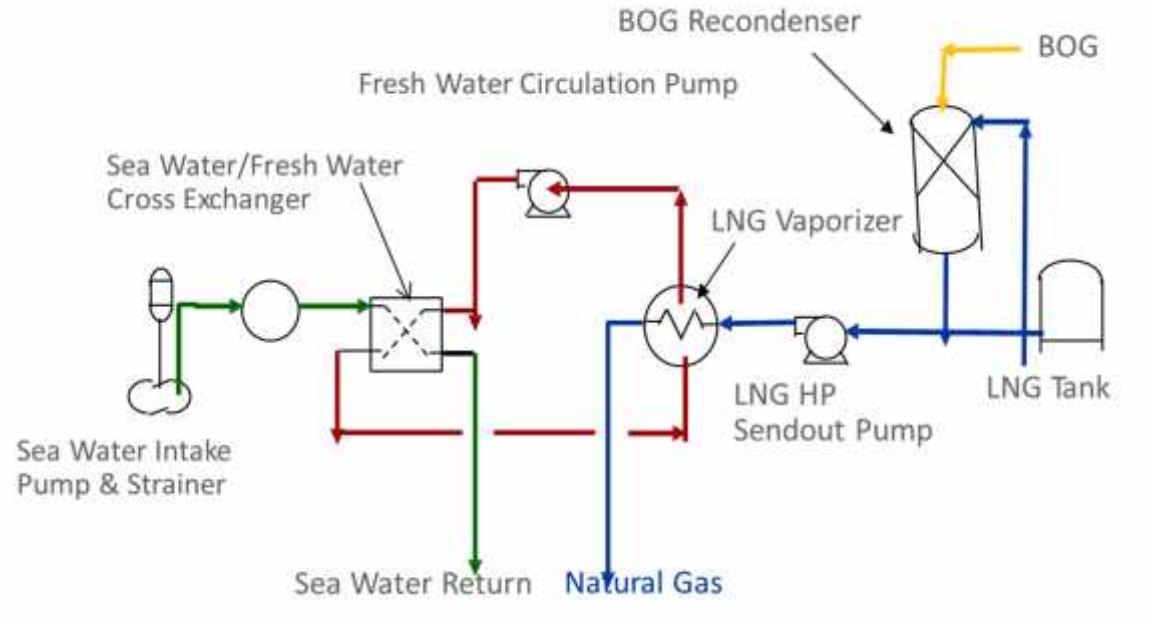
- Closed-loop mode, in which LNG vapour is burnt in the FSRU boilers to produce steam which is then used to heat fresh water or glycol circulated through the shell-and-tube vaporizers in the re- gasification plant.
- Open-loop mode, in which relatively warm seawater is drawn in through the FSRU's sea chests. This warm seawater is used as a heat source and passed through the shell of the shell-and-tube vaporizers, causing the vaporization of the LNG. During this process, the temperature of the seawater is lowered.
- Combined mode, in which seawater at temperatures between 45 and 58 degrees Fahrenheit can be used when heated by steam from the FSRU boilers to provide sufficient heat for the vaporization of the LNG

Closed loop systems must create heat by burning LNG rather than use the ambient heat of seawater. As such whilst closed loop systems will not interact with the surrounding water they do produce larger amounts of air emissions than an open loop system.

Open Loop System

In the proposed project at Hazira an open loop system will be used.

A flow diagram for the open loop system to be used for the long term FSRU option proposed at Hazira is as below.



The FSRU, moored at the proposed location, provides all the functionalities of a land-based terminal and thus includes LNG storage, re-gasification units and their related utilities, metering and analysing unit, cargo transfer systems, safety systems.

For this solution a HP gas pipeline transfers natural gas from the jetty to the grid tie-in point.

Due to the land reclamation and construction of LNG tanks requirements it is proposed that in Phase –I, a FSRU based Terminal will be set up in Tapi Estuary area and in Phase –II, a FSRU based LNG Terminal will be set up south of Phase 1 area.

4.4 PROJECT LAYOUT & PROPOSED CONFIGURATION.

In the layout configuration the FSRU and the LNG carriers will be moored in a parallel banking manner or side by side. LNG will be transferred from the LNG carrier to the floating facilities for storage and regasification by flexible hoses (8 Nos.). After regasification, gas will be transferred through adequate sets of flexible hoses/ un-loading arms.

Re-gasification will be carried out using seawater as the primary heating medium. The seawater is pumped into vaporisers, vaporising the LNG and the sea water is then discharged back into the sea.

LNG sampling for custody transfer and Gas metering and analysis equipment will be provided at the pipeline land fall point station. At the shore, the pipeline will run under ground up to the land fall point station assumed to be the tie-in point to the grid.

The marine structure will consist of the berthing and mooring structures including other associated structures, the quick release hooks, fenders, platform structures and top side equipment (unloading arms, cryogenic pipeline, drain drum, HP arm).

Other Terminal Infrastructures including Well connected Service road for movement of Terminal Maintenance vehicles, Utilities, Fire Fighting systems, Utilities HSE and security systems.

4.5 PRELIMINARY SOLUTION MARINE AND PIPELINE WORKS

All dredging works will be carried out before the LNG facility becomes operational. The size of the turning circle and berth pockets will be subject to detailed study in stage for getting adequate tranquility during Berthing, Mooring and Operation but the preliminary concept is for providing a 600m turning circle, an approach channel width of 300m, and Berth Pockets etc., all to a depth of 14m below chart datum. EESL shall follow appropriate SIGTTO and PIANC guidance for terminal layout.

EBTL has already got approval for 3 turning circles in the channel out of which 1 turning circle is already operational and the other 2 turning circles will be used for phase 1 and phase 2 LNG facilities. Each of the 2 turning circles are yet to be dredged. In addition to turning circle, basin may have to be dredged which will require additional capital dredging of 12 million cum and additional maintenance dredging of 2 million cum.

An HP gas pipeline will transfer gas from the jetty to the grid tie-in point. It is proposed to pre-invest in a pipeline which will able to accommodate the expansion of the terminal. This pipeline would size upto 24", sufficient to accommodate maximum send out volumes.

