Development of Offshore LNG FSRU Facility at Kakinada Deep Water Port, Kakinada, Andhra Pradesh

AUGUST 2012
Table of Contents

1 Introduction ................................................................................................................................................. 4
  1.1 Background ........................................................................................................................................... 4
  1.2 Project Objectives ................................................................................................................................. 5
  1.3 Project Overview & Environmental data ............................................................................................... 5

2 Need to Import LNG: ................................................................................................................................. 8
  2.1 Andhra Pradesh – An Emerging Gas Hub .......................................................................................... 8
     2.1.1 Gas Demand in AP ......................................................................................................................... 8
     2.1.2 Andhra Pradesh as an Attractive LNG Market ............................................................................ 9

3 Site overview ............................................................................................................................................... 11
  3.1 Site selection - Kakinada Deep Water Port ....................................................................................... 11
     3.1.1 Kakinada Deep Water Port Salient Features ............................................................................. 11
     3.1.2 Weather and Site Conditions ....................................................................................................... 12
     3.1.3 Availability of Land for Future Onshore Terminal ..................................................................... 13
     3.1.4 Location for the FSRU .................................................................................................................. 13
     3.1.5 Operational Days .......................................................................................................................... 14
     3.1.6 Impact of the Terminal on Other Port Activities ......................................................................... 14
     3.1.7 Distance to Populated Areas ........................................................................................................ 14
     3.1.8 Distance to Existing Gas Transmission Infrastructure ............................................................. 14
     3.1.9 Geotechnical Aspects .................................................................................................................. 15
     3.1.10 Site Selection Criteria ................................................................................................................ 15

4 Analysis of Alternative Processes/ Practices ............................................................................................ 16
  4.1 Land or FSRU ....................................................................................................................................... 16
     4.1.1 Land-based Solution ...................................................................................................................... 16
     4.1.2 Offshore (Open sea buoy) Solution ............................................................................................... 17
     4.1.3 FSRU at a Near Shore Berth ........................................................................................................ 18
  4.2 Screening of Design Concepts ............................................................................................................. 18
  4.3 Project Layout & Proposed Configurations ....................................................................................... 20
  4.4 Preliminary Solution Marine and Pipeline Works ............................................................................. 25

5 Project Basis of Design & Budget: ........................................................................................................... 26
  5.1 Criteria to Arrive at Proposed Design Capacity ............................................................................... 26
  5.2 Concepts & Process Brief of FSRU .................................................................................................... 26
  5.3 FSRU Vessel ......................................................................................................................................... 28
     5.3.1 FSRU Vessel Selection .................................................................................................................. 28
1 Introduction

1.1 Background

Andhra Pradesh Gas Distribution Corporation Limited (APGDC) is a Joint Venture of Andhra Pradesh Gas Infrastructure Corporation Pvt. Ltd (APGIC), a wholly owned company of APGENCO & APIIC and GAIL Gas Limited, a wholly owned subsidiary of GAIL (India) Limited, a Public Sector Undertaking under the Ministry of Petroleum & Natural Gas, Govt. of India. APGDC is responsible to create Natural Gas pipeline infrastructure, City Gas Distribution Networks, CNG Stations and LNG importation terminal in the State of Andhra Pradesh.

APGDC Board has resolved to promote an FSRU Project on the East Coast of India, in the State of Andhra Pradesh. This would help meet the growing gas demand requirements in the region. The Government of Andhra Pradesh and Govt. of India have supported APGDC’s initiative for FSRU terminal. The FSRU is required at the earliest possible timeframe at the East Coast of Andhra Pradesh. The Andhra Pradesh Government has also signed a MoU with APGDC during the Partnership Summit held during 11-13th January, 2012, assuring all support for this prestigious Project.

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. A brief profile of the market conditions from a Natural Gas perspective for India and specifically for the State of Andhra Pradesh has been covered in Appendix A.

APGDC has selected GDF Suez LNG UK Limited (GDF Suez) as Strategic Partner to implement this project. GDF SUEZ which holds 38 MTPA of re-gasification capacity worldwide is the number two terminal operator in Europe with an overall re-gasification capacity of more than 20 MTPA. GDF SUEZ has over 40 years of operating and maintenance experience of the land based terminals and more recently expanded to floating terminals. All of the GDF SUEZ terminals are operating without any significant incident which is due to continuing integration of past experience.

GAIL (India)Limited, the promoter company of APGDC through GAIL Gas is a Navratna Central PSU having business interest in supply chain of Natural Gas from exploration, transportation of Natural Gas and LPG, fractionation of Natural Gas to produce LPG, Propane and other Liquid hydrocarbons. GAIL is operating one of the gas based biggest Petrochemical Complex in Uttar Pradesh meeting almost 1/4th of the Polyethylene requirement for India. GAIL is also having various Joint Venture Companies to promote City Gas Distribution. GAIL is having equity participation in LNG terminals in India.

GAIL is transmitting 3/4th of the Natural Gas through pipeline with more than 50% of market share in Natural Gas business in India. GAIL is operating 8 LPG Recovery plants and producing more than 1 Million Tons of LPG.
1.2 **Project Objectives**

APGDC together with GDF Suez (“the Promoters”) are planning to develop a Floating Storage Re-gasification Unit (FSRU) for LNG import in Kakinada Deep Water Port (“the Project”) through an SPV to be incorporated.

The objectives set for the Project are defined hereunder:

- **Send-out demand and flexibility:**
  - Annual capacity: up to 6.5 MTPA.
  - Maximum send out flow rate shall be 50% above the average.

- **FSRU output:**
  - Pressure: Min 80 bars, Max 120 bars
  - Temperature: Min 0°C, Max 10°C

- **Marine specifications – Vessel size:**
  - Marine facilities will be designed to accommodate LNG vessels between 120,000 M³ and 215,000 M3. However, mooring and berth shall be designed to accommodate up to 265,000 M³ (Qmax) class vessels.
  - Call duration (including berthing, mooring, cool down, unloading, cast off) will be 30 hours for a 160,000 M³ LNG carrier (assuming availability of storage on the FSRU).

- Flaring: zero flaring or no gas release to atmosphere (including during unloading) will occur under normal operation.

- Schedules: A key objective of the Promoters is to build and commission a floating type LNG import terminal by early 2014.

1.3 **Project Overview & Environmental data**

<table>
<thead>
<tr>
<th>Capacity of the FSRU project</th>
<th>6.5 Million Tons per Annum (MTPA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Kakinada Deep Water Port, Beach Road, Kakinada Andhra Pradesh- - 533 007</td>
</tr>
<tr>
<td>Access to site</td>
<td>By road- Samalkot-Kakinada bypass road , nearest National Highway- NH 214 (approx. 7 km from the proposed site)</td>
</tr>
<tr>
<td>Nearest railway station –</td>
<td>Kakinada Port Railway station, 5.1 km from the proposed site</td>
</tr>
<tr>
<td>Nearest Airport:</td>
<td>Rajahmundry, 70 km from the proposed site</td>
</tr>
<tr>
<td>Site features</td>
<td>Site - Kakinada Deep Water Port</td>
</tr>
<tr>
<td>District</td>
<td>East Godavari</td>
</tr>
<tr>
<td>State</td>
<td>Andhra Pradesh</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Latitude</td>
<td>16° 58.37’ N</td>
</tr>
<tr>
<td>Longitude</td>
<td>82° 17.06’ E</td>
</tr>
<tr>
<td>Elevation</td>
<td>2.3 m MSL</td>
</tr>
<tr>
<td>Nearest Metrological station</td>
<td>Kakinada (Stn No.43189)</td>
</tr>
<tr>
<td>Mean Maximum temperature</td>
<td>43.8 Deg. C</td>
</tr>
<tr>
<td>Mean Minimum temperature</td>
<td>15.8 Deg. C</td>
</tr>
<tr>
<td>Annual maximum humidity</td>
<td>82%</td>
</tr>
<tr>
<td>Annual Minimum Humidity</td>
<td>61%</td>
</tr>
<tr>
<td>Predominant wind direction</td>
<td>South West and South East</td>
</tr>
<tr>
<td>Annual rainfall</td>
<td>1113.2 mm</td>
</tr>
<tr>
<td>Nearest habitation</td>
<td>Kakinada</td>
</tr>
<tr>
<td>Nearest major town/Nearest major city (more than 2,00,000 population)</td>
<td>Kakinada</td>
</tr>
<tr>
<td>Defence Installations</td>
<td>Nil within 10 km radius</td>
</tr>
<tr>
<td>Protected area as per WP Act, 1972</td>
<td>Coringa Wildlife sanctuary, approx. 15 KM</td>
</tr>
<tr>
<td>Reserved/Protected forest</td>
<td>Nil within 10 km radius</td>
</tr>
<tr>
<td>Nearest water bodies streams/Rivers/sea</td>
<td>Sea (Bay of Bengal)</td>
</tr>
<tr>
<td></td>
<td>Bhogamdani Cheruvu – 4.2 km</td>
</tr>
<tr>
<td></td>
<td>Kulai Cheruvu – 6.3 km</td>
</tr>
<tr>
<td>Major Industries</td>
<td>Two Fertilizer Plants (namely Nagarjuna Fertilisers and Coramandel Fertilisers ) and few Gas based power plants such as GMR Barge mounted Plant, Spectrum Power Etc.</td>
</tr>
<tr>
<td>Seismic zone</td>
<td>Zone III as per IS 1893:2002</td>
</tr>
<tr>
<td>Pipeline for natural gas transportation</td>
<td>750 mm dia (30”) 2.5 km sub-sea Gas pipeline</td>
</tr>
<tr>
<td>Project schedule</td>
<td>Commercial operation-18 months</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Project cost</td>
<td>Rs.1000 Crores approx.</td>
</tr>
</tbody>
</table>
2 Need to Import LNG:-

2.1 Andhra Pradesh – An Emerging Gas Hub

Andhra Pradesh is the fourth largest state by area and fifth largest by population in India. Andhra Pradesh is blessed with a long coastline and has the second largest coast line of 972 km among the states of India. Over the past decade, it has emerged as one of India’s fastest growing states. The state’s GDP is estimated to be more than USD 120 Billion and stands third among states of India.

The State has emerged as an important hub for natural gas industry post the Krishna – Godavari basin gas discovery. A large number of gas based power plants and other industries have been set up and many are under planning stage. Andhra Pradesh has a good pipeline infrastructure connecting it to the other regions of India. So, a terminal in Andhra Pradesh could supply gas to many other regions in India. Further, the pipeline infrastructure in the state is expected to get a further boost once the planned pipelines are commissioned. Some of the pipelines being planned in the state are Kakinada-Chennai in Tamil Nadu Kakinada-Haldia in West Bengal State and Kakinada- Vijayawada-Nagpur-Bhilwara in Rajasthan State.

Furthermore, the Petroleum, Chemical & Petrochemical Investment region (PCPIR) is being setup in the east coast along the Kakinada-Visakhapatnam Industrial Corridor. Many SEZ’s are planned to be setup in the area with Refinery / Petrochemical Feedstock Company. This investment region would further boost the demand for gas in the state.

2.1.1 Gas Demand in AP

Power sector is a major consuming sector for gas in the State of Andhra Pradesh. The energy consumption in the state is growing at double digits during past several years. With an installed capacity of more than 15,500 MW, Andhra Pradesh represents one of the largest power markets in India. The AP state power utilities have power purchase agreements for around 2,700 MW of gas based power plants in the state. However, due to shortfall in domestic gas, these plants are not operating at their optimal capacities. The gas based plants in the state are currently operating at 50% - 60% of their capacity. Further, an estimated 13,000 MW of gas based plants are expected to come up in the state in the coming years subject to gas availability given the constraints in coal supply. With increased power tariffs and rising imported coal prices, the affordability for gas is on the rise. This would lead to a further increase in demand for natural gas in the state.

The state of Andhra Pradesh is experiencing huge energy deficits owing to shortfall in domestic coal and gas supplies. Due to this, the state is left with no option but to impose load restrictions on the consumers in the state. During the load restrictions, the industries mostly run their plants on liquid fuel. The cost of power from diesel generators is estimated to be around Rs. 16/unit (USD 0.32 /unit). Given this backdrop, the industrial associations have approached the Andhra Pradesh Power distribution licensees for supply of uninterrupted power to mitigate load restriction measures. Accordingly, the licensees have proposed to tie-up power from idle gas based power capacity using RLNG fuel. In this context, alternate fuel like RLNG would be in demand despite the relatively higher costs when compared to coal based power generation.

City gas distribution demand comprising compressed natural gas (CNG) for usage as transport fuel and piped natural gas (PNG) for replacing LPG – is an attractive demand segment from an affordability perspective. There are significant plans of APGDC to spread the gas distribution infrastructure to all the regions in AP which will drive the demand. PNGRB has allotted licenses to a number of players for CGD implementation in the state of
Andhra Pradesh. Gas demand from these cities like Visakhapatnam, Nalgonda, Rajahmundry, Kakinada, etc. is expected to increase once these projects are implemented. Due to rapid economic growth, the natural gas demand from other industrial sectors like ceramics, metals and bulk drugs is expected to go up. The expected gas demand from sectors other than the power sector is likely to be around 30 MMSCMD. But, due to shortfall of domestic gas, a lot of this demand is currently not being met. So, an LNG terminal on the Andhra Pradesh coast is necessary to bridge this gap.

The summary of existing demand for gas from all the sectors is shown in the table below:

<table>
<thead>
<tr>
<th>Sector</th>
<th>Allocation</th>
<th>Requirement</th>
<th>Supply</th>
<th>Alloc-Req</th>
<th>Alloc-Sup</th>
<th>Req-Sup</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MMSCMD</td>
<td>MMSCMD</td>
<td>MMSCMD</td>
<td>MMSCMD</td>
<td>MMSCMD</td>
<td>MMSCMD</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>4.797</td>
<td>3.27</td>
<td>3.215</td>
<td>1.527</td>
<td>1.582</td>
<td>0.055</td>
</tr>
<tr>
<td>Ceramics, Glass, Steel and Others</td>
<td>0.71944</td>
<td>0.9205</td>
<td>0.3855</td>
<td>-0.20106</td>
<td>0.33394</td>
<td>0.535</td>
</tr>
</tbody>
</table>

Furthermore, there are many announced projects that could increase the demand for gas. For example, the additional demand from Power Sector from announced capacity addition programs from projects in Andhra Pradesh are likely to be around 40 MMSCMD. Some of the announced and under construction power plants are from large players like Reliance, GMR, Lanco and GVK.

2.1.2 Andhra Pradesh as an Attractive LNG Market

The gap will have to be met from RLNG as the domestic gas supply is on a decline. Furthermore the RLNG terminal on the east coast will be more economical than on the west coast. This can avoid additional taxes and transportation charges that make the delivered price of RLNG costly. The following tables illustrate the difference in the delivered price of gas in two scenarios considering crude price of $100 –

Scenario – 1 – RLNG transported from West Coast to AP

In case the gas is transported from the West Coast, there is additional implication of taxes and transportation charges as shown in the table below:
Scenario – 2 – FSRU on the East Coast of AP

In case the FSRU is located on the East Coast in AP, then the delivered price will be lower due to the avoidance of additional taxes and transportation charges as shown in the table below:

For further details refer Appendix-A
3 Site overview

3.1 Site selection - Kakinada Deep Water Port

Kakinada Deep Water Port has been selected as the most preferred location among three existing ports located on the coast of north eastern Andhra Pradesh, at the outset of a site selection study completed by the Indian Port Association & IIT Madras (see in Appendix B detailed Site Selection Report). This selection has been justified based on the following criteria:

- Kakinada presents the most cost-effective option at this stage compared to developing in the other two locations (breakwater requirements and land availability concerns at the other ports will increase development costs compared to Kakinada);
- Kakinada is close to the existing KG Basin Gas transmission network of GAIL, and the gas market, thus reducing the cost of connectivity which will have a significant share of the overall CAPEX;
- Kakinada enjoys relatively mild metocean conditions with less cyclonic activity than other areas of eastern India;
- The traffic density with 6 existing berth and around 10 MTPA of traffic compatible with the installation of a LNG terminal;
- Land at Kakinada is suitable for a future on-shore extension;
- Kakinada is a sheltered port endowed with a natural protection (Hope Island) and an existing breakwater would further protect the FSRU from NE prevailing waves.

The selection of Kakinada Deep Water Port as the best location for an FSRU project in Andhra Pradesh was based on the comparative survey carried out by Indian Port Association end 2011 assessing details of three potential locations, i.e.: Kakinada, Visakhapatnam and Gangavaram. The complete study is attached in Appendix B; its key findings are as follows:

3.1.1 Kakinada Deep Water Port Salient Features

Kakinada deep water port is located on the east coast of Andhra Pradesh at latitude 16° 58.37’N and longitude of 82° 17.06’ E. It is situated at 170 km. south of Visakhapatnam and 650 km north of Chennai Port. This port is the main gate way for the rich agricultural belt of East Godavari, West Godavari & Krishna districts of Andhra Pradesh. Moreover, in view of its strategic proximity to the Krishna-Godavari Basin, there is significant traffic in Off Shore Supply Vessels.

Kakinada occupies a unique site location on the East Coast of India where a headland to the south of the city has caused the development of a spit generated by the littoral drift caused by the South West monsoon which is not reversed during the North East monsoon because of the embayment to the north of the city. The result is that Hope Island now provides a natural protection to the inner harbour area from waves from the SE and East.

Kakinada Deep Water Port was predominantly a lighterage port prior to the development of sheltered deepwater berths protected by a breakwater from waves from the NE. Regular maintenance dredging is
required to maintain a -14.5 Mts. CD outer channel. The maintained depths at various berths permit vessels with draught from 11.5Mts.CD to 13.5Mts.CD, to access to the harbour at high tide.

Available port facilities include a quay length of 610 Meters and a new 910 meters length single quay for multiproduct handling and stand-alone facility for Oil Supply Vessels (OSV) of the KG basin. After extension Kakinada Deep Water Port has 6 berths and handled traffic of about 9.9 million tonnes during 2010-11 with vessel traffic of 766. The movement of other vessels including offshore supply vessels was 1466.

Kakinada Deep Water Port is under private management by M/s. Kakinada Sea Port Limited (KSPL).

The port is managed by Kakinada Seaport Limited (KSPL), a Special Purpose Company established in 1999 as part of the privatisation initiative of the Govt. of A.P.

The area on the leeside of the north breakwater has been made available for the envisaged LNG berth by KSPL. This isolated area is separated from the environmentally sensitive Hope island area, and more than 2km away of the existing berths. Interference with existing port operations to the LNG traffic, which, at nominal capacity of the terminal will be one LNG carrier per week, is considered as minimal.

### 3.1.2 Weather and Site Conditions

The tidal range in Kakinada is as follows:

<table>
<thead>
<tr>
<th>Tide</th>
<th>Level in m (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean High Water Springs (MHWS)</td>
<td>1.5</td>
</tr>
<tr>
<td>Mean High Water Neaps (MHWN)</td>
<td>1.2</td>
</tr>
<tr>
<td>Mean Low Water Neaps (MLWN)</td>
<td>0.6</td>
</tr>
<tr>
<td>Mean Low Water Springs (MLWS)</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Source: Admiralty Chart

The wind table for a location close to Kakinada is provided in the table below:

<table>
<thead>
<tr>
<th>Wind speed (m/s) 1999-2008</th>
<th>Percentage of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 - 1.00</td>
<td>3.71</td>
</tr>
<tr>
<td>1.00 - 2.00</td>
<td>6.62</td>
</tr>
<tr>
<td>2.00 - 3.00</td>
<td>9.35</td>
</tr>
<tr>
<td>3.00 - 4.00</td>
<td>12.32</td>
</tr>
<tr>
<td>4.00 - 5.00</td>
<td>15.10</td>
</tr>
<tr>
<td>5.00 - 6.00</td>
<td>16.61</td>
</tr>
<tr>
<td>6.00 - 7.00</td>
<td>13.40</td>
</tr>
<tr>
<td>7.00 - 8.00</td>
<td>9.44</td>
</tr>
<tr>
<td>8.00 - 9.00</td>
<td>6.18</td>
</tr>
<tr>
<td>9.00 - 10.00</td>
<td>3.55</td>
</tr>
<tr>
<td>10.00 - 11.00</td>
<td>1.85</td>
</tr>
</tbody>
</table>
### Wind speed measured at a coastal site

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Wind Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.00-12.00</td>
<td>0.94</td>
</tr>
<tr>
<td>12.00-13.00</td>
<td>0.46</td>
</tr>
<tr>
<td>13.00-14.00</td>
<td>0.19</td>
</tr>
<tr>
<td>14.00-15.00</td>
<td>0.14</td>
</tr>
<tr>
<td>15.00-16.00</td>
<td>0.09</td>
</tr>
<tr>
<td>16.00-17.00</td>
<td>0.05</td>
</tr>
<tr>
<td>17.00-18.00</td>
<td>0.03</td>
</tr>
<tr>
<td>18.00-19.00</td>
<td>0.04</td>
</tr>
<tr>
<td>19.00-20.00</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Strong winds above 15 Mts/sec. liable to disturb LNG operations are relatively rare (about 1 day per annum).

The area is prone to occasional cyclone landfalls which are likely to generate wind and sea conditions potentially affecting LNG operations. About 15 cyclonic storms and super cyclonic storms have crossed around the region during the 1891-200 period. Tracks of the major cyclones passing very close to Kakinada are shown in Figure here down:

![Map of Cyclone Tracks](image)

3.1.3 Availability of Land for Future Onshore Terminal

At Kakinada Deep Water Port the required land for a possible future onshore terminal is available on the coast within the Port boundaries between the shore line and ADB road (see General Arrangement in Appendix E).

3.1.4 Location for the FSRU

At Kakinada Deep Water Port, the FSRU is being proposed to be located on the leeside of the breakwater moored to a conventional jetty. This will be at a distance of about 2.5km from the onshore terminal location.
At a later stage the same jetty could be used for berthing LNG Carrier and it would be possible to connect to the ship using a trestle if required (not part of this MOEF application).

3.1.5 Operational Days
At Kakinada Deep Water Port, since the FSRU is within the protection of the breakwater, the terminal will be operable for most of the year except during extreme cyclonic conditions.

3.1.6 Impact of the Terminal on Other Port Activities
At Kakinada Deep Water Port the location of the conventional jetty is sufficiently away from the main activity zones of the port providing the required safety distances. Even the barge movement of the anchorage port will be away from the FSRU location.

3.1.7 Distance to Populated Areas
At Kakinada Deep Water Port the populated area is about 5km. Only a few industries are near the likely location of a future onshore terminal, sufficiently away to provide the required safety distances.

3.1.8 Distance to Existing Gas Transmission Infrastructure
At Kakinada Deep Water Port the gas transmission network of GAIL passes very close at a distance of around 2 KM and it will be very easy to get connected (see map below).
3.1.9 Geotechnical Aspects

Some geotechnical information has been identified from local sources. The investigations carried out at the port area indicate that in the major portion of the off shore area, the sea bed comprises of soft sediment layers to a depth of 10 m to 15 m from sea bed level, followed by a medium stiff clay. We understand that no hard strata or rock has been observed to occur at shallow depth.

Some of the onshore bore holes indicate variable rock levels varying from 22 m to 32 m below the chart datum in near Balacheruvu Creek entrance.

3.1.10 Site Selection Criteria

It is the intention of APGDC and the Govt. of Andhra Pradesh to quick start the FSRU project within the shortest time to meet the shortfall in supply of natural gas. Kakinada Deep Water Port is the most preferred location based on the following:

- Kakinada, Visakhapatnam, and Gangavaram Port have been looked at by GDF SUEZ as part of wider activities. It is thought that Kakinada presents the most cost-effective option at this stage compared to developing an FSRU Project in the other two locations (breakwater requirements and land availability concerns at the other ports will increase development costs compared to Kakinada);
- Kakinada is close to the existing Andhra Pradesh gas transmission infrastructure of GAIL, and the market thus reducing the cost of connectivity which will have a significant share of the overall CAPEX;
- Kakinada enjoys relatively mild metocean conditions with less cyclonic activity than other areas of eastern India;
- The traffic density with 6 existing berth and around 10 MTPA of traffic looks compatible with the installation of a LNG terminal;
- Land at Kakinada looks suitable for a future on-shore extension pending zoning consent;
- Kakinada is a sheltered port endowed with a natural protection (Hope Island) and an existing breakwater would further protect the FSRU from NE prevailing waves.

The limited interference expected with the port operation due to the isolated location of the envisaged LNG receiving facilities behind the north breakwater combined with relatively mild metocean conditions (wind and waves), makes the Kakinada Deep Water Port an ideal location for an LNG port. However, with respect to the stringent safety/availability requirements associated with LNG operations, a fast-time simulation will be performed in order to investigate the arrival and departure of the LNG Carrier under a variety of normal and extreme conditions during the engineering studies with the purpose to and in order to optimize its design. A real time manoeuvring simulations will also be performed during the FEED. Similarly a metocean study is being developed as part of engineering studies in order to quantify precisely the expected downtime and determine the design criteria for the facilities (extreme winds, storm surge).
4 Analysis of Alternative Processes/ Practices

4.1 Land or FSRU

With Kakinada chosen as the site, the project developers then had to choose between a land offshore marine, or near shore marine based solution.

4.1.1 Land-based Solution

The main process sections and the supporting utilities of the land-based LNG Receiving Terminal are shown in the block diagram below.

Block diagram for the land-based LNG receiving facility

Unloading of the LNG is accomplished via hard-piped liquid unloading arms located on the jetty platform and the unloading lines to the LNG storage tank(s), located on a trestle running to shore. Vapour displaced from the land-based storage tanks whilst ship unloading is also returned to the ship via a vapour return line and a vapour return arm.

The Boil off Gas (BOG) from the LNG tanks is compressed and routed to a recondenser where the BOG vapours are condensed with LNG from the tank at a pressure of some 5-10 bar to achieve total condensation of the BOG.

The LNG is pressurised by the High Pressure (HP) pumps to the send-out pressure and then vaporised and superheated at high pressure.
A total land area of 23.5 ha must be reclaimed to accommodate the land-based terminal. The surface area of the platform is to be of sufficient size for construction and operation of the land-based facilities taking into account lay-down and working space for construction and expansion.

In order to accommodate LNG vessels, berth structure, break-water and dredging are also required.

### 4.1.2 Offshore (Open sea buoy) Solution

The solution would consist of utilising an existing FSRU with a capacity of 145,000 m³. In this case, the FSRU would be anchored in the open sea. It would deliver natural gas via a Submerged Turret Loading (STL) buoy into a Pipe Line End Manifold (PLEM) on the seabed where it will be sent onshore via a subsea pipeline. The LNG would be transferred from an LNG vessel into the FSRU by a ship to ship transfer arrangement.

The figure below provides an overview of this system:

Two options have been considered:

- One located approximately 10km from the land-based tie-in point in waters of an average depth of 12m, referred to as the “Shallow Water” solution.

- the other located approximately 20km from the land-based-in point in waters of an approximate depth of 40m, referred to as the “Deep Water” solution.

They are technically similar but differ by the fact that the “Shallow Water” solution requires dredging and a 10km pipeline to shore whereas the “Deep Water” solution does not need dredging but requires a 20km subsea pipeline.
4.1.3 FSRU at a Near Shore Berth

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.

Also an island terminal berth structure and a breakwater are required in this solution to accommodate the FSRU and the incoming LNG vessel.

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

4.2 Screening of Design Concepts

APGDC and GDF Suez have reviewed the options for the proposed regas terminal concept and completed an initial screening based on a set of criteria, the first of which was an early completion schedule as this was deemed a key requirement.

Due to the land reclamation and LNG tank construction requirements, 2017 would be a realistic start-up date. Note in particular that LNG tanks require at least 33 months to be built. In addition, the CAPEX is much higher than that for an FSRU solution (see hybrid solution for details).

This immediately eliminated the fully land-based solution which will be looked at a later date.