4.6 PROPOSED LAYOUT

The proposed layout highlighting the 2 locations (location 1 and 2 pertaining to phases 1 and 2 development respectively) for setting up FSRU based LNG terminals is as follows:

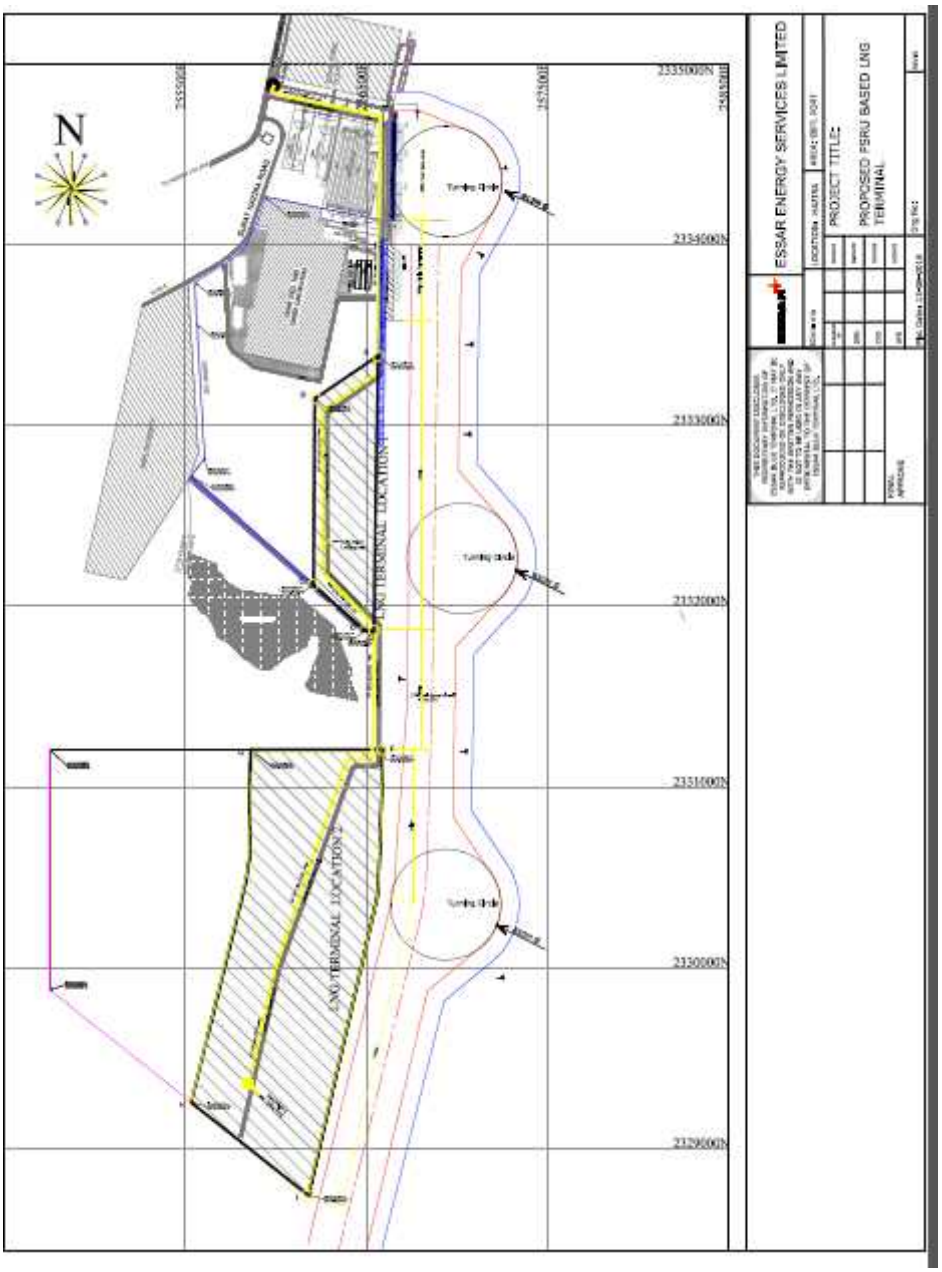


Figure : Proposed Layout of LNG Terminal

The unloading area near the carrier berthing structure would support the primary equipment needed to safely unload LNG, including LNG loading and vapour return arms (hard or flexible); LNG and vapour transfer piping and manifolds; gas and fire detection, fire protection, and firefighting facilities; life-saving equipment; telecommunications equipment; an access gangway; and a small crane.

The re-gasification process takes place on the ship (FSRU). The FSRU will send out High Pressure Natural Gas through HP gas send out arms located on the Jetty.

The main features of the FSRU vessel, its general arrangement, containment system, cargo system machinery, safety, detection & fire-fighting equipments, pollution & waste treatment equipments, control system and communication are described in this document.

The permanently berthed FSRU Terminal concept is assumed to be fully self-sufficient in providing power, water and life-support on-board.

All receiving facilities, marine structures such as Breasting mooring and other associated structures and marine furniture unloading platforms etc those are required together with dredging of the berth pocket, turning circle and access channel connecting to main shipping channel, will be designed to comply with the FSRU vessels

The LNG is contained at a temperature of -161^{o}C and at atmospheric pressure (or slightly above). There are no refrigeration facilities onboard the FSRU; Instead the cargo tanks are made of extremely high performing insulation material to prevent heat leak into the cargo. Temperature rise is extremely low and the typical amount of lost cargo per day (Called boil off gas or BOG) is less than 0.15% of the cargo tank volume. This excess gas is partly reliquefied or partly consumed as fuel. No gas is vented to atmosphere at any time during normal operations.

4.7 FEATURES OF REGASIFICATION UNIT ON FSRU:

Regasification unit on FSRU takes LNG from a cargo tank and warms and pressurizes it for send- out to the pipeline as vaporized natural gas.

LNG enters the regas area at a nominal pressure of 5 to 6 bar. HP Send-out Pumps discharge the LNG at 80 to 100 bar via the send out header to the LNG vaporisers.High pressure LNG is sent to the shell and tube vaporizers where fresh water /propane/glycol with water etc.is used to vaporize the LNG. The vaporizers operate in parallel so one can be taken off line when lower send out rates are required.

Vaporized gas is sent to the custody transfer meters before progressing to the pipeline. High integrity protection systems for both high pressure and low temperature (HIPPS and HITPS) is provided to ensure the final product does not exceed the design conditions of the pipeline.

4.8 DETAILS OF PROPOSED FSRU

DETAILS OF PROPOSED FSRU	
Type of Unit	Non-propelled floating storage and Regasification unit
Design life Fatigue design life	20 years 30 years
Period on site without dry docking	20 years
Plant Description	The LNG enters the regasification area at a nominal pressure of 5 to 6 bar. The HP Send-out Pumps discharge the LNG at approximately 80 to 100 bar via the send out header to the LNG Vaporizers. The high pressure LNG is sent to the shell and tube vaporizers ,which is used to vaporize the LNG.
Send out capacities	Maximum regasification capacity: 750 MMSCFD

Environmental conditions	The limiting environmental conditions are: Sea water temperature (regasification plant design) 15°C to 36°C Sea water temperature drop max. 10°C Ambient temperature: 10°C to 45°C
Boil-off Gas	BOG treatment capacity :8,000 kg/h. The excess boil-off gas shall be sent to the regasification plant by a non- cryogenic oil flooded compressor, where it is condensed in the BOG Recondenser and combined with the LNG for vaporization. The LNG at the inlet of the regasification plant will be subcooled and this subcooled liquid shall be used to re-
Rules and regulations	The FSRU and equipment shall comply with the following main Rules and Regulations: • Rules for Classing Offshore LNG Regasification Terminals • International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) • International Finance Corporation (World Bank Group) Environmental, Health and Safety Guidelines for Liquefied Natural Gas (LNG) Facilities • Code for the Construction and Equipment of Mobile Offshore Drilling Units (2009 MODU Code) • International Convention for the Prevention of Pollution from Ships

4.9 DREDGING

The existing Channel in the Tapi river estuary will be deepened further to 14m draft by EBTL as parts of their expansion as approved vide Env Clearance dated: 06-05-2014. For the proposed LNG Terminals, around 12 million m3 of additional dredging envisaged for the Turning circle and Terminal Berth pockets including any basin required. This additional dredging will be carried out through Cutter suction dredgers in 10 months period. The dredged materials will be used for reclamation. Basin for LNG terminal will lead to additional maintenance dredging of approximately 2 Million m3 per annum for the proposed LNG terminals. The dredged material from maintenance will be disposed in the GMB approved disposal sites. Development of turning circle is part of environment clearance taken for the full port facility.

4.10 DISTANCE TO EXISTING GAS TRANSMISSION INFRASTRUCTURE

From EBTL the gas transmission network of GSPC passes very close at a distance of around 5 km from the proposed terminal location. The Pipeline from the terminal will be connected to the Grid as per the direction of GSPC.

4.11 HEALTH, SAFETY AND ENVIRONMENTAL (HSE) SYSTEM

Studies such as EIA, Risk Assessment, Bathymetry etc. are undertaken to identify and reduce all HSE risks. It is also important to integrate all the elements (health, safety, security, environment and social performance) of HSSE risks as early as possible. All the decisions in the conceptualization stage and during design stage will balance and reduce overall risk. This ensures that the residual risks handed over to the operation group are as low as reasonably practicable (ALARP) and will continue to be managed as part of the Operations Phase of the project

The guiding principle is that the best HSE outcome results from the identification and management of critical HSE issues as early as possible in the project development. For many activities, high-level screening activities or coarse studies are specified in early project stages followed by detailed studies as more data become available.

Competent HSE professionals from owner and operator of the FSRU and Essar will participate in the project from the start to apply the appropriate tools effectively.

4.12 HSE MANAGEMENT IN OPERATIONS

An HSE Management System will be established as the framework for systematically managing all HSE risks; it will define the organisation structure, responsibilities, practices, procedures and resources for managing business and marine activities. It will be the responsibility of senior operations staff to provide leadership and so ensure that an HSE culture is embedded within the entire workforce and that everyone involved on the land-based facilities and FSRU fully understands, participates in and is committed to HSE.

Existing operations will also comply with ISPS standards. A Port Facility Security Officer (PFSO) included in terminal organization will be trained and certified.

Key staff will ensure that process and personal HSSE considerations are fully understood and evaluated throughout the life cycle, from the concept stage, through project execution, start-up and operations and finally to decommissioning. Performance targets will be set and indicators will be established to determine how well the operation is performing in key areas.

An HSE case or safety case will be prepared, which gives an overview of the potential hazards affecting the project, focuses on the major HSSE issues as the design develops, records how these have been controlled or mitigated and, ultimately, provides assurance to regulators and other interested parties of the safety of the facility. It will eventually be developed to become the operational safety case prior to start-up in accordance with regulatory requirements. QRAs, HAZIDs and HAZOPs are supporting elements of the HSSE case.

An Emergency Response (ER) plan will develop contingency plans that focus on the management of all the potential incidents during all phases of the life cycle of the integrated production system.

The FSRU will maintain a crew that is fully trained and competent to deal with emergencies on board and supplemented as required by the local authorities in the event of escalation.

5 SITE ANALYSIS

5.1 LOCATION

The Site Hazira is situated 230 km north of Mumbai, 30 km from Surat city, access is via National Highways 6 and 8 and Surat domestic airport. Four/Six-lane project of NH -6 is underway and widening of the road with flyover on Kribhco and ONGC railway line at Hazira is under construction. The proposed LNG Terminal will be located between following latitude and longitude.

Locations as per layout for the 2 proposed FSRU based LNG Terminals is as follows:

Terminal- 1

Point A:- Latitude: 21^0 05'07.217.9" N Longitude: 72^0 39'24.594" E.

Point B :- Latitude: 21^0 04'59.401" N Longitude: 72^0 39'12.633" E.

Point C :-Latitude: 21^0 04'25.925" N Longitude: 72^0 39'12.869" E.

Point D :-Latitude: 21^0 04'17.767" N Longitude: 72^0 39'22.805" E.

Point E :-Latitude: 21^0 04'17.764" N Longitude: 72^0 39'24.699" E.

Terminal-2

Point F:- Latitude: 21^0 03'56.444" N Longitude: 72^0 39'26.585" E.

Point G :- Latitude: 21^0 03'56.102" N Longitude: 72^0 39'01.387" E.

Point H :-Latitude: 21^0 02'52.570" N Longitude: 72^0 38'50.952" E.