The remaining options were then:

- FSRU
- Open sea buoy terminal
- Hybrid solution which is a temporary floating terminal during construction of an on-shore facility

These were further assessed based on the following criteria:

- Schedule risks
- Cost
- Expandability
- Proximity to selected site
- Throughput flexibility

The hybrid solution meets the schedule but the cost of a land terminal is significantly higher compared to the floating solutions, without major benefits for this phase of LNG imports. At this stage it is preferred to build a floating installation with a land-based terminal to follow at a later date once the throughput capacity justifies this solution.
The preferred solution was therefore sought in the FSRU based solutions.

A) Open sea buoy FSRU terminal:-

- had to be located too far away from the selected site due to shallow water around Kakinada
- presented little opportunity to add extra storage
- did not bring Capital Expenditure (CAPEX) advantage compared to a floating terminal at the selected site
- expansion was more costly as a second FSRU would have to be used and significant CAPEX would be required to add another STL Buoy system
- downtime caused by delayed Ship to Ship cargo transfer in open sea in a cyclonic prone area was anticipated to be unacceptable by RLNG gas customers

Hence the Open sea buoy FSRU Terminal is eliminated.

B) The floating FSRU terminal within Kakinada Deep Water Port:-

- Had the least schedule risks
- Had the lowest CAPEX
- Provided a safe and reliable solution providing a high availability level
- Offered expandability options

Accordingly the floating FSRU terminal was therefore selected as the preferred solution.

This decision process can also be visualized in the following figure:-

Summary of selection process for the preferred floating solution

Other parameters were also considered during this above evaluation exercise such as:

- Reliability to meet gas demand
Logistics

Impact on port operation

Based on the above criteria, APGDC and GDF Suez have concluded that a FSRU solution at Kakinada is the optimal solution. This solution meets all the project criteria, is the most cost efficient and allows for a seamless expansion to increase the capacity when required.

4.3 Project Layout & Proposed Configurations

The Promoters have selected a jetty based, near shore solution for the following reasons:

- A jetty based solution is known to present lower CAPEX costs for development than an offshore turret system and associated pipeline to shore. It also has a higher availability of LNG transfer from shuttle vessels to the FSRU, hence lower likelihood of the FSRU running low on LNG for regasification;
- There are only a few ships currently available that can connect to an offshore buoy solution which may increase the price of FSRU charters. A jetty based system opens up the FSRU market to a much larger choice of ships which will result in a more cost effective and faster to market solution;
- A jetty capable of accommodating a variety of FSRU sizes allows for expansion of the FSRU without the need to migrate to an onshore facility.
- If the terminal moves to a larger onshore solution then there is no need for additional expenditure on a new jetty;
- The sheltered near shore location of the jetty reduces construction costs for the pipeline, and reduces the chance of weather related delay to construction schedules;
- A near shore jetty allows port services (dredger, tugs, pilot, channels etc.) to be pooled with existing port users.
Concept wise, two configurations shall be considered at the onset of the pre-FEED study. These configurations will be modified during the pre-FEED study to improve the speed to market, cost effectiveness, and to best match local market conditions. From an environmental impact point of view, there are not significant differences between these two lay-out options.

The Promoters have selected these configuration/layouts due to the advantage that each solution will provide depending on how the market may develop.

These configurations are shown overleaf:
Configuration 1: FSRU - Twin jetty with over the jetty transfer of the LNG from the LNG carrier to the FSRU:

Proposed lay-out configuration 1 to be modified in Pre FEED (Orientation to be confirmed in study)
Configuration 2: FSRU - Single jetty with side by side Ship-to-Ship transfer of the LNG from the LNG carrier to the FSRU:

Layout of Configuration 2

Proposed lay-out Configuration 2 to be modified in Pre FEED (Orientation to be confirmed in study)
In configuration 1, the FSRU and the LNG carriers are moored in a traditional manner each side of a twin jetty. LNG is transferred from the LNG carrier to the FSRU across the jetty platform. Two sets of cryogenic hard arms are installed on the jetty.

In configuration 2, the FSRU is moored at a single jetty and the visiting LNG carrier is moored side by side (SBS) to the FSRU. LNG is transferred directly from the LNG carrier to the FSRU through cryogenic hard arms. The unloading arms are installed on the FSRU deck.

The obvious difference between these two is the jetty structure itself and the arrangement of pipe work and arms which would be present at the start of the project.

Moreover, in the event of a future transfer to an onshore solution Configuration 2 would require further modification such as:

- the building of cryogenic arms on the jetty;
- installation of utilities;
- potential creation of a second jetty structure to for increased LNG ship turnover etc.);
- further dredging to create a second jetty pocket;
- cost of removal of hard arms from FSRU so it can operate at as a normal carrier again (difficult to place an FSRU directly from one project straight into another).

Due to these being additions to a Configuration 2 layout all of these modifications would come at increased cost compared to installation up front as in Configuration 1.

However, more significant is the impact such construction activities would have on on going re-gas operations. Send out to customers would cease for a number of months as construction take place, with associated loss of revenue and attractiveness as a supplier. Hence whilst Configuration 1 may have higher up-front costs, in the long term it may be a more cost effective solution for the project and hence Configuration 1 is effectively set up as a jetty that would be ready both for FSRU operations and also as a conventional jetty for a future onshore terminal.

The FSRU receiving facilities will be designed to accommodate LNG from shuttle LNG vessels of up to 265,000m³, which is the largest existing LNG vessel size in the industry. LNG will be transferred directly from the shuttle vessel moored alongside the FSRU over a jetty using cryogenic arms placed on the jetty structure (Configuration 1).

Maximum re-gas capacity can be up to 26.9 MMSCMD (depending on market conditions and cost effectiveness) of which 14.2 MMSCMD is a typical average use.

It is anticipated that customers from the power sector could form a significant part of the customer base and the extra capacity above the average send out rate of 14.2 MMSCMD of gas is required to accommodate swings in send out which inevitably will occur in day to day operation. In addition to supporting the needs of the power sector, the ability of the FSRU to reach an interruptible peak capacity of 26.9 MMSCMD for a limited period, would ensure energy security for APGDC in the event of unforeseen circumstances/outages with other sources of gas supply.
Re-gasification will most likely be carried out using seawater as the primary heating medium. The seawater is pumped into shell and tube vaporisers, vaporising the LNG and the sea water is then discharged back into the sea.

The FSRU will re-gasify LNG at send out pressure and deliver natural gas via one of two HP gas arms to the jetty and then to a subsea pipeline. As a key potential bottleneck in assuring gas to customers, two HP arms are used to allow suitable redundancy.

LNG sampling for custody transfer and Gas metering and analysis equipment will be provided at the land fall point station (see Appendix E &F). At the shore, the pipeline will be 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 dolphins, the quick release hooks, fenders, platform structures and top side equipment (unloading arms, cryogenic pipeline, drain drum, HP arm).

4.4 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, entrance channel, run-off channel and berth pockets will be subject to detailed study in the FEED stage but the preliminary concept is for a 600m turning circle (it is assumed that during the initial stage, the SPV will receive ships of maximum size of 215000 m$^3$), an approach channel width of 300m, and all to a depth of 15m below chart datum. This follows appropriate SIGTTO and PIANC guidance for terminal layout.

It is assumed that suitable dredged material may be used in reclaimer activity if required. Otherwise surplus or unsuitable material is assumed to be disposed of at an approved/designated offshore disposal location, which is less than 10 km from the proposed FSRU location at Kakinada Deep Water Port, subject to necessary permitting and environmental assessment.

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 able to accommodate the expansion of the terminal. This pipeline would size for a nominal 28.3 MMSCMD capacity and peak capacity of up to 42.5 MMSCMD, as the additional mobilization and installation cost for a second pipeline far outweighs the incremental cost of increased pipeline diameter installed upfront.

The appropriate level of peak capacity to support the hourly variations in power sector gas demand would be validated by the gas market study element of the feasibility study.
5  Project Basis of Design & Budget:

5.1 Criteria to Arrive at Proposed Design Capacity

In comparison with an on-shore terminal, on a floating LNG re-gasification unit, the designer is constrained by space available on the vessel deck and by the number of tanks of the ship.

The existing FSRU vessels vary in the following range:

- Storage capacity: 125000 to 175000 m$^3$
- Send out: 2.5 to 6.5 MTPA (base-load)

However, these relatively small capacities fits well to a nascent LNG market like Andhra-Pradesh especially in an Indian context where international market price remains an issue in terms of affordability. Thus the floating option while reducing the capex exposure of the promoters, allow a fast track cost efficient access to natural gas resource.

The final capacity of the project will result from the best possible compromise between the FSRU market opportunities and the RLNG demand as assessed per the on-going market study.

5.2 Concepts & Process Brief of FSRU

Promoters, particularly GDF SUEZ, have experience from other projects that suggests what is likely to be the optimum layout for the facility. Whilst this prior experience is not intended to pre-empt the final technical design of the LNG terminal that the feasibility study will recommend, this understanding will simplify and accelerate the implementation of the feasibility study.

Promoters have identified two configurations options as the starting point for its feasibility study. These layouts will be modified during the feasibility study to improve the speed to market, cost effectiveness, and to best match local market conditions. These initial designs are based at Kakinada Deep Water Port with respect to the selection criteria listed hereunder. However, this choice will have to be confirmed during the feasibility study:

**Configuration 1: Over the Jetty Transfer (twin jetty)**
In this configuration, both FSRU and LNG shuttle are berthed on a traditional solid LNG berth. The unloaded LNG is transferred from the shuttle to the FSRU where it stored and re-gasified before being sent out through a High Pressure arm to the subsea pipeline.

The process flow diagram here under illustrates the ship jetty ship configuration

**Configuration 2: Ship to Ship Transfer (single jetty)**
In this configuration, LNG carrier berth alongside the FSRU. Each LNG carrier would be secured to the FSRU using mooring lines equipped with quick-release hooks that would be permanently attached to the FSRU. Floating pneumatic fenders would be used to separate and prevent contact between the hull of a moored vessel and the side of the FSRU.

The unloading area near the carrier berth 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 fire fighting facilities; life-saving equipment; telecommunications equipment; an access gangway; and a small crane.

In both above configurations 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.

5.3 **FSRU Vessel**

5.3.1 **FSRU Vessel Selection**

The final FSRU will not be selected until after the project has received its environmental clearances. It is also possible that an initial “bridging” vessel will be selected from the existing world fleet to cover the start-up of the project, which will then be replaced by a new vessel of larger size and regas capacity. This allows the project to start up prior to the new vessel being completed in the shipyard. However the general parameters of an FSRU can be specified at this stage, and worst case values from both the bridging and new vessel are used in the Form I. Any studies carried out will apply to both vessel types.

5.3.2 **FSRU Regulation**

It should be noted that the FSRU’s will comply with international marine regulation. This is a prescriptive approach rather than a risk based system normally found in onshore systems.

Regulations concerning shipping are developed at the global level. Because shipping is inherently international, it is vital that shipping is subject to uniform regulations on matters such as construction standards, navigational rules and standards of crew competence. The alternative would be a plethora of conflicting national regulations resulting in commercial distortion and administrative confusion which would compromise the efficiency of world trade.

Hence the concept of whether the FSRU is acceptable in terms of build quality, safety, operations etc, is regulated under an extensive range of internationally agreed and accepted rules, regulations and independent verification. These rules are centrally developed under the United Nations Agency entitled the International Maritime Organization (IMO). The IMO’s primary purpose is to develop and maintain a comprehensive regulatory framework for shipping and its remit today includes safety, environmental concerns, legal matters, technical co-operation, maritime security and the efficiency of shipping.

IMO has adopted a comprehensive framework of detailed technical regulations, in the form of international diplomatic conventions which govern the safety of ships and protection of the marine environment. National
governments, which form the membership of IMO, are required to implement and enforce these international rules, and ensure that the ships which are registered under their national flags comply.

The level of ratification and enforcement of IMO Conventions is generally very high in comparison with international rules adopted for shore based industries.

The principal responsibility for enforcing IMO regulations concerning ship safety and environmental protection rests with the flag states (i.e. the countries in which merchant ships are registered – which may be different to the country in which they are owned).

Flag states enforce IMO requirements through inspections of ships conducted by a network of international surveyors. Much of this work is delegated to bodies called classification societies.

Hence the FSRU is treated as being acceptable in terms of design and operations if it meets these international regulations and passes regular independent inspection and verification. Thus any ship entering Indian waters that meets its own national flag regulations needs not be reassessed for internal safety against Indian regulations.

5.3.3 FSRU Vessel Specifications

A typical FSRU vessel specification is given in appendix G.

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 jetty, mooring and breasting dolphins, unloading platforms and breakwater that are required together with dredging of the berth, turning circle and access channel connection to main shipping channel, will be designed to comply with the FSRU vessel and in order to ensure the compatibility with the visiting LNG shuttles.

The LNG is contained at a temperature of -161°C and at atmospheric pressure (or slightly above). There are no refrigeration facilities onboard the FRSU. 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 generally fed to the regas or power systems to be used as fuel. Some modern FSRU’s have the ability to re-condense the spare boil off gas and inject it into the re-gas system. No gas is vented to atmosphere at any time during normal operations.

The FSRU’s are double barrier concepts. This means that there are two hull structures between the tanks and the outside sea. Not only does this limit the risk of cargo spillage, but it also provide space for ballast water to be stored (only LNG is ever stored in the main cargo tanks)

For further details see Appendix G.
5.3.4 Regas 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 whether the medium used to heat the LNG and convert it from a cold liquid to a ~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).

5.3.5 Vaporization of LNG

To accomplish the task of offshore LNG vaporization FSRUs may be operated in one of 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 by approximately 13 degrees Fahrenheit (7 degrees Celsius). For this reason, the open-loop mode is not applicable for water temperatures below 45 degrees Fahrenheit;

- 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.

This reflects the system onboard the likely FSRU’s that could be used at Kakinada. It may be that such an FSRU of suitable containment/re-gas size for the project is not available in the early years of the project and must be built in the yard and arrive on site a few years later than project start date. As such a temporary and smaller bridging vessel would be required from the existing fleet. A bridging vessel would have the technology described above or would be a closed loop only type.

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 in Kakinada, they do produce larger amounts of air emissions than an open loop system. As such it is expected that an open loop system will be utilised in Kakinada in the long term.