Point I :-Latitude: 21^0 02'36.204" N Longitude: 72^0 39'13.537" E.

Gujarat Map

Essar Bulk Terminal , Hazira – Proposed Location

5.2 HINTERLAND CONNECTIVITY

Hazira is situated 230 km north of Mumbai, 30 km from Surat city, access is via National Highways 6 and 8 and Surat domestic airport. Four/Six-lane project of NH -6 is underway and widening of the road with flyover on Kribhco and ONGC railway line at Hazira is under construction. It is expected that complete 6 lane project will be completed by Dec'2014.

Road and Rail Network: The below Map shows that Surat which is just 40 Km away from Hazira is located on the important broad gauge route that runs between Delhi and Mumbai. This route has double tracks, completely electrified and the tracks are designed to handle faster trains thus ensuring that transportation of cargo are both faster and more efficient as compared with other rail routes.

Figure : Road & Rail Network to Hazira Connectivity to Essar Port

Rail Transportation

It is planned by the GOG and Railways that the railway line will be laid from Main Railways line between Surat Vadodara station of western Railways to Hazira. It is estimated that 3 years would be required to lay the railway line and Connect Hazira to Railways network.

5.3 METROLOGICAL DATA

Hazira industrial belt on the banks of the Tapi estuary falls in the Surat District of Gujarat. Prior to 1980s when industrialization commenced, Hazira region comprised of 3 islands connected by a causeway. The islands with villages Mora, Suvali and Hazira were in the midst of extensive tidal flats particularly on the seaward side. Large areas of these flats have been reclaimed over the years for setting-up of industries and their townships. Surat is roughly 27 km from Essar establishment at Hazira and is well connected to the city by road and railway. The 720 km long Tapi River originates near Multai in Madhya Pradesh and after meandering through the hilly terrain of the Western Ghats before entering the coastal alluvial plains of Gujarat to meet the Arabian Sea near Hazira. The flow of the Tapi to the sea is controlled by the Ukai and Kakrapar Dams constructed on the river at 141 and 115 km upstream respectively. Mean runoff of Tapi which was 17982 million m3 in 1975 has reduced considerably after the construction of dams. In 1995 a weir-cum-causeway was constructed across the river at Rander, about 2.5 km upstream of Surat that prevents seawater incursion further inland. The Surat District has an extensive network of canals originating from the Kakrapar Dam and other weirs downstream. The industries at Hazira receive water through the Kakrapar Right Bank Canal, Jahangirpura Weir and from the pump-house at Variav. The ground water in the Hazira belt generally has high total dissolved solids due to ingress of salinity

5.4 CLIMATE

The climate at Hazira is tropical and may be characterized by annually recurring seasons:

Table-1 Hazira Climate variation

Period	Season	Characteristics
Mid Jun-Sept	SW monsoon	Winds mod-strong, Occasional cyclones
Oct-Nov	Interim Period	Winds lighter, Occasional cyclones
Dec-Feb	NE monsoon	Winds light NE, effectively no cyclones
March-Mid June	Hot season	Winds mod-strong SW, May/June frequent mostly distant cyclones

5.4.1 Temperature

The month of January is the coldest month of the year with mean maximum and minimum temperatures as 31.5°C and 14.3°C respectively. Likewise June is the hottest month of the year with maximum and minimum temperatures as 33.8°C and 26.6°C respectively.

5.4.2 Rainfall

The south-west monsoon normally enters into the state in the first week of June and prevails till last week of September. The average annual rainfall in the study area

district is 1209.4 mm. Majority of rainfall (85%) is received under the influence of south-west monsoons during June to September. January and February are generally the driest month of the year.

5.4.3 Humidity

The relative humidity was observed to be high during the monsoon months from June to September. The relative humidity was lower in other months of the year, with the lowest being recorded in the months of November to January.

5.4.4 Winds

The annual average wind speed ranged between 1 and 19 km/h with predominant wind in the SW direction during March-October and NE in November-February, and (iv) the relative humidity in the region varied from 32.8% (March) to 86.6% (August).

Table :3 Average meteorological conditions of the project area district

Month	Mean Temp. Daily (°C)		Rainfall (mm)	No. of rainy days	Relative Humidity (%)	
	Max.	Min.			8:30 hrs	17:30 hrs
January	31.5	14.3	0.0	0.0	65	39
February	33.5	16.1	0.4	0.0	62	33
March	36.2	20.1	1.5	0.2	64	32
April	37.7	23.7	0.3	0.0	66	38
May	36.4	26.4	7.3	0.3	68	55
June	33.8	26.6	249.3	8.0	79	70
July	31.0	25.4	417.7	15.4	88	79
August	30.6	25.0	299.4	13.2	89	79
September	32.2	24.4	190.7	7.6	86	70
October	35.9	23.0	27.2	1.2	72	49
November	35.3	19.3	13.0	0.8	61	43
December	32.9	16.1	2.6	0.1	65	43
Total			1209.4	46.8		

Source: India Meteorological Department (IMD)

5.5 TIDES

The funnel shape of the Gulf coupled with the resonance effect results in exceptionally high tides in the region. Along its eastern shore the mean spring high water range increases from 5.7 m at Hazira to 7.4 m at Luhara Point.

Tapi estuary experiences fairly high tidal ranges in the mouth segment due to its proximity to the Gulf. Marked changes in the tidal range and durations of flood and ebb phases, however, occur as the tide progresses along the length of the estuary. Available information indicated that the spring rise of 5.7 m at Hazira decreases to 4.5 m at Magdalla and further down to 2.3 m at Surat. During neap, this decrease is from 2.3 m at Hazira to 1.7 m at Magdalla and 0.4 m at Surat.

There are instances when high precipitation in the catchment in the monsoon season leads to considerable freshwater dominance in the estuary. During such instances, flood duration of 6 h in the open shore reduces to 4 – 5 h in the estuary mouth and is barely 2 h at Surat with the corresponding increase in the ebb period. Decrease in the flood period, though to a lesser extent, occurs into the estuary during the dry season also.