A flow diagram for the open loop system to be used for the long term FSRU option in Kakinada is shown below.
For the bridging vessel, an open or closed loop system may be used. If it is open then it follows the same flow diagram as for the long term solution. Should a closed loop system be utilised in a bridging vessel then it has the following flow diagram.
5.4 General Arrangement of Receiving Facilities

The receiving facilities considered to be developed for this project are described on the plot plan given in Appendix E.

It comprises:

- Navigational access system: access channel, turning circle, berth pit(s),
- An island jetty with its top-sides (unloading arms, drain drum, cryogenic pipeline, HP arms),
- A buried subsea pipeline connecting the island jetty to the shore line and to land fall point station,
- A land fall point station covering an area of approx. 2 ha.

The overall view of the facilities is shown here under:

Prospectively, this map also indicates an area suitable for a potential future on-shore terminal development which is not part of the present permitting application.
5.5 Subsea Pipeline

A HP subsea gas pipeline will transfer gas from the jetty to the grid tie-in point.

Two HP gas arms (2 x100%) on the jetty will transfer gas from the FSRU to the subsea pipeline.

The subsea gas pipeline to the shore line will be approx. 2.5 km length and will be prolonged underground on approx. 300 m till the land fall point station (see general arrangement). This is expected to be a 750 mm (30”) high pressure pipeline. It will be buried or otherwise protected against damages, particularly from anchorage deployed by vessels moored for discharge of lighter cargo. It is important to note that this pipeline will not cross the Kakinada Deep Water Port shipping channel.

The installation method assumed for the submarine pipeline section involves prefabrication of pipe sections land-based and tow out to the proposed FSRU site.

A preliminary estimate of corridor width for the main pipe string fabrication is around 10 -15 meters; a more detailed review of land availability and access requirements would be required to confirm actual requirements.

The installation options will need to be further reviewed during front end engineering.

5.6 Landfall Point Station

Gas Metering and custody transfer is assumed to be at the inlet to the HP gas pipeline, inside the battery limit of the terminal project at the land fall point station. The HP gas pipeline connectivity downstream of the landfall point station up to the tie-in point is not included within the perimeter of the terminal project.

The facilities/equipment installed within the landfall point station includes:

- An administrative building,
- Two metering skid systems (ultrasonic) with associated gas quality analysis,
- Safety isolation valves system,
- Pig receiving facilities,
- Cathodic protection system,
- An autonomous power generator (approx 200 kW)
An indicative plot plan of the landfall point station is given hereunder:

---

**5.7 Dredging**

To allow Kakinada Deep Water Port to accommodate larger LNG vessels of Q flex size, its navigation access capacity will have to be increased. This will translate in important dredging works described in IPA Site selection report (see Appendix B) and summarized in the table hereunder:

<table>
<thead>
<tr>
<th>Components</th>
<th>Dredging work description</th>
<th>Dredging material (estimated) Million m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access channel</td>
<td>Widening of existing 10km 160 m width to 300 m width</td>
<td>7 to 10</td>
</tr>
<tr>
<td>Additional turning circle</td>
<td>Creation of a dedicated turning circle of 600 m diameter north of the inner channel</td>
<td>3 to 4</td>
</tr>
<tr>
<td>Manoeuvring area &amp; berth pocket(s)</td>
<td>Creation of one or two berth pockets with accessing manoeuvring area</td>
<td>2 to 4</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>12 to 18</strong></td>
</tr>
</tbody>
</table>

All dredging works will be carried out before the LNG facility becomes operational. The size of the turning circle, entrance channel, run-off channel and berth pockets will be subject to detailed study in the FEED stage.

Current estimated dredging volume is between 12 and 18 million cubic meters.

Subject to further soil investigations, it is expected that dredging will be carried out using a Trailing Suction Hopper Dredger (TSHD) and Cutter Suction Dredger (CSD). The CSD will be able of dredging cap rock which would not otherwise be dredgeable with TSHD.

Suitable dredged material will be used in reclamations and port development activity within Kakinada Deep Water Port, if required. Otherwise surplus or unsuitable material is assumed to be disposed of at the approved/designated offshore disposal location of Kakinada Deep Water Port, subject to necessary permitting and environmental assessment.
## 6 FSRU Specification Table

A shortened overview of the FSRU characteristics is shown below. Full details are contained within Form I.

<table>
<thead>
<tr>
<th>General Information</th>
<th>Long Term Vessel</th>
<th>Bridging Vessel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Builder</td>
<td>Korean or Japanese</td>
<td>Korean or Japanese</td>
</tr>
<tr>
<td>Date keel laid</td>
<td>After 2013</td>
<td>After 2000</td>
</tr>
<tr>
<td>Date launched</td>
<td>After 2015</td>
<td>After 2002</td>
</tr>
<tr>
<td>Class society</td>
<td>DNV, LR, ABS, BV</td>
<td>DNV or BV</td>
</tr>
<tr>
<td>Cargo capacity</td>
<td>120,000 to 215,000 m³</td>
<td>138000 to 151,000 m³</td>
</tr>
<tr>
<td>Cargo tank working pressures</td>
<td>Likely 1-102kpa.</td>
<td>4-10kpa gauge</td>
</tr>
<tr>
<td>Design draft and displacement (m)</td>
<td>Up to 12.3m</td>
<td>11.4</td>
</tr>
<tr>
<td>Ballast draft and displacement (m)</td>
<td>down to 9.5m</td>
<td>9.6</td>
</tr>
<tr>
<td>Loaded draft and displacement (m)</td>
<td>up to 12.5m</td>
<td>11.64</td>
</tr>
<tr>
<td>Max air draft (m)</td>
<td>50-54m</td>
<td>40.4</td>
</tr>
<tr>
<td>Propulsion type and characteristics</td>
<td>Likely steam or DFDE</td>
<td>Likely steam or DFDE</td>
</tr>
</tbody>
</table>

### Regasification System

<table>
<thead>
<tr>
<th>Regas technology</th>
<th>Probably Open Loop</th>
<th>Open or Closed Loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP Gas Pressure and temperature</td>
<td>80-120 Bar 0-10°C</td>
<td>80-120 Bar 0-10°C</td>
</tr>
<tr>
<td>Min/Max continuous send out</td>
<td>1.4MMSCMD to 22.6MMSCMD</td>
<td>1.4MMSCMD to 14.2MMSCMD</td>
</tr>
<tr>
<td>Max send out</td>
<td>26.9MMSCMD</td>
<td>21.2MMSCMD</td>
</tr>
<tr>
<td>Spare philosophy</td>
<td>N+1 on critical equipment</td>
<td>N+1 on critical equipment</td>
</tr>
</tbody>
</table>

### Other

<table>
<thead>
<tr>
<th>Staff/crew composition</th>
<th>Operation phase – 32 persons on board and 20 persons for terminal operations</th>
<th>Construction phase – 1000 workers Operation phase – 32 persons on board and 20 persons for terminal operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visiting LNG Ship Capacity</td>
<td>Up to 265,000 m³</td>
<td>Up to 265,000 m³</td>
</tr>
</tbody>
</table>

### Resource requirement

<p>| Land | 2 Hectares for on-shore receipt terminal | 2 Hectares for on-shore receipt terminal |</p>
<table>
<thead>
<tr>
<th>Water</th>
<th>320000 KLD sea water as heating medium for RLNG and 35000 KLD as cooling water for machinery</th>
<th>35000 KLD as cooling water for machinery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>100 Tons of LNG per day equivalent to approximately 64 MW per day which will be generated by FSRU itself.</td>
<td>80 to 340 Tons of LNG per day (depending on regas rate) equivalent to approximately 51 to 218 MW which will be generated by FSRU itself</td>
</tr>
<tr>
<td>Construction Material</td>
<td>Jetty- approx. 21000 M$^3$ concrete</td>
<td>Jetty- approx. 21000 M$^3$ concrete</td>
</tr>
<tr>
<td>Safety &amp; Social Aspects</td>
<td>Refer Appendix-C</td>
<td>Refer Appendix-C</td>
</tr>
<tr>
<td>Safety, Health &amp; Environmental protection system</td>
<td>Refer Appendix-H</td>
<td>Refer Appendix-H</td>
</tr>
</tbody>
</table>
7 Current Status of Project

- APGDC and GDF SUEZ have executed the Project Framework Agreement for development of FSRU facility at Kakinada, Andhra Pradesh on 17th April, 2012 in New Delhi in the presence of Hon’ble Chief Minister, Andhra Pradesh, Union Minister for Petroleum and Natural Gas, C&MD, GAIL, President, GDF Suez LNG UK Ltd and other dignitaries.

- Report for selection of suitable site for establishing the FSRU project has been submitted by Indian Port Association (IPA) and IIT Madras. (Copy attached as Appendix-B). The IPA and IIT, Madras has suggested establishing the project in Kakinada Deepwater Port area in the report.

- During Partnership Summit held between 11th January and 13th January, 2012, GAIL Gas Limited, a 100% subsidiary company of GAIL has entered into a MoU with the Government of Andhra Pradesh to establish an RLNG Terminal in the Coast of Andhra Pradesh through APGDC. (Copy attached as Appendix-I).

- Consent letter has been received from M/s. Kakinada Sea Ports Limited (concessioner for operating Deep Water port at Kakinada) for establishing of LNG FSRU project within the boundary limits of Deep Water port (copy attached as Appendix-J).
8 Preliminary Environmental Assessment

8.1 Background

This section deals with the Initial Environmental Evaluation of the proposed project of Development of Offshore LNG FSRU Facility at Kakinada Deep Water Port, Kakinada, East Godavari District, Andhra Pradesh State. The section considers the environmental settings of the project site and surrounding study area including identification of notified ecological sensitive areas as per Ministry of Environment and Forests, Government of India followed by Potential Environmental Impacts due to the proposed project.

8.2 Environmental Setting of the study area

As discussed above, the Offshore LNG FSRU Facility is proposed at Kakinada Deep Water Port, Kakinada. The site is located at a distance of 2.5 Km from the Berth 1 of Kakinada Seaport Limited. Hope Island, located to the east of the proposed berth on the lee side of the breakwaters is within a distance of 10 Km, this was formed due to the sand drifting from the tributary of River Godavari. The island stretches across Bay of Bengal and forms the Bay of Kakinada between the island and the main Kakinada Coast. The northern part of the island is called Godavari point which overlooks the entry point into the Bay of Kakinada and the Kakinada Harbour. On the shore line, Kakinada fishing harbour is located on the northern side of the port. NH214 lies on the Western Direction of the port.

Coringa Wildlife sanctuary lies to the south of the port. It is located at a distance of about 15 Km from Kakinada on Kakinada – Yanam road. Coringa Sanctuary, named after a tiny village Coringa in East Godavari District of Andhra Pradesh, a part of Godavari Mangroves was declared as a wildlife sanctuary by Government of Andhra Pradesh vide G.O.Ms. No. – 484, Forests and Rural Development (For.III) Department dated 05.07.1978 was to conserve the mangrove vegetation of the estuary, extending in an area of about 235 sq. Kms. It is located between 16° 30’ to 17° 00’ N latitudes and 82° 14’ to 82° 23’ E longitudes. Mangroves are salt tolerant ecosystems of tropical and sub-tropical intertidal regions of the world.

East Godavari receives rainfall during June to October both southwest and northeast monsoon. Average rainfall varies widely from 1000 mm at the northern part of the coast to 1400 mm at the extreme western parts of the hills. The district has two major fertilizer plants and gas based power plants and edible oil refineries. Brief Summary of Environmental settings of the study area of 10 Km is provided in the following table.
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particulars</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Latitude &amp; Longitude</td>
<td>16° 58.37’ N 82° 17.06’ E</td>
</tr>
<tr>
<td>2</td>
<td>Elevation</td>
<td>2-3 m MSL</td>
</tr>
<tr>
<td>3</td>
<td>Nearest Meteorological station</td>
<td>Kakinada (Stn No. 43189)</td>
</tr>
<tr>
<td></td>
<td>Mean Maximum temperature</td>
<td>43.8°C</td>
</tr>
<tr>
<td></td>
<td>Mean Minimum temperature</td>
<td>15.8°C</td>
</tr>
<tr>
<td></td>
<td>Annual Maximum Humidity</td>
<td>82%</td>
</tr>
<tr>
<td></td>
<td>Annual Minimum Humidity</td>
<td>61%</td>
</tr>
<tr>
<td></td>
<td>Predominant direction</td>
<td>South West and North East</td>
</tr>
<tr>
<td></td>
<td>Average wind speed</td>
<td>9.6 kmph</td>
</tr>
<tr>
<td></td>
<td>Annual rainfall</td>
<td>1113.2 mm</td>
</tr>
<tr>
<td>4</td>
<td>Nearest habitation</td>
<td>Kakinada</td>
</tr>
<tr>
<td>5</td>
<td>Nearest major town/Nearest major city (more than 2,00,000 population)</td>
<td>Kakinada</td>
</tr>
<tr>
<td>6</td>
<td>Nearest highway</td>
<td>NH 215, 4.2 km Western side connecting Yanam and NH -5 at Kathipudi</td>
</tr>
<tr>
<td>7</td>
<td>Nearest railway station</td>
<td>Kakinada R.S 4.5 km from the port</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kakinada Port R.S &lt;1Km from the Port</td>
</tr>
<tr>
<td>8</td>
<td>Nearest airport</td>
<td>Rajahmundry, 70 Km</td>
</tr>
<tr>
<td>9</td>
<td>Nearest tourist places</td>
<td>Hope Island, within 10 Km radius</td>
</tr>
<tr>
<td>10</td>
<td>Defence installations</td>
<td>Nil within 10 Km radius</td>
</tr>
<tr>
<td>11</td>
<td>Protected area as per WP, act, 1972</td>
<td>Coringa Wild life sanctuary, approx. 15 Km</td>
</tr>
<tr>
<td>12</td>
<td>Reserved/Protected forest</td>
<td>Nil within 10 Km radius</td>
</tr>
<tr>
<td>13</td>
<td>Nearest water bodies</td>
<td>Sea (bay of Bengal)</td>
</tr>
<tr>
<td></td>
<td>streams/rivers/sea</td>
<td>Bhogamdani Cheruvu – 6.5 Km</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kalai Cheruvu – 14 Km</td>
</tr>
<tr>
<td>14</td>
<td>Major Industries</td>
<td>Two large Fertilizer Plants (namelyNagarjuna and Coramandel), Few Gasbased power Plants such as GMR Barge mounted Plant, Spectrum Power etc.</td>
</tr>
<tr>
<td>15</td>
<td>Seismic zone</td>
<td>Zone III as per IS 1893:2002</td>
</tr>
</tbody>
</table>
8.3 List of Ecologically Sensitive Places as defined by Ministry of Environment and Forests, Government of India.