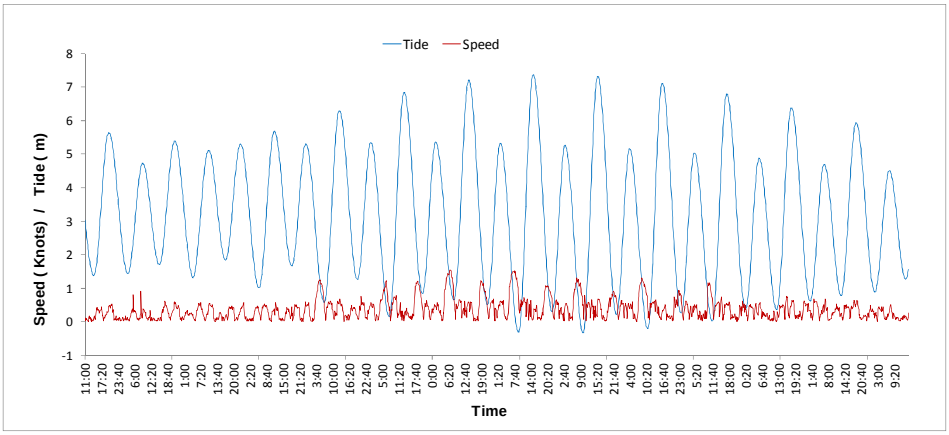
Occasional flood during July-September raises the water level substantially particularly when the flood coincides with spring tide. Since 1883 high floods in Tapi occurred 12 times during July – September. The flood of August 2006 was devastating when the water level of 0.9 m near Surat (Hop Bridge) on 5th August 2006 rose to 12.4 m on 8th August 2006. The high monsoonal river flow effectively cleanses the estuary of accumulated contaminants particularly in the inner segments, at least on a yearly cycle.

The tide measurements carried out off the Deep Water Berth of Essar are illustrated in Figure-6. These recordings were made over 20 – 30 days during January, April and July 2011. From these results it is evident that spring and neap tidal changes off the Deep Water Berth were 6.7 - 7.1 and 3.5 - 4.5 m respectively.

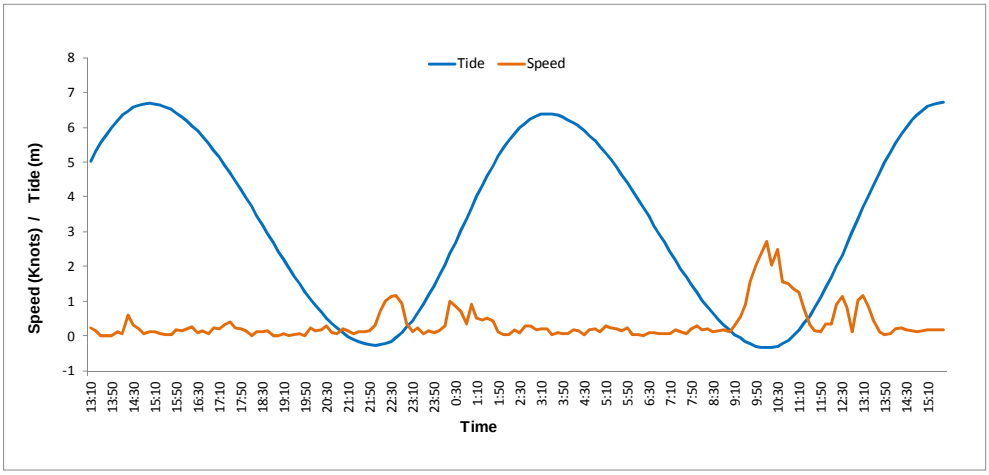
5.6 CURRENTS AND FLUSHING TIME

The high tidal influence leads to strong currents the speeds in the Gulf particularly in the channels in-between the sand and mud banks. Speeds of 2 m/s are common off Hazira during spring tide and increase substantially in the inner Gulf areas. Typically, the currents are bimodal in the Gulf with prominent northerly direction during flood and southerly direction during ebb.

The representative measured currents off the Deep Water Berth during the present study are illustrated in below fig.



Current & tide recorded during 10 – 23 May 2011 off Deep Water Berth



Currents & tide recorded off Deep Water Berth in August 2011

The shallow Tapi estuary is well flushed with flushing time of less than 2 tide cycles calculated based on the tidal prism method. Modified Tidal Prism Method indicated the flushing time of 3 – 7 tide cycles for the Magdalla-Hazira segment of the estuary when the river freshwater flow is meagre 10 – 45 cum/s.

The flushing time however increases to 11 – 24 tide cycles when the whole estuary is considered thereby indicating that the inner estuary is flushed at a much slower rate. Thus, due to excellent flushing of the Magadalla-Hazira segment, the contaminants entering the outer estuary are effectively removed to the sea and the accumulation of contaminants in this segment of the estuary where the present developments are considered, is unlikely.

This is the main process because of which the outer estuary is largely free from the effects of contaminant entering the estuary, particularly sewage that is released in the inner segments.

5.7 WATER ENVIRONMENT

5.7.1 Tapi Estuary

The estuary of the Tapi River is just about 25 km long though the river which originating in the Multai Ghats in Betour district of Madhya Pradesh runs over a distance of 720 km and passes through three states: Madhya Pradesh, Maharashtra and Gujarat. The estuary opens in the Arabian Sea in the mouth of the Gulf and hence experiences considerably high tides in the outer zone.

In the upper reaches, the river receives discharge from 14 main tributaries of which the Purna and the Girna are the most important, accounting for 45% of the total catchment area of 65,145 km2. The estuary receives an annual average river runoff of 7,686 million m3 with annual ground water flow of 18,000 million m3. The high seasonal monsoonal discharge effectively flushes the estuary on a yearly cycle. During monsoons, the Tapi River is frequently in spate and floods occasionally cause havoc in the plains of lower reaches. The floods of 1998 and 2006 were severe and several industrial complexes at Hazira had to shut down their operations for a few days.

The Tapi and the adjacent Mindola Rivers open to the Arabian Sea through a common wide and shallow mouth. The shallow and wide lower segment of the Tapi River exhibits characteristics of a typical estuary with variable salinity and strong currents associated with significantly high tidal influence up to 25 km upstream. Further inland however, seawater excursion is restricted due to the Rander weir which also regulates the freshwater outflow during lean periods. Phulwadi a hamlet about 1 km downstream of Rander and 1.5 km upstream of Surat is the location of release of part of the untreated domestic effluents.

The Tapi River cuts across the city of Surat, where a jetty is available, which is approachable only to small crafts during high tide due to shallow reaches. Downstream of Umra the segment is shallow and wide up to Magdalla which is a minor port. In the mouth segment, the estuary bifurcates into 2 channels due to the presence of Kadia Bet and Mora Bet which are low-lying areas that largely submerge at high spring tides. The eastern channel is shallow and has limited navigability, while, the western channel has been recently dredged to create navigational channel to the Deep Water Berth of Essar.

5.7.2 Marine environment

The general domain of the South Gujarat coast is under the profound influence of the Gulf. Malacca Banks lie in the entrance to the Gulf off the Tapi estuary with deep channels cutting through the shoals. Out of these, the Grant and Sutherland Channels are safe navigational routes than the channels between the banks. Malacca Banks itself consists of four prominent shoals several kilometres long and named as Eastern Bank, Breaker Bank, Narmada Bank and Western Bank. Sands and banks in the inner part of the Gulf are subject to changes due to tidal bores and voluminous freshwater inflows through rivers during monsoon

The hinterland along the east coast of the Gulf is urbanised and industrialized. A considerable fraction of effluents generated in the coastal region is transported to the Gulf either via rivers or released directly depending on the location of the settlement / industry. The available information however indicates that the ecological quality of the coastal area has not been grossly changed due to these anthropogenic interventions.

5.7.3 Environmental Sensitivity of the Project:

The environmental sensitivity of the project region within 15 km radius from Landfall point are given below.

S.No	Areas	Name/ Identity	Aerial distance (within 15 km) proposed project location boundary)
1	Areas protected under international conventions, national or local legislation for their ecological, landscape, cultural or other related value	None	
2	Areas which are important or sensitive species for ecological reasons – wetlands, watercourses	None	

	or other water bodies, coastal zone, biospheres, mountains, forests		
3	Areas used by protected, important or sensitive species of flora or fauna for breeding, nesting, foraging, resting, over wintering, migration	No	
4	Inland, coastal, marine or underground waters	Yes.	Project will come in Tapi river estuary & Gulf of Khambhat which is at a distance of 2.6 KM from Terminal 1 and 500 mts from Terminal 2
5	State, national boundaries	None	-
6	Routes or facilities used by the public for access to recreation or other tourist, pilgrim areas	None	-
7	Defense installations	None	-
8	Densely populated or built up area	None	Surat – nearest densely populated city – is located 30 km from the proposed location
9	Areas occupied by sensitive man-made land uses (hospitals, schools, places of worship, community facilities)	Yes	Essar Township Hospital & School – 5.0 Km (NW) Junagram School - 2.0 (W) Hazira School – 6.5 Km (W) Gundardi School – 8 Km (W)
10	Areas containing important, high quality or scarce resources (ground water resources, surface resources, forestry, agriculture, fisheries, tourism , minerals)	None	-
11	Areas already subjected to pollution or environmental damage (those where existing legal environmental standards are exceeded)	None	-
12	Areas susceptible to natural hazard which could cause the project to present environmental problems (earthquakes, subsidence, landslides, erosion, flooding or extreme or adverse climatic conditions)	Seismic Zone (III) & Stable Coast	• The project falls under Seismic Zone (III). Structures will be designed accordingly and no environmental problems are envisaged. • As per MoEF based on Anna university study, this Hazira Coast is stable and no erosion is envisaged.

5.8 Existing Facilities

Facilities

Essar Energy Services Limited is a wholly owned subsidiary company of EBTL. EBTL entered into a Lease agreement with GMB on March 25, 2010 for construction and use of 550m Deep Draft Captive jetty for handling of captive cargo for a period of 25 years. EBTL has developed a 550m deep water berth (jetty), with a turning circle of 600m diameter, dedicated navigational channel of 7.2 kms length with a width of 300 m (initially 230 m) and operational tidal draft of 11 m along with cargo handling equipments like ship unloaders, conveyors for transportation of raw materials to the stack house. In 2007, EBTL received EC for the establishment of the 550 m jetty and the reclamation of the 350 Ha. In line with the development programme of EBTL, the company completed permanent shore protection for an additional 1100 m adjacent to the existing 550 m berth.

EESL will cater to off takers such as Essar Steel Limited and Essar Power Limited.

Essar Steel

The 10 MMTPA Hazira Steel Complex spans the entire value chain, comprising of iron making units, steel-making units, steel finishing facilities and down-stream facilities besides specialized products like Wide Plates, Pipes, etc. The facilities are configured in a manner to provide flexibility in the use of inputs for steel-making [-Direct Reduced Iron (DRI), hot metal, scrap] and energy sources (natural gas, coal, corex gas, coke).

The Steel Complex is also connected by a sophisticated Inter-Plant Logistics network comprising of rail and specialised (Essar-patented) carriers to transport materials and finished products in an efficient manner.

ESIL uses all the three technologies of iron making, i.e. DRI / HBI, Corex and Blast Furnace technology in a single location. While DRI / HBI are in solid form, Corex and Blast Furnace produce molten iron or Hot metal. While DRI / HBI Plant use natural gas, the Blast Furnace uses Coke and the Corex modules uses Coal as the source of energy. Besides, ESIL has a Sinter plant which helps in recycling the steel plant waste generations (iron ore fines, coal fines, lime etc.) and feeds the Blast furnace.The Cold-Rolling Complex at Hazira comprises of pickling and oiling lines, a reversing 6 Hi Cold Rolling mill, a continuous Tandem Cold Rolling mill, two galvanizing lines, Hot Skin pass facilities etc. The Hazira complex also houses downstream facilities like Slitting lines, Shearing lines, etc. A dedicated Coke oven is also being set up to effectively control the cost of coke and insulate ESIL from fluctuations in international prices of Coke.

ESIL also operates a 1.50 MMTPA capacity, wide width Plate Mill in Hazira capable of producing high-grade plates with width upto 5000 mm (5 m wide).

The Pipe Mill plant at Hazira has facilities to produce both Longitudinally Submerged Arc Welded (LSAW) and Helical Submerged Arc Welded (HSAW) pipes with internal and external coating facilities. The LSAW pipes are manufactured out of Plates/ Sheets. The plate is formed, blended and expanded to give it a round uniform pipe with one welded seam. The HSAW pipes are made out of strips/ coils formed helically and welded simultaneously.