- Religious and historic places
- Archaeological monuments/sites
- Scenic areas
- Hill resorts-mountains/hills
- Beach resorts
- Health resorts
- Coastal areas rich in corals, mangroves, breeding grounds of specific species
- Estuaries rich in mangroves, breeding ground of specific species
- Gulf areas
- Biosphere reserves
- National park and wildlife sanctuaries
- Natural lakes, swamps, seismic zones tribal settlements
- Areas of scientific and geological interests
- Defence installations, especially those of security importance and sensitive to pollution
- Airport
- Tiger reserves/elephant reserve/turtle nestling grounds
- Habitat for migratory birds
- Lakes, reservoirs, dams
- Streams/rivers/estuary/seas
- Railway lines
- Highways

As per the list mentioned above, Hope Island is located within 10 Km radius of the project site and considered as local tourist spots. Apart from the large fertilizer plants, Kakinada seaport, barge mounted gas based power plant is under operations. Yanam Island located at a distance of 20 Km where number of wetlands is present and attracts migratory birds to the area.
8.4 Environmental related studies that are proposed for the project

- Comprehensive EIA (marine and terrestrial) studies;
- Disaster Management Plan, Quantitative Risk Assessment Studies;
- CRZ map indicating HTL and LTL demarcated studies due to landfall point.

8.5 Social and Environmental aspects construction and operation phase

- Brief details of the social and environment aspects during the construction and operation phase have been worked out and enclosed as Appendix-C.
- The detailed study shall be carried out in EIA, Risk Assessment and Disaster Management Plan.

8.6 Summary

This consideration of environmental issues has been prepared based on the inputs taken from site and also through published information from MoEF/CPCB/Government of India Portal.

The project is located at a distance of 2.5 Km from the shore line. The project is for the installation of LNG FSRU facility within Kakinada Deep Water Port Limit, and transfer to the landfall point; it has insignificant environmental impacts on the marine biodiversity.

However, it is recommended to conduct detailed EIA studies covering marine and terrestrial, Risk Assessment, Disaster Management Plan for the proposed project.

Preliminary Site Selection Report has been appended as Appendix –B.
9 Budgetary Cost Estimates and Project Schedule

9.1 The Expected Project Costs

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>Configuration 1 FSRU twin-jetty OJ transfer (Million INR)</th>
<th>Configuration 2 FSRU Single jetty STS transfer (Million INR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feasibility and BOD studies</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>FEED</td>
<td>168</td>
<td>168</td>
</tr>
<tr>
<td>Jetty Structure</td>
<td>2800</td>
<td>1960</td>
</tr>
<tr>
<td>Jetty Topsides</td>
<td>1400</td>
<td>560</td>
</tr>
<tr>
<td>Subsea Pipeline+ Onshore facility</td>
<td>560</td>
<td>560</td>
</tr>
<tr>
<td>Dredging (turning circle, berth pocket)</td>
<td>3080</td>
<td>2520</td>
</tr>
<tr>
<td>Additional ship Modification</td>
<td>0</td>
<td>560</td>
</tr>
<tr>
<td>Additional investment for Common Port Facilities : Dredging (widening and</td>
<td>2000</td>
<td>2000</td>
</tr>
<tr>
<td>deepening of Port access channel)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>10064</td>
<td>8384</td>
</tr>
</tbody>
</table>

9.2 Project Schedule

The table below show the timeline for construction activities related to the project.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Description</th>
<th>Target Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Detail Feasibility Report</td>
<td>December 12</td>
</tr>
<tr>
<td>2</td>
<td>Final design for Jetty and other facilities</td>
<td>May 13</td>
</tr>
<tr>
<td>3</td>
<td>Ordering and receipt of long lead items</td>
<td>Jan 14</td>
</tr>
<tr>
<td>4</td>
<td>Construction of Jetty</td>
<td>Nine months from MOEF clearance</td>
</tr>
<tr>
<td>5</td>
<td>Dredging work</td>
<td>Nine months from MOEF clearance</td>
</tr>
<tr>
<td>6</td>
<td>Sub-sea pipeline construction</td>
<td>Six months from MOEF clearance</td>
</tr>
<tr>
<td>7</td>
<td>Ship fixing &amp; FSRU conversion</td>
<td>Feb 14</td>
</tr>
<tr>
<td>8</td>
<td>Ship sailing and commissioning</td>
<td>March 14</td>
</tr>
</tbody>
</table>

Note: The above schedule is subjected to MoEF clearance
10 Conclusions & Recommendations

The study concludes that it would be technically feasible to establish an island jetty based FSRU, LNG receiving terminal, in Kakinada.

Kakinada is located close to the existing grid and East West pipeline; this would allow the promoters of the Project to achieve the connectivity between the LNG receiving facilities and the gas market in a short period of time (2 to 3 years), thus enjoying the benefits of a fast track LNG floating solution, with an optimized time to market.

The leeside of the north breakwater offer a suitable, protected marine area suitable to set up an LNG berth. Offshore open sea locations have been ruled out, as harsh weather conditions in a cyclone prone area, with waves heights exceeding 2 meters for 32% of the time during NE monsoon, and 68% of the time during SW monsoon¹, are considered as a strong deterrent with respect to the downtime generated on cargo transfer operations.

The design options described in this report are indicative only and will have to be assessed, precised and selected, during consolidated engineering studies; similarly further investigations relating to environmental issues and FSRU operation impact will be required during EIA studies. Then only the outlined figures given will be confirmed.

The ultimate viability of the project will be determined and established by a comprehensive Detailed Feasibility Report collecting and analysing site specific data in particular Metocean data

¹See IPA Site Selection Report (page 38) attached in Appendix B
APPENDIX A

BRIEF PROFILE OF MARKET CONDITIONS FOR NATURAL GAS IN ANDHRA-ПRADESH
Andhra Pradesh – An Emerging Gas Hub

Andhra Pradesh is the fourth largest state by area and fifth largest by population in India. Andhra Pradesh is blessed with a long coastline and has the second largest coast line of 972 km among the states of India. Over the past decade, it has emerged as one of India’s fastest growing states. The state’s GDP is estimated to be more than USD 120 Billion and stands third among states of India.

The State has emerged as an important hub for natural gas industry post the Krishna – Godavari basin gas discovery. A large number of gas based power plants and other industries have been set up and many are under planning stage. Andhra Pradesh has a good pipeline infrastructure connecting it to the other regions of India. So, a terminal in Andhra Pradesh could supply gas to many other regions in India. Further, the pipeline infrastructure in the state is expected to get a further boost once the planned pipelines are commissioned. Some of the pipelines being planned in the state are Kakinada-Chennai in Tamil Nadu Kakinada-Haldia in West Bengal State and Kakinada- Vijayawada-Nagpur-Bhilwara in Rajasthan State.

Furthermore, the Petroleum, Chemical & Petrochemical Investment region (PCPIR) is being setup in the east coast along the Kakinada -Visakhapatnam Industrial Corridor. Many SEZ’s are planned to be setup in the area with Refinery / Petrochemical Feedstock Company. This investment region would further boost the demand for gas in the state.

Gas Demand in AP

Power sector is a major consuming sector for gas in the State of Andhra Pradesh. The energy consumption in the state is growing at double digits during past several years. With an installed capacity of more than 15,500 MW, Andhra Pradesh represents one of the largest power markets in India. The AP state power utilities have power purchase agreements for around 2,700 MW of gas based power plants in the state. However, due to shortfall in domestic gas, these plants are not operating at their optimal capacities. The gas based plants in the state are currently operating at 50% - 60% of their capacity. Further, an estimated 13,000 MW of gas based plants are expected to come up in the state in the coming years subject to gas availability given the constraints in coal supply. With increased power tariffs and rising imported coal prices, the affordability for gas is on the rise. This would lead to a further increase in demand for natural gas in the state.

The state of Andhra Pradesh is experiencing huge energy deficits owing to shortfall in domestic coal and gas supplies. Due to this, the state is left with no option but to impose load restrictions on the consumers in the state. During the load restrictions, the industries mostly run their plants on liquid fuel. The cost of power from diesel generators is estimated to be around Rs. 16/unit (USD 0.32 /unit). Given this backdrop, the industrial associations have approached the Andhra Pradesh Power distribution licensees for supply of uninterrupted power to mitigate load restriction measures. Accordingly, the licensees have proposed to tie-up power from idle gas based power capacity using RLNG fuel. In this context, alternate fuel like RLNG would be in demand despite the relatively higher costs when compared to coal based power generation.

City gas distribution demand comprising compressed natural gas (CNG) for usage as transport fuel and piped natural gas (PNG) for replacing LPG – is an attractive demand segment from an affordability perspective. There are significant plans of APGDC to spread the gas distribution infrastructure to all the regions in AP which will drive the demand. PNGRB has allotted licenses to a number of players for CGD implementation in the state of Andhra Pradesh. Gas demand from these cities like Vishakhapatnam, Nalgonda, Rajahmundry, Kakinada, etc. is expected to increase once these projects are implemented.
Due to rapid economic growth, the natural gas demand from other industrial sectors like ceramics, metals and bulk drugs is expected to go up. The expected gas demand from sectors other than the power sector is likely to be around 30 MMSCMD. But, due to shortfall of domestic gas, a lot of this demand is currently not being met. So, an LNG terminal on the Andhra Pradesh coast is necessary to bridge this gap.

The summary of existing demand for gas from all the sectors is shown in the table below:

<table>
<thead>
<tr>
<th>Sector</th>
<th>Allocation (A)</th>
<th>Requirement (B)</th>
<th>Supply (C)</th>
<th>Alloc-Req (A-B)</th>
<th>Alloc-Sup (A-C)</th>
<th>Req-Sup (B-C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer</td>
<td>4.797</td>
<td>3.27</td>
<td>3.215</td>
<td>1.527</td>
<td>1.582</td>
<td>0.055</td>
</tr>
<tr>
<td>Ceramics, Glass, Steel and Others</td>
<td>0.71944</td>
<td>0.9205</td>
<td>0.3855</td>
<td>-0.20106</td>
<td>0.33394</td>
<td>0.535</td>
</tr>
</tbody>
</table>

Furthermore, there are many announced projects that could increase the demand for gas. For example, the additional demand from Power Sector from announced capacity addition programs from projects in Andhra Pradesh are likely to be around 40 MMSCMD. Some of the announced and under construction power plants are from large players like Reliance, GMR, Lanco and GVK.

**Andhra Pradesh as an attractive LNG market**

The gap will have to be met from RLNG as the domestic gas supply is on a decline. Furthermore the RLNG terminal on the east coast will be more economical than on the west coast. This can avoid additional taxes and transportation charges that make the delivered price of RLNG costly. The following tables illustrate the difference in the delivered price of gas in two scenarios considering crude price of $100 –

**Scenario – 1 – RLNG transported from West Coast to AP**

In case the gas is transported from the West Coast, there is additional implication of taxes and transportation charges as shown in the table below:
Scenario – 2 – FSRU on the East Coast of AP

In case the FSRU is located on the East Coast in AP, then the delivered price will be lower due to the avoidance of additional taxes and transportation charges as shown in the table below:

<table>
<thead>
<tr>
<th></th>
<th>Ex-Terminal Price</th>
<th>Regas</th>
<th>Taxes</th>
<th>Transportation</th>
<th>Other</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12.74</td>
<td>0.30</td>
<td>2.03</td>
<td>0.40</td>
<td>0.21</td>
<td>15.68</td>
</tr>
</tbody>
</table>

Natural Gas Demand Drivers

The consumption of natural gas has been growing at around 9.9% CAGR. Power and fertilizer sector contribute around 70% of total gas demand in the country. The key demand segments are as follows:

Power - Currently, power plants contribute more than 40% of natural gas consumption in India. The Indian Power Sector has been growing at a rapid pace and the pace is likely to be sustained in the coming years to meet the growing power demand. The installed capacity has increased from 105GW in 2001-02 to more than 180GW in 2011. Even with such increase in installed capacity, the power deficits in the country exceed 10%. Given the shortage of domestic coal, the primary fuel used for power generation, there is emphasis on leveraging all possible sources of energy for meeting the deficit. Given the shortage of domestic coal and gas resources, there is increased dependence on imported coal and LNG. At present there is about 2300 MW capacity that exists without allocation of gas and about 1700 MW that are under execution without having firm gas tie-up. Further about 700 MW of gas plant are being run on liquid fuels. In addition, there are many plants that are running below capacity owing to less supply of domestic gas. Thus there is a window of opportunity for LNG suppliers to cater to partial/full requirement of the existing and new plants.

Fertilizers - The fertilizer sector contributes more than 25% of the natural gas consumption. Government of India has decided that all existing gas-based urea plants would be supplied gas to meet their shortfall to ensure full capacity utilization. All existing plants in this sector have been accorded highest priority for domestic gas allocation.

City Gas Distribution (CGD) - PNGRB has granted licenses/approvals for CGD implementation in many cities of India. The CGD network in India has been steadily increasing and Government of India has a vision to expand the CGD network to 200 cities by 2015. Since the alternate fuel for CGD network is expensive liquid fuels (Furnace Oil, Commercial LPG, Petrol prices are deregulated in India), this segment has emerged as an attractive market segment for gas from an affordability perspective.

Supply Constraints

The supply of gas in India has not matched the demand growth. Some of the factors limiting the supply of gas are:
Maturing Oil / Gas fields: The gas production from existing fields like Mumbai High and Reliance KG basin has decreased. The current production from KG basin is much lower as compared to the estimates a few years earlier.

Limited Oil & Gas reserves: The participation from global oil majors in the NELP bidding rounds has not been very encouraging.

Unconventional resources are yet to be fully tapped: Major unconventional sources of supply such as CBM, shale gas and gas hydrates are still in nascent stages of development. There has been some tight gas discoveries in the Cambay basin, but the commercial monetization of such discoveries will take time.

All the aforementioned constraints limit the availability of domestic gas in the country. Import of LNG is an important option by which India could enhance the gas supply position in the country. India is already importing more than 40 MMSCMD through the LNG route.

Demand Supply scenario

The demand supply shortfall is estimated at close to 100 million metric standard cubic meters per day (MMSCMD). This in turn, has resulted in the inadequate or sub-optimal use of infrastructure: both gas-based power plants and fertilizer units either remain idle or operate using expensive liquid fuels, such as naphtha.

The graph below shows the estimated deficits.

Given the shortfall and domestic gas supply constraints, there is an urgent requirement for increased LNG regas capacity and imports.

Natural Gas Infrastructure

Pipeline Infrastructure: India has more than 11,000 km of pipeline with capacity of more than 270 MMSCMD. Gas pipeline infrastructure predominantly meets the demand in the Western and Northern parts of the country. The pipeline capacity is expected to rise substantially going forward on the back of the proposed pipeline capacity and from the pipeline capacity already under construction. The Petroleum and Natural Gas Regulatory Board (PNGRB) was constituted in 2007 to promote competition and to authorize entities to build.
the required infrastructure and monitor the downstream sector. Thus there is a significant thrust to develop the pipeline capacity and it is not a major constraint once a gas source is identified.

**RLNG Terminal Capacity:**

Presently, India’s LNG import capacity is around 13.5 MMTPA through its terminals at Dahej of 10 MTPA and Hazira of 3.5 MTPA. The contribution of imported gas through RLNG is around 20% of the total gas supply of the country. Furthermore, the LNG terminals at Kochi and Dabhol are likely to be operational soon. It may be mentioned here that all the LNG terminals (existing + under construction) in the country are currently located on the western coast. Despite high demand for gas in east coast region of India, there is no RLNG terminal on the east coast.
APPENDIX B

SITE SELECTION REPORT IPA &

IIT CHENNAI
APPENDIX C

SAFETY & SOCIAL ASPECTS
Safety Aspects – Navigation

1. HYDRAULIC CONDITIONS

Currents are dominated by the tidal flows, with predictable variations over diurnal, monthly and annual time scales.

Very strong currents in the order of 0.4 to 0.8 m/s occur between the sand pit and the breakwater, which are capable of moving sediments into and out of the bay.

The currents in the vicinity of the port and within the dredged channels are relatively weak, with a maximum of only 0.2 m/s.

Currents generally flow in a North/South direction, roughly parallel with the shoreline.

The predominant wind directions are South-West and South-East. The mean wind speed is about 14.4 km/h (4 m/s). The maximum mean wind speed is 49.7 km/h (13.8 m/s).

During cyclone the region experiences a maximum wind speed in excess of 117 km/h (32.5 m/s).

2. TRAFFIC INTENSITY AND SAFETY ISSUES

Kakinada Deep Water Port has development plans for expansion. Therefore, we should expect traffic to increase over the next decade. The Terminals shipping requirements may impact on the Ports development plans, however, in this instance there is no detrimental impact on the provision of additional berthing.

The traffic intensity is moderate but the bulk carriers do have a significant Deadweight of around 100,000 Tons. Even at low speeds this bulk carrier can cause severe damage to an LNG carrier in a collision. This risk can be easily mitigated with good basic traffic control.

The berth arrangement is perpendicular to the entrance channel, with a clearance of approximately 300m. The change of collision is therefore minimised. The existing turning circle will be increased to 600m dia to suit the LNGCs, which will be “reversed” into position using tugs. Careful river management will be necessary during turning when the vessel is vulnerable because the side of the vessel is exposed to channel traffic.

The ignition zone of 250m around the berth is not interfering with the other activities.

3. MANOEUVRABILTY

Since Kakinada is a sheltered harbour location already accommodating large ocean going vessels it has been assumed at this stage that wave, wind and current heights and speeds are normally not excessive or restrictive.

A fast-time simulation study will be performed in order to investigate the arrival and departure of the LNG Carrier under a variety of normal and extreme conditions. A real time manoeuvring simulations will also be performed during the FEED.
Social and Environmental aspects

DURING CONSTRUCTION

The development of an LNG terminal on the eastern coastline of India has potential to impact the environment as per follows:

- Direct damage to marine and terrestrial habitats and species via dredging and construction activities,
- Accidental spillage of oils, fuels and chemicals from construction vessels,
- Local re-suspension of sediments and increase of turbidity with resultant impacts, such as decrease of primary production for benthic and pelagic flora due to reduced light penetration, and smothering of benthic organisms,
- Spread of potentially contaminated sediments through construction activities, in particular dredging works,
- Effect of surface water run-off which may contain contaminants,
- Wastewater from the construction site including accidental spillages could enter water sources e.g. during unloading or transportation processes or by being washed into water courses during rainfall,
- Changes to tidal flow and wave energy characteristics with a resultant change to the habitat for pelagic and benthic organisms,
- The water environment could be polluted through waste and litter being discarded or blown in to the surrounding water courses, terrestrial environment or into the sea,
- Impacts of noise and vibration during construction works on birds, terrestrial animals and underwater fauna,
- Decreased air quality from exhaust gases during transportation of equipment, construction activities.

Potential social impacts include:

- Impacts to water quality outlined above also have potential to cause social impacts to local people through declines to water which may be used for drinking or bathing.
- Changes to air quality through:
  - Exhaust gases from construction vehicles. Most vehicles and construction equipment use petrol or diesel as fuel and will discharge gaseous pollutants;
  - Dusts from construction activities may be transferred into the atmosphere locally which could impact on workers and neighbours’ residential areas.
- Fire and explosion risks associated with flammable substances such as gas and oils.
- The concentration of personnel/labour can cause public health problems through potential spread of infectious diseases and increased pressure on public services such as health care.
- There can also be potential for increased levels of crime as a result of the influx of workers.
- Noise and vibration during construction works on human receptors,
- Increased employment as a result of the development of an LNG terminal is predicted to cause
beneficial impacts to the local community, in terms of socioeconomics.

Potential impacts listed above shall be minimized and controlled through appropriate mitigation.

DURING OPERATION

The LNG terminal on the eastern coastline of India has potential to impact the environment as per follows:

- Direct damage to marine and terrestrial habitats and species via dredging maintenance and operational activities,
- Accidental spillage of oils, fuels and chemicals from vessels using the LNG terminal during operation,
- Local re-suspension of sediments and increase of turbidity with resultant impacts, such as decrease of primary production for benthic and pelagic flora due to reduced light penetration, and smothering of benthic organisms.
- Effect of surface water run-off which may accidentally contain contaminants.
- Depending upon the vaporization process, discharge of sea water which could be used in this process during operation. This water would be 5-7°C cooler, with a maximum chlorine component of 1ppm. The discharge rate will be a maximum of 11,500 m³/h (for 2.5 MTPA) or 23,000 m³/h (for 5 MTPA).
- Changes to tidal flow and wave energy characteristics with a resultant change to the habitat for pelagic and benthic organisms.
- The water environment could be polluted through waste and litter being accidentally discarded or blown in to the surrounding water courses, terrestrial environment or into the sea.
- Decreased air quality from exhaust gases during operational vessel traffic and potential accidental gas leakage.

Potential social impacts include:

- Impacts to water quality outlined above also have potential to cause social impacts to local people through accidental declines to water which may be used for drinking or bathing.
- Changes to air quality through:
  o Uncontrolled equipment emissions NOx, CO, SO2, PM10, CO2 and NH3
  o Land based emissions CO2 and NOx
  o Discharge of cold gas from safety valves in the event of fire.
- Fire and explosion risks associated with flammable substances such as gas and oils.
- Increased employment as a result of the operation of an LNG terminal is predicted to cause beneficial impacts to the local community, in terms of socioeconomics.

Potential impacts listed above shall be minimized and controlled through appropriate mitigation.
APPENDIX D

BASIC PROCESS FLOW DIAGRAMS

FSRU
APPENDIX E

GENERAL ARRANGEMENT – BASIC DESIGN
APPENDIX F

PLOT PLAN LANDFALL POINT STATION
APPENDIX G

FSRU VESSEL SPECIFICATIONS
Please note that these are typical FSRU specifications. Exact details are to be finalised subsequent to completion of Pre-Feed and inputs from EIA clearance. However, the quantifications given in the Form I will be worst case and any studies carried out to attain EIA approval will always be in excess of what will be finally commissioned.

FSRU Regulatory Compliance

National Rules of the Flag of Registry

- International Convention on Load Lines;
- International Convention for the Prevention of Pollution from Ships;
- International Convention for the Prevention of Collisions at Sea;
- International Telecommunication Union Radio Regulations;
- International Tonnage Measurement and Certification;
- Suez Canal Navigation Rules, incl. Regulations for Measurement of Tonnage; and
- Safety and Health Regulations for Long shoring, U.S. Department of Labor.

International Maritime Organization (IMO):

- IMO Publication No. 978 Performance Standard for Navigational Equipment;
- IMO Resolution A.665 (16) “Radio Direction Finding System;”
- IMO Draft Guidelines of Bridge Visibility;
- IMO Resolution A 468 (XII) “Code on Noise Levels on Board Ships;”
- IMO Resolution A343 “Recommendation on Methods of Measuring Noise Levels at Listening Posts;” and

An example layout of an FSRU is shown overleaf.
LNG Containment System

The cargo system has 4-6 reinforced membrane-type tanks. The LNG with a specific gravity of typically between 0.43 and 0.47 is stored at -261°F. The guaranteed daily boil-off rate is approximately 0.16% of the vessel's total cargo capacity. The design chosen complies with all International Maritime Organization (IMO) requirements in accordance with a 40-year World Wide Trade operational lifespan.

The containment of the LNG may be either in Mark III or No 96 systems, both from the manufacturer GTT of France.

The main components of the MARK-III Containment system are applied as follows:

- The insulation which consists mainly in rigid polyurethane foam with reinforcing glass fibers in between two (2) plywood sheets. Insulation transmits cargo pressure to the internal structure of the Vessel.

- The 1.2 mm thick stainless steel primary barrier whose main feature consists in an orthogonal system of corrugations which compensate for thermal contraction and mechanical ship's deflections.

- The secondary barrier, which are laminated composite material, and which are made of two (2) glass cloths (for the resistance) with an aluminium foil (hereinafter call "Triplex"), in between, for the tightness. The secondary barrier, whose purpose are to sustain LNG in case of any accidental leakage through primary barrier, are inserted in the insulating structure.

The layout of these panels is shown overleaf.
Layout of Mark III Containment Tank

Layout of Mark III Containment System
Should a No96 system be chosen then it has the following layout.
Cargo System Machinery

Typical cargo systems include the necessary pumps and control systems for monitoring and control of the LNG in the storage tanks. The onboard classification society approved load and stability calculator will assure that liquid cargo (LNG), and ballast water is properly distributed to minimize the stresses in the FSRU’s hull. The operator is able to monitor the cargo levels, temperatures and processes within each tank, and control the valves for filling, discharging, and stripping the tanks. The operator will also monitor and control the auxiliary equipment associated with the cargo system, to include the following:

- **Cargo machinery room and electric motor room**: The cargo machinery room and electric motor room are arranged on deck. The electric motor room is separated from the cargo machinery space by a certified gastight steel bulkhead and is designed as gas safe space.

- **Cargo compressors**: Two low-duty (LD) compressors are used to handle the quantity of gas compatible with 100% gas burning on the auxiliary boilers. To protect the cargo tanks from being over pressurized due to natural boil-off the gas has to be consumed by the ships engines, the regas boilers burned in the gas combustion unit or as a last resort vented to the atmosphere. The Low Duty compressors will supply the natural boil-off gas to the duel fuel engines and the gas combustion unit as fuel gas to keep the vapour pressure stable. If the duel fuel engines require less fuel gas than that which is naturally boiling off, the vapour header pressure will increase. To prevent an increase in the pressure the gas control unit will be activated to burn the remaining natural boil off.

- **Cargo vaporizer**: One vaporizer capable of supplementing natural boil-off gas during 100% gas burning operation and that will:
  - Supply cargo vapor to the cargo tanks when the cargo pumps are discharging, without vapor return from shore; and
  - Purge inert gas from cargo tank.

- **Cargo discharge pumps**: Each LNG tank is outfitted with two cargo discharge pumps. These pumps are single-stage, centrifugal pumps with one inducer stage. The single stage will help to obtain a very low net positive suction head. The pumps are of the submerged motor type, with the motor windings cooled by the pumped LNG. The LNG also will lubricate and cool the pump and motor bearings.

- **Emergency cargo pump**: Each tank is equipped with a column where an electric motor-driven emergency cargo pump can be lowered.
• **Inert gas plant:** Inert gas/ dry air plant is installed, consisting of inert gas plant for gas oil burning, scrubber and dryer of combined refrigerating/ absorbent type, two blowers (electrical driven). The inert gas produced is to have a maximum oxygen content of 1.0 % and a dew point below -45°C. The same plant is capable of supplying dry air into the cargo tanks.

• **Nitrogen generators:** Two equal nitrogen generator sets of membrane type are supplied with air from two dedicated oil-free compressors. The generators will discharge to a buffer tank of about 10 m³ volume at a pressure of about 10 bar, purity 97%, and dew point minus 70°C. The nitrogen generators are installed to provide nitrogen for the following purposes:
  
  o Cargo compressor gland sealing;
  
  o Cargo tank insulation space and inter-barrier space inerting and purging;
  
  o Cargo line purging; and
  
  o Fuel gas to DF generators and auxiliary boilers line purging.

• **LNG custody transfer system:** An LNG custody transfer system is provided to enable accurate LNG quantity measurement when loading or unloading LNG; this will work independently from the export gas fiscal metering. The system will measure liquid levels, liquid and vapor temperatures, and vapor pressure within each LNG tank. This data, together with the tank calibration tables, is used to automatically calculate the LNG quantities before and after the transfer of the LNG.

• **Gas metering system:** The metering system is located on the forward part of the main deck between the vaporization units and the unloading buoy trunk. The metering system will include the following main items:

  o **Ultrasonic gas metering system:**

    Two ultrasonic gas flow meters,

    Two pressure transmitters, and

    Two temperature transmitters.

  o **Gas analyzer system:**

    Sample probe,

    Two gas chromatographs,
Pressure reduction cabinet, and

Analyzer cabinet.