Essar Power

Essar Power Limited, also an Essar Energy subsidiary, is one of India's leading private power producers with a 14-year operating track record. Essar Power has seven operational power plants in India and one operational power plant in Algoma, Canada, with a total installed generation capacity of 3,910 MW.

Essar Power Assets at Hazira include Natural Gas fired power plants of Essar Power (515 MW) and Bhander Power Limited (500 MW).

515 MW multi fuel combined cycle power plant, Hazira, Gujarat (EPoL) – The multi fuel combined cycle plant with gross capacity of 515 MW can operate on both natural gas and Naphtha. The plant started its commercial operation in 1998. For evacuation, it is connected to the 220 KV switchyard, which in turn is connected to Essar Steel's Main Receiving Sub-Station. The annual natural gas requirement of the plant is 35,804,762 MMBTU. The plant is not operational since June 2013. Reason behind non-operation of plant is unviable economics due to non-allocation of domestic natural gas and high cost of imported natural gas in recent past.

500 MW natural gas based power plant, Hazira, Gujarat (BPL) – The natural gas based combined cycle power plant with gross capacity of 500 MW started its commercial operation in 2006. The plant is captive to Essar Steel. For evacuation, it is connected to the 220 KV switchyard, which in turn is connected to Essar Steel's Main Receiving Sub-Station. The annual natural gas requirement of the plant is 34,761,905 MMBTU. The plant is not operational since early 2013 due to unviable economics owing to non-allocation of domestic natural gas and high cost of imported natural gas in recent past.

5.10 STUDIES AND INVESTIGATION

5.10.1 Quantitative risk assessment & HAZOP

QRA and HAZOP for the proposed terminal are being undertaken by DNV. The scope of QRA Study includes process hazards for proposed facilities comprising of LNG unloading from LNGC, FSRU facilities, Onshore receiving facility, Pipeline up to Take off point. Recommendations of the report will be implemented to mitigate any risk.

5.10.2 Geo Technical Studies

To determine the soil properties of the area and to arrive at the most suitable foundation system for the proposed structure and select the type of dredger to execute the dredging work for the proposed expansion of the deep water berth, the soil exploration was undertaken by M/S DBM Geotechnical and Construction Pvt. Ltd, Mumbai.

The subsurface investigation was carried out as per IS: 1892-1979. Various Tests were carried out,

- Standard Penetration Tests (i.e. SPT) were carried out in soil at maximum intervals of 1.5m, in accordance with IS 2131-1981.
- Static Cone Penetration Tests (SCPT) were conducted at this site.
- Electrical resistivity tests are carried out.
- Wenner.s four pin electrode method is used for investigation.
- Undisturbed soil (UDS) samples were obtained using reusable thin walled tube samplers of 100mm diameter, as per IS-2132.
- Select soil and water samples were subjected to laboratory testing.
- Laboratory tests on SPT and UDS samples included mechanical analysis, and, grain size, Atterberg Limits, shear tests specific gravity were conducted according to IS2720 relevant parts. Triaxial Tests and Unconfined
- Compression Tests were also conducted on UDS samples in the Laboratory.

5.10.3 Hydrographic Studies

In order to study the changes in coastal hydrodynamics and siltation pattern due to the proposed development, mathematical model studies were conducted by CWPRS for simulating tidal hydrodynamics and sedimentation in the approach channel.

5.10.4 Mathematical Model Studies

Mathematical Model studies for tidal hydrodynamics and sedimentation were conducted by Central Water and Power research station (CWPRS) in 2006 .These studies were conducted for different channel layouts using sediment transport models to investigate the current pattern and siltation in the channel due to the proposed dredging. Using the information about the bathymetry, the hydraulic parameters like tides, currents and the velocity field, silt concentration, sediment transport model was run for estimation of likely maintenance dredging in the channel. The hydrodynamic conditions also provided input for and ship navigational studies. Review of these Mathematical Model Studies was also done by HR Willingford.

5.10.5 Navigational Studies

The Navigational studies of the channel carried out to optimize the approach channel dimensions and orientation for safe navigation of the ship under the prevailing environmental conditions of wind, waves and currents. For the LNG Terminal Navigation studies are being conducted for mooring analysis, ship collision studies and marine risk assessment.

6 REHABILITATION AND RESETTLEMENTS (R& R) PLAN

Since the Project does not require private land and that the location being reclaimed intertidal area there is no Rehabilitation and Resettlement (R&R) involved in the project.

7 PLANNING BRIEF

7.1 Marine Structures

The Jetty Structures comprises of Un-loading/ Service Platform, Breasting Dolphins, Mooring Dolphins, Connecting Walk ways and all associated structures for safe berthing, Mooring and unloading operation of the LNG by maintaining the required tranquility conditions inside the berth basin.

Since theTerminal-1 is adequately well inside the Tapi river estuary and also located north of south reclamation area, sufficient tranquility from predominant waves generated from South west and West side will be maintained well within the berth pocket such that safe berthing, de-berthing, Mooring and also the transfer of LNG can be done safely without any interception in all whether condition.

However, the berth basin at South reclamation may require additional structures like breakwater to maintain the tranquility condition inside the berth basin. Subsequent to carrying out detailed hydro-dynamic studies, the appropriated break water system will be adopted. For the preliminary planning purpose rubble mounted breakwater with amour stones and Acro/Tetrapode as secondary and primary layer has been adopted. The type of the structure will be finalized during the detailed engineering stage. However, the preliminary design has been considered with the following Structures. The orientation and the dimension of the structure will be finalized based on model studies.

A) FSRU/FSU Berthing Structure.

The initial planning is to adopt a closed type Gravity structure of Cellular diaphragm type made out of Steel Sheet Piles. This structure will also act like a Service platform to install the required Top side equipment like un-loading arms etc. Over the gravity type structure, the required marine fixtures like Fenders, Mooring Hooks/ Bollards and other ancillary items like mooring rings, ladders etc. The bulk head system between the Fenders and Bollards/Mooring hooks will transfer the loads from the floating units safely over the Gravity Structures.

Additional Breasting Dolphins also be installed at appropriated spacing for transferring the vessels berthing and mooring loads from breasting lines safely below the sub-strata. These breasting Dolphins will be sub-structured by proving appropriated foundation, preferably by Piles. Appropriated fandering and mooring systems will be designed and installed for the safe berthing and mooring of the floating crafts/vessels.