- Metering control system:
  
  Metering cabinet,
  
  Two flow computers,
  
  Terminal flow computers and gas chromatographs,
  
  Supervisory computer and operator station, and
  
  Local area network (LAN) switch.

- **Cargo leak detection**: Minute cargo leakage within the membrane inter-barrier space is detected at an early stage by the gas detection system. The gas detection system will continuously monitor the inter-barrier space by circulation of nitrogen within the space. Should a leak occur, it is detected. Cargo would be restrained from coming into contact with the inner hull of the LNG carrier by the secondary barrier membrane. An assessment of the leak could then be made and any special recovery measures such as emptying the tank concerned could be implemented.

- **ESD system**: The ESD system is designed to ensure a controlled shutdown of LNG equipment to avoid any unsafe conditions. It is essential that the LNG pumps be stopped and valves closed in the correct sequence to avoid inertial pressure surges.

- **Ship-to-shore link**: Linked ship-shore emergency shutdown systems are required by SIGTTO for loading LNG and discharging at shore-side LNG piers. They will minimize the potential consequences of an accident or, if abnormal conditions arise, they will allow the process to be shut down averting any LNG escape. This reduces and or avoids:
  
  - Excessive surge pressure on the loading arm connection causing damage in the event of an upstream valve closing first,
  
  - Overfilling the cargo tanks, and
  
  - Risk of damage or spillage due to excessive movement of the LNG carrier with respect to the shore side berth.
The ship-to-shore link consists of a triple system including,

- Pneumatic connection
- Fiber Optic connection
- Electrical/Pyle connection

Depending on the terminals shore side systems, either the Fibre Optic, or Electrical Pyle connection can be used in conjunction with the pneumatic ESD and communication system.

This system shall have ship/shore connections compatible with the discharge terminal. Fibre optic, intrinsically safe types and pneumatic types shall be installed.

Fibre optical link shall be based on the Furokawa/Seatechnick system or equivalent and shall incorporate ESD, telephone function and mooring tension monitoring.

Pyle National hardwired electric link with Miyaki adapter shall incorporate ESD and telephone function.

All cable for ship/shore ESD link shall be supplied by loading and discharging port.

The following systems shall be provided:

a) Fiber Optic System

This system shall be installed for:

- ESDS signal from shore
- ESDS signal to shore
- Communication signal to shore
- Communication signal from shore

b) Electrical System

This system shall be provided for ESDS in accordance with SIGTTO recommendations and shall consist of ship assembly.

c) Pneumatic System

This system shall be provided as an ESDS back up between ship and shore and shall consist of an adjustable pressure switchbox, a selector switch and pneumatic hose. Hose quick connections are not to have non-return valves fitted.
• **LNG tank high-level shut-off system:** Each LNG tank will have an independent high-level alarm and shut-off function, which will work independently of each other. The shut-off function is connected to the high-level alarm system. A pre-warning alarm is sounded when the tank volume reaches 95%. This will activate an alarm in the cargo control room and an alarm horn with a different tone will sound on deck, accompanied by an orange flashing warning light. When the liquid level in the tank reaches a position equal to 99.2% full by volume, a signal is sent to the tank loading valve remote control system to close the valve automatically. When this valve is activated, red warning lights will flash and an alarm horn will sound on deck.

• **LNG tank relief valves:** Each LNG tank will have two pilot-operated pressure/vacuum relief valves as required by the IMO code. This will assure that cargo tank pressure is maintained within safe limits prescribed by the shipbuilder.

• **Accommodation and machinery spaces gas detection system:** This gas detection system will monitor the accommodation and machinery space areas throughout the FSRU. The system will automatically (or manually) switch between the measurement locations. The range of measurement is from 0 to 100% of the Lower Explosion Limit. The system will continuously scan the locations sequentially 24 hours-per-day, seven days-per-week. In addition, a separate gas detector is installed for continuous monitoring of fuel gas supply at the auxiliary boiler furnace fronts and DF generators enclosed rooms.

• **Cargo areas gas detection system:** A separate gas detection system will cover the LNG insulation spaces and cargo handling machinery compartments. The control unit is similar in operation to the accommodation and machinery spaces gas detection system.

• **Each of the three regasification unit’s housings enclosures is equipped with gas analyser sampling tubes connected to the gas detection system.**

• **Fire detection and alarm system:** The fire detection system is computerized, with fully addressable analogue fire alarm system and analogue detectors. The central control unit with back-up battery, operating panel and power supply is contained in a central cabinet on the bridge. There is a repeater panel in the fire control headquarters. The system is interfaced to the Distributed Control System. The Distributed Control System will indicate loop status and will control the fire pumps. The operator also is able to access mimic deck plans indicating the exact location of individual detectors and their status. The system will use a wide range of detectors and sensors to suit different needs and conditions. It will include detectors with different alarm parameters (for example, ion and optical smoke detectors, heat and flame detectors, manual call
points, short-circuit isolators, and timers where required). The detectors are wired in a loop configuration with four loops in total. A fault in the system or a false alarm is detected immediately since the function of the detectors and other installed loop units is tested automatically and continuously.

- **Public address system:** A public address system is provided with sufficient numbers of loudspeakers arranged in the accommodation, public rooms, engine room, and open deck.

**High Integrity Pressure Protection (HIPPS)**

A High Integrity Pressure Protection System protects the export piping from the skids to the HP manifold from over pressurisation, by limiting the pressure. These are not control valves and close in case of failure.

The HIPPS valves are not expected to close during any part of the start-up or shutdown process and are equipped only as a safety device. Their task is to protect the equipment downstream of the regasification equipment and to keep the pressure in the regas system below design pressure in all situations.

**Cargo Lines:** The system is shown diagrammatically in principle on the separate drawing of Cargo Piping Diagram below. All Cargo Lines, and valves are constructed of high grade stainless steel, for use under cryogenic conditions.
Cargo Piping has the following key characteristics:

Two (2) main liquid and one main vapour crossovers, common to all cargo tanks, are provided. Four (4) liquid shore connections and one vapour connection are provided at each side of the Vessel.

One common liquid header, one common vapour header and one stripping/spray header are provided. The liquid lines terminate at the bottom at the aft end of each cargo tank.

The liquid domes extend from inside the cargo tank up to a suitable height above the weather deck. The vapour line are connected at the middle of each tank.

All cargo and associated piping are laid on the trunk deck. Special attention is given to the arrangement in way of dome area to allow safe and easy access for maintenance work.

Piping drainage arrangements are provided so that the liquid in cargo piping can be drained back into cargo tanks from shore connection.

An electrical bonding system is provided throughout to ensure that potential differences are avoided.

Small drip pans of stainless steel are provided under all flange connections in liquid cargo lines (removable type)

One (1) stainless steel liquid header is led between No.1 and No.4 cargo tanks on the trunk deck and are connected with the crossovers.

One (1) liquid connection is branched off the liquid header and led to each cargo tank.

In each cargo tank, two (2) cargo discharge lines with cargo pumps at the bottom, and one (1) cargo filling line extended to the bottom are provided. In addition, a well is provided for lowering down the emergency cargo pump. These lines shall penetrate the liquid dome and are connected to the cargo liquid branch for each tank.

**Cargo manifold arrangement**

Loading stations are provided port and starboard on platform above upper deck as shown below:
The cargo manifold consisting of four (4) liquid lines and one (1) vapour line is arranged L.L.V.L.L. and provided port and starboard on platforms above the main deck and are in compliance with OCIMF standards and the loading and discharging ports.

The spacing between liquid line and vapour line are in accordance with loading and discharging terminal’s arm locations and the distance between ship manifold flange and ship side is 3.5m.

The distance between the bottom edge of the manifold flange and the top of the deck or working platform is 900 mm.

The shore connections shall consist of:

- Two (2) 600 mm dia. liquid crossovers connected to the fore and aft liquid header and terminating with Y branch at each end.
- A hydraulically operated butterfly valve with emergency shutdown and a manually operated butterfly valve is fitted to each manifold liquid line with blank flange.
- One (1) 600 mm dia. vapour crossover connected to the fore and aft vapour header and terminating with one (1) hydraulically operated butterfly valve and with blank flange at each end.

The outer length of each manifold up to the first support are increased to schedule 40S pipe for the loads imposed by hard-arms, and are provided with a pressure gauge and drain connection.

Water curtain pipes (90-10 copper-nickel) are provided at ship side in way of each loading station to protect the side shell during loading and discharging. (Not spraying type, film type)

Sea water for sea water curtain is supplied from fire and deckwash main line near the loading station.

All remotely operated valves as well as emergency shutdown valves are operable from the IAS and valves are capable of manual operation locally at solenoid rack and by hydraulic hand pump.

**Loading platform**

The loading platform is constructed of stainless steel (SUS 304) with coaming and small stainless steel drip pans are provided under the ends of shore connection of low temperature liquid line.

GRP grating on manifold deck is provided within the area surrounded by coaming, including stainless steel (SUS 304) grating inserts in load bearing areas.

The means *(spill line and valve)* are provided to deflect a spill of LNG overboard to facilitate the rapid escape and evaporation of the liquids in accordance with the OCIMF standards.

Separate coaming with drain plug are installed around bunker manifold.

**Vent masts for cargo tanks**

Four (4) vent masts about 14.5m high above the trunk deck are provided and fitted with a nitrogen purging connection.

The vapour header is permanently connected to forward vent mast which is fitted with a pressure control valve, and a trip closing arrangement operated from the IAS & W/H, with manual override.

The vent mast are of stainless steel pipe (SUS 316L). A bottom plate and a drain connection with small drip tray are provided at the bottom of each vent mast.

Ladders are fitted on the vent mast for access to the head of each mast top and wire rope stays are provided to prevent vibration.

The top of each mast are designed to prevent rain from entering the mast but allow gas to escape vertically upwards.
Safety Equipment

Life Boats

The lifeboats are of the totally enclosed free-fall type, and will accommodate the full complement in accordance with the ship’s safety certificate. The lifeboat davit is positioned aft.

High Speed Rescue Boat and Davit

A davit launched high-speed rescue boat for 12 persons is provided with the davit. The boat is propelled with an inboard diesel driven water jet designed for a speed of 25 knots with 12 people.

Life Rafts and Davits

- Two life rafts for 25 persons, inflatable, davit launch type with hydrostatic releasing device;
- Two life rafts for 25 persons, inflatable, throw overboard-type with hydrostatic releasing device; and
- One life raft for six persons, inflatable, throw overboard-type and manual releasing device.

Personal Life-saving Equipment

Life-saving equipment, such as life jackets, life buoys, line throwing appliance, and distress flares, are provided in accordance with rules and regulations. Survival suits for the full complement are provided and stored in safety equipment lockers.

Fire-fighting Equipment

Fire-fighting equipment is installed in accordance with regulatory requirements and class notations notation, or equivalent.

As per the IMO Regulations for the Construction and Equipment of Ships Carrying Gases in Bulk, The FSRU is split into fire fighting zones as specified overleaf:
Hazardous Areas and Gas Dangerous Zones
Gas dangerous zones, are zones on the open deck, within 3m of any cargo tank outlets, gas or vapour outlet, cargo pipe flange, cargo valve and entrances and ventilation openings to the cargo compressor house. They also include the open deck over the cargo area and 3m forward and aft of the cargo area on the open deck up to a height of 2.4m above the weather deck, and a zone within 2.4m of the outer space of the cargo containment system where such spaces are exposed to weather.

The entire cargo piping system and cargo tanks are also considered gas dangerous.

In addition to the above, the code also defines other gas dangerous spaces.

The area around the swept trunk in which the gas fuel line to the engine room is situated, is not considered a gas dangerous zone under the Code.

All electrical equipment used in these zones, whether a fixed installation or portable, is certified “safe type equipment”. This includes intrinsically safe electrical equipment, flame proof type equipment and pressurized enclosures type equipment. Exceptions to this requirement apply when the zones have been certified gas free e.g. during refit.

**Fire Main System**

The fire main system is supplied with seawater by two main fire pumps. An approved instantaneous coupling of non-corrosive material is used at all hydrants to quickly connect reeled fire hoses. The system is installed in all external and internal areas of the vessel where required, such as exposed deck, engine room, and accommodation areas. The firewater ring main routed throughout the vessel is permanently pressurized and circulated. A dedicated pressurizing pump, circulating pump, and two fire pumps are provided. In addition, one emergency fire pump is provided located in the forward pump room. All fire pumps are electrically driven.

The Deck and Accommodation fire systems are shown overleaf.
Fire and Deck Wash System

FWD bulkhead water spray system is operated via gas detection at the Rogas skid.
Water Spray System
Freshwater Fire Fighting System

A freshwater fire fighting system consisting of a fire main and hose reels is provided in the accommodation. The hose reels are stowed in recessed bulkhead lockers. Any point in the accommodation may be reached with water spray from at least one hose reel.

Fixed Water Spray System

The system is provided for cargo tank domes, cargo manifold valves, unloading buoy trunk area, cargo machinery rooms, lifeboat areas, and front of the accommodation deckhouse.

Water from the fresh water tanks is used for exercise and testing. Change-over between fresh water and seawater is controlled from the fire control room.

Manifold Water Curtain System

An independent water curtain system with dedicated pump will cover the shell and deck plating in way of the cargo manifold area to vaporize LNG leaks, should they occur to protect the vessel’s steel from cold embrittlement.

Carbon Dioxide Fire-Extinguishing System

A total-flooding carbon dioxide (CO₂) fire-extinguishing system is provided for the engine room, control rooms, switchboard rooms, incinerator room, and other areas. Certain rooms will have a local CO₂ extinguishing system.

Local Fire Extinguishing System in Engine Room

Local high-pressure water mist system is applied in high risk areas e.g. fuel oil purifier room, in accordance with rules and regulations.

Dry Powder Fire Extinguishing System

Dry powder stations are provided at each cargo tank dome with reeled hose lines and nozzles to fight local fires. Nitrogen stored in bottles is the propellant gas; bottles are refilled on board from the nitrogen generator via a high pressure compressor.