The deck at elevation 9.0 m will be provided to support the walkway bridge and to provide access. This structure will be made of RCC. All the control cables for the quick release mooring hooks will be embedded through this structure for protection against storm waves.

B) **MOORING DOLPHINES Structure.**

Mooring dolphins will be provided at appropriated spacing matching with the LNGC/ FSU Mooring lines on both Aft and Stern lines (Main Mooring lines). The loads from mooring lines will be transferred to the dolphin structure via mooring hooks/Bollards of adequate capacity. Piled foundation will be provided to transfer the loads from the Dolphin decks to the sub-strata.

An elevated access deck at elevation 9.0 m will be provided to support the walkway bridge and to provide access. This structure will be made of RCC. All the control cables for the quick release mooring hooks will be embedded through this structure for protection against storm waves.

Quick Release mooring Hooks of adequate Capacity will be provided for stern and aft lines. This will be finalised by detailed mooring analysis using OPTIMOOR or any other approved software.

7.2 Floating Storage and Regasification Units

DETAILS OF PROPOSED FSRU	
Type of Unit	Floating Assets for storage and regasification
Design life	20 years
Plant Description	The LNG enters the regasification area at a nominal pressure of 5 to 6 bar. The HP Send-out Pumps discharge the LNG at approximately 80 to 100 bar via the send out header to the LNG Vaporizers. The high pressure LNG is sent to the shell and tube vaporizers to vaporize the LNG.
Capacity	Storage capacity: 265,000 cum Maximum regasification capacity: 3 X 250 (750) MMSCFD

Environmental conditions	The limiting environmental conditions are: Sea water temperature (regasification plant design) 15°C to 36°C Sea water temperature drop max. 10°C Ambient temperature: 0°C to 45°C
Boil-off Gas	The excess boil-off gas shall be sent to the regasification plant by a non- cryogenic oil flooded compressor, where it is condensed in the BOG Recondenser and combined with the LNG for vaporization. The LNG at the inlet of the regasification plant will be subcooled and this subcooled liquid shall be used to re-condense the boil-off gas.

7.3 Onshore receiving Facility & Link to users

The onshore receiving facilities will included Un-loading arms/ Hoses, all other associated accessories for the safe and efficient transfer of the LNGC to FSU/FSRU and in turn from FSRU to grid line. The Pipe line from the jetty to the tie in point (as per layout) will be designed and installed and will be strictly complying latest applicable relevant standards and norms. The pipe line corridor will be well protected from the entry of unauthorized persons.

7.4 Resource Utilisation

- **Fresh water:** For operation of the facility approximately 600 m3 per day of freshwater is required for Domestic/Fire system. Fresh water sourced from existing Essar Steel facilities
- **Sea water:** 40,000 m3 per hour of sea water required for both terminals gasification process which will be sourced from the sea
- **Fuel:** required is approximately 2 KL/day
- **Power:** Power required for offshore and onshore facilities including area lighting at jetty is ~ 5 MW per day for each phase
- **Construction materials:** Construction material such as steel, cement, aggregates, steel sheet piles, armour rock

7.5 Utilities

The key utility systems include the following:

Firewater system: firewater system to comply with both marine and offshore safety practices

Firefighting system: to include electrical based as well as diesel engine based firefighting system

Standby Power and distribution system: for backup power distribution

Compressed air systems: for the supply of compressed air such as Plant air, compressed un-dried air, compressed dry air, air driven tools, instrument air,

Miscellaneous instrumentation and automation systems

7.6 Waste Management

7.6.1 Liquid and solid waste

Conversion of liquefied LNG to re-gasified LNG may not lead to or generate any process waste. Whatever waste, generated from FSRU & FSU will be transported to port waste management facility for treatment and disposal. Mainly the following wastes will be generated form FSRU & FSU

- Bilge water from FSRU & FSU - 20 m3/day from both terminals
  - Will be disposed as per MARPOL Regulations
- Waste Oil from FRSU, FSU & Jetty side equipments – 50 KL/year
  - Will be disposed to GPCB/CPCB authorized recyclers
- Treated Sewage water from FSRU & FSU- 30 m3/day
  - Will be disposed in Tapi estuary after confirming the GPCB Standards.

7.6.2 Air Emissions

Since LNG is a clean fuel and no combustion of fuel is planned. It's only a phase transfer of LNG. There might possibilities for generation of NOx emissions while power generation with Blow off gas at FSRU and Flue gases generation from Diesel operated Fire pumps. A suitable flare stack will be provided if needed.

7.7 Greenbelt

Greenbelt will be developed around the storage facilities and other areas. 25% of the total area will be allotted for Greenbelt development. Development plan will be finalized based on CCoE approval/ and considering the safety aspects & PESO regulations.

7 PROJECT SCHEDULE & COST ESTIMATE

7.1 IMPLEMENTATION SCHEDULE

The Project shall be implemented within shortest possible time once all the permission and clearance from State and Central statutory bodies are obtained. It is estimated that since the start of the construction work it will take 16 months to commission the Terminal.

7.2 COST ESTIMATES

Cost estimates have been worked out for the recommended layout and design of the proposed terminal. The same has been sub divided into following components:

- Reclaimed Land Development
- Dredging
- Marine Civil Works including
- FSRU (it is planned to be taken on long term charter)
- Marine Equipment and Top Side
- Onshore civil works
- Preliminary and pre-operative expenses

Cost estimates have been worked out for the recommended layout and design of the proposed FSRU based Terminal as per below.

Phase-1 Summary of capital cost estimate

S. No.	Heads	Port Related costs Rounded (INR Crores)	Floating Asset Costs Rounded (INR Crores)
1	Floating assets (FSRU + FSU, either purchased or chartered)		1950.00
2	Land and land development (~50 ha)	10.00	
3	Dredging (~ 12 Million cbm)	200.00	
4	Shore protection (sheet Piling)	120.00	
5	Berth Construction	100.00	
6	Marine Equipment- Topsides	100.00	
7	On shore civil, pipeline , services & utilities	100.00	
8	Preliminary and Pre-operative	100.00	
	Total Amount	**730**	**1950.00**