Fire Control Station

A control station is arranged at main deck level with access from both deck and accommodation areas, with control and communication for operation of fire alarm, CO₂ release, fire pump control, oil valve controls, telephone, fireman’s equipment etc. In addition, a station for fire equipment storing spare parts and consumables is provided.
Pollution Prevention Equipment

The FSRU is in full compliance with MARPOL and will carry an annual, renewable International Oil Pollution Prevention (IOPP) Certificate. The certificate describes fully how the FSRU handles and logs operational onboard oil transfers, bilge pumping and waste management.

Powered hydraulics is limited to the crane and mooring buoy connection equipment located forward. During the vessel’s stay at the port, the crew will patrol the deck around the clock. In addition, closed-circuit television cameras from the cargo control room and the bridge will continuously monitor all deck areas. The vessel is able to respond immediately if any oil leak should occur.

Additional oil spill recovery equipment is deployed adjacent to possible sources for hydraulic oil spills. Such equipment will include sawdust, shovels, portable pumps and empty barrels.

Waste Treatment Equipment

Sewage Treatment Unit

The FSRU is equipped with an approved sewage treatment unit to suit the size of the FSRU quarters’ capacity for grey and black water. While at the port, the discharge from the sewage treatment unit and other accommodation drains is collected in a tank for later disposal at sea, away from the port and in accordance with MARPOL regulations.

Oily Water Separator

Bilge drains in machinery spaces are directed to a contaminated bilge holding tank. An emulsion breaking oily water separator fulfilling the latest rules and regulations is fitted to separate the oil from the water. The capacity is 3.5 cubic meters per hour (m3/hr) and would be fully automatic.

Two bilge holding tanks, one forward with capacity of about 200 m3 and one aft of about 300 m3, will each be arranged to enable the vessel to retain all bilges including rainwater from utility areas at deck level while at the buoy.

While at the berth, the bilge water is retained in bilge holding tanks. In accordance with MARPOL regulations waste products will be disposed of ashore.

Incinerator

The diesel oil-fired incinerator is used to incinerate fuel/lube oil sludge, cleaning materials, used oil and grease, and oil recovered from the machinery space bilge separating system.

Trash Compactor

All trash from the accommodations, including plastic, is compacted into manageable bundles for proper disposal ashore.
Communications

The FSRU is equipped with the following main communication systems

<table>
<thead>
<tr>
<th>Communication equipment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>International call sign</td>
<td>LADW7</td>
</tr>
<tr>
<td>Radio station</td>
<td>MMSI 257352000</td>
</tr>
<tr>
<td>Satcom B</td>
<td>FLEET 77</td>
</tr>
</tbody>
</table>
| Telephone/telex                            | TEL 764915932  
|                                             | TLX 600963967 |
| Telefax                                     |          |
| Satcom C Telex                             | TLX No.1 425735210  
|                                             | TLX No.2 425735211 |

IAS

The IAS is a distributed monitoring and control system which due to its flexibility and modular architecture can be extended to cover a wide range of applications and types of vessel.

The IAS is built from a full range of hardware and software modules to form optimum solution to any requirement. Normal configuration of the IAS includes machinery control and monitoring, propulsion/thruster control and monitoring as well cargo and ballast control and monitoring integrated in the same equipment. All connected equipment can be controlled from any operator station throughout the vessel according to command control setup.

All operator stations and field stations are self-contained unit and independent of the other units, i.e. a failure in one station will not cause any other station to break down. All process logic including equipment safety and control functions are contained in the respective process station.

Each operator station contains a hard drive with all system configurations. A number of dedicated operator stations contain all configuration and acts as back-up for each other during system start-up and process station software loading.

Redundant network based on the Ethernet principles installed as standard. The two nets are installed in different cable paths as far as possible. Each unit is interfaced to both nets.
APPENDIX H

Safety, Health and Environmental Protection System
Safety, Health and Environmental Protection System

Safety culture

Safety has always been paramount to APGDC and its strategic partner - GDF SUEZ. As leading players in the LNG industry both companies have been leaders in setting industry safety standards and forming industry associations to share best practice.

In the past four decades APGDC’s strategic partner - GDF SUEZ has developed vast HSSE experience and expertise in all parts of the LNG chain: development and liquefaction of LNG supplies, development and safe operation of LNG regasification terminals around the world and LNG shipping.

In its operational regasification terminals it has an exemplary safety record helping it to achieve high reliability and availability of its terminals. The availability achieved in the last years is over 99%. To achieve such high terminal availability, GDF SUEZ has implemented numerous improvements in operating facilities, and operational procedures, and environment protection.

GDF SUEZ was also one of the founding members of the International Group of LNG Importers (GIIGNL) established shortly after the birth of the LNG industry in the 1960s. GIIGNL is a non-profit organisation that studies and promotes the development of activities related to LNG, in particular purchasing, processing, importing, transporting, handling, re-gasification and various uses of LNG. GIIGNL promotes the exchange of information and experience among its members to enhance the safety, reliability and efficiency of LNG import activities and of the operation of LNG import terminals in particular. Jean-Marie Dauger, Executive Vice President of GDF SUEZ, oversees GIIGNL’s Executive Committee.

GDF SUEZ is also active participant in a number of other international organizations and help to shape the future industry standards. These organisations include:

- Society of International Gas, Tanker and Terminal Operator (SIGTTO)
- The International Maritime Organisation (IMO)
- The International Association for Natural Gas (CEDIGAZ)

On a wider basis the transporting LNG by sea requires special engineering techniques and contingency measures to minimise the risks created by the hazardous nature of the cargoes carried. The very first modern LNG vessels were built in 1960 and the LNG industry has now expanded to over 350 vessels. The safety record is impeccable with no major release of LNG and no loss of life. During the last 5 years the industry has moved on to dedicated FSRU type vessels. The companies operating these types of complex vessels have extended the safety culture to enhance safety in design and operations. Again the industry prides itself with an unrivalled track record of no major incidents or loss of life or damage to installations or impact upon the environment.
Codes and Standards

The purpose of this section is to provide an indication of the likely applicable codes and standards for the design, supply, construction, inspection, commissioning and operation of the Kakinada Regas Terminal.

It should be noted that this list of codes and standards is not exhaustive and the future requirements during the Re-gasification Project may require and/or add new codes and standards, including company’s specific requirements (based on process safety requirements which are more stringent than international standards mentioned below).

The design, supply, construction, commissioning and operation of the Kakinada Regas Terminal will be in compliance with local regulations and applicable codes and standards for the Re-gasification Project.

Except where otherwise stated, the applicable codes and standards shall be the latest edition, including all amendments, as applicable at the Contract Award date.

The Kakinada Regas Terminal will be built in compliance with NFPA 59A (ed. 2006) or equivalent EN 1473 complemented by the applicable local Indian regulations and reference standards. NFPA 59A or the equivalent EN 1473 establishes essential requirements and minimum standards for the design, installation, and safe operation of liquefied natural gas (LNG) facilities and prevails on other codes.

Beyond that other standards likely to be applied and which could contribute towards safety of the terminal are as follows:

**GENERAL CODES AND STANDARDS**

- **LNG CODES**
  - NFPA 59A (2006)
  - EN1473
- **EARTHQUAKE CODES**
  - NFPA 59A (2006) and reference standard ASCE 7
- **OTHER CODES**
  - Associated NFPA, IEEE, API and UL Standards
  - ISO 9000
  - ISO 14000
- **CIVIL WORKS**
  - AWS D.1.1-92
  - ISO 10319 (1993)
  - ISO 12236 (2006)
• AISC-ASD 9th edition
• IBC
• Applicable Indian Standards – (TBA)
• ACI Standards
• ASTM Standards

• EQUIPMENT VESSEL AND ROTATING MACHINES
  • Associated API/ASME/ISO/EN Standards
  • LNG UNLOADING ARMS & SHIP-SHORE LINK
  • ASME B31.3
  • EN 1532
  • OCIMF (3rd Edition 1999)
  • SIGTTO
  • EN 1474

• VALVES
  • Associated API/ASME codes
  • MATERIALS
  • ASTM
  • SFA AWS
  • EN 10204

• INSPECTION & TESTING
  • Associated ASTM and ANSI Standards

• PIPING
  • Associated ASTM and ANSI Standards

• PAINTING & PROTECTION
  • Associated ISO Standards

• THERMAL INSULATION
  • Associated ASTM Standards
INSTRUMENTATION

- Associated IEC, ISO, ASME and API Standards

COMMUNICATION STANDARDS


ELECTRICITY

- Associated IEC, ISO, ASME and API Standards

Implementation of Philosophy and Codes

HSSE Principles

APGDC recognise that in order to achieve the sustainable development objectives of helping to meet the world’s growing energy needs in economically, environmentally and socially responsible ways they need to ensure that the risks and opportunities around health, safety, security, environment, social performance, local content and permitting are understood and integrated into their decision-making processes early.

Throughout the project, the intention is to identify and reduce all HSSE risks and to maximise benefits. This is most effective during the early stages of the project when changes may be made relatively easily. It is also important to integrate all the elements (health, safety, security, environment and social performance) of HSSE risks as early as possible. Once the strategic decisions have been made at the beginning of the project, design effort in balancing and reducing overall risk continues to the end of the execute phase. This ensures that the residual risks handed over to the operation group are as low as reasonably practicable and will continue to be managed as part of the Operations Phase of the project.

The guiding principle is that the best HSSE outcome results from the identification and management of critical HSSE 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 HSSE professionals will participate in the project from the start to apply the appropriate tools effectively.

Project HSSE activity plan

An HSSE activity plan will be developed early in the project, in cooperation between the project manager and the HSSE representative.

The HSSE activity plan shall make clear who is responsible for each activity. The HSSE activity plan will be continuously reviewed and updated at the end of each project phase.

The objectives of the plan for the project are to:
• identify applicable HSSE activities with respect to the scope of the project;
• define deliverables for the project and ensure all HSSE documentation is provided for the decision
gate reviews;
• assign roles and responsibilities in relation to delivering the HSSE activities;
• identify work that will be contracted to others;
• schedule all HSSE related activities within the overall project work plan;
• create a budget based on the timing, resourcing and support activities needed for the project.

HSSE management in operations

An HSSE Management System will be established as the framework for systematically managing all HSSE
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 HSSE 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 HSSE.
Continuous development is important for a HSSE MS to be effective.

The HSSE MS will cover the following:

• management and leadership;
• policy and strategic objectives;
• organisation and responsibilities;
• hazards and effects management process (HEMP);
• standards, procedures and document control;
• planning;
• implementation, monitoring and corrective actions; and
• audit requirements.

• marine risks

The International Ship & Port Facility Security Code (ISPS) will be applied. A Port Facility Security Plan
(PFSP) will be developed, implemented and submitted for approval by the appropriate authorities for the
land-based facilities before commencement of operations. The FSRU will arrive with ISPS certification. A
Port Facility Security Officer (PFSO) included in terminal organisation will be trained and certified; this is
normally a marine person.
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, 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 HSSE 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.

Simultaneous Operations (SIMOPS) are defined as the simultaneous execution of two or more activities that, owing to their interaction, may result in an increased operational complexity and/or an enhanced level of risk. SIMOPS will be avoided, as far as possible, through proper planning and design. However, where the requirement for SIMOPS is identified, in order to, for example, limit substantial gas deferment or enable major breakdown maintenance in a live plant, the facilities will be designed to allow such activities safely and procedures developed to reduce the risk. An example is the LNG high pressure pump removal while other re-gasification trains are on line.

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.
APPENDIX I

MOU SIGNED WITH
ANDHRA PRADESH GOVERNMENT
MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding is entered on 12th day of January, 2012 at Hyderabad International Convention Center (HICC), Hyderabad, Andhra Pradesh during Partnership Summit 2012

Between

M/s GAIL Gas Limited, a fully owned subsidiary of GAIL (India) Ltd, incorporated under the Companies Act, 1956 having its Corporate Office at A-1, Sector-2, NOIDA – 201 301 (U.P.)

And

The Government of Andhra Pradesh

M/s GAIL Gas Limited wishes to establish the following project in Andhra Pradesh

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Project</th>
<th>Location</th>
<th>Proposed Investment (Rs. In Crs)</th>
<th>Employment</th>
<th>Proposed year of Commencement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>JSRII Project &amp; online LNG Terminal</td>
<td>Kakinada/Vizag</td>
<td>5000 crores</td>
<td>1000</td>
<td>2013 End</td>
</tr>
</tbody>
</table>

Government of Andhra Pradesh would facilitate M/s GAIL Gas Limited/APGDC, Hyderabad to obtain necessary Permissions/Registrations/Approvals/Clearances etc., from the concerned departments of the state, as per the existing policies / rules and regulations of the State Government.

This Memorandum of Understanding is made to facilitate M/s GAIL Gas Limited through its joint venture viz APGDC with the support of GAIL (India) Ltd for establishment of the aforesaid Project(s) in Andhra Pradesh in a time bound manner.

For and on behalf of
Government of Andhra Pradesh

For and on behalf of
M/s GAIL Gas Limited

Principal Secretary to Government Infrastructure & Investment Department
A.P. Secretariat, Hyderabad-500 022.
CONSENT LETTER FROM
KAKINADA SEAPORTS LIMITED
7th August, 2012

The Managing Director,
Andhra Pradesh Gas Distribution Corporation Limited
Parisrama Bhavan, 2nd Floor, 5-9-59/B, Fateh Maiden Road
Hyderabad – 500 004

Kind Attn: Shri S. Narayanan

Ref: Your Letter Ref no. APGDC/ FSRU/ 2012/2012-13/17, dtd: 27/07/2012

Dear Sir,

With reference to the correspondence cited and subsequent discussions, KSPL hereby gives its consent to APGDC for establishment of LNG FSRU Project through their proposed SPV within the boundary limits of Deep Water Port, specifically on the leeside of breakwater at Kakinada and authorizes them to take necessary clearances from MoEF and other statutory Agencies, subject to the terms and conditions stipulated in the Concession Agreement between GoAP and KSPL.

Memorandum of Understanding between KSPL and APGDC for establishment of LNG FSRU Project is under finalization and shall be submitted to the concerned authorities after its execution.

Thanking you,

Yours Sincerely,

(K.V. Sekhara Rao)
Chief Financial Officer