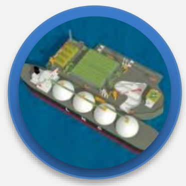
SOFREGAZ

SMALL SCALE TERMINAL

SOFREGAZ AT A GLANCE

1000 projects executed

In 90 countries



60 years of experience in LNG

DEFINITIONS

Small Scale

Ship size:

200 – 25 000 m³

Storage:

< 30/50 000 m³

Medium Scale

Ship size:

25 000 – 100 000 m³

Storage:

30/50 000 <> 100 000 m³

Large Scale

Ship size:

100 000 – 270 000 m³

Storage:

> 100 000 m³

SMALL SCALE LNG AT PORT - FUNCTIONS

General functions:

- To safely operate the facility
- To store the LNG
- To load the LNG onshore tank(s)
- To manage the BOG
- Ensuring commercial business (Metering)
- Ship mooring

Other potential conventional functions:

- To deliver gas to grid
- To deliver fuel gas to local customers
- To load the LNG trucks
- To load the LNG bunker barge
- To load the LNG driven ship tank(s)
- To load railcars

Other non conventional functions:

- To fill the LNG driven trucks
- To produce electric power to port
- Delivering electricity to the moored ship during berthing
- Emptying of LNG ship tank (for maintenance)
- To cool down ships
- To produce cold for customers
- Other needs to neighbour industrials

GENERAL CONSIDERATIONS

- Functions implemented shall be determined on market analysis and ROI analysis.
- Phasing of development shall take into account the uncertainty of the market(s).
- The technology choice is also governed by both market and ROI analyses as well as on the phasing.
- Small Scale Terminals can be considered more complex than classic LNG Receiving terminal with consideration of:
  - Simultaneous Operating mode.
  - Operating flexibility (different operating flow and pressure)
  - Harbour constraints (Shipping traffic)
  - Surrounding area close to public facilities that shall be considered in Quantitative Risk Assessment
- Small scale terminal has same components than classic LNG Receiving terminal and include utility needs such as Water, Instrument Air, Nitrogen, Fire Fighting, Flare, Power, Control room, Gate house, workshop, access control…
- Special attention will be given at the engineering stage to the optimization of the pre-fabricated structures design linked to the construction and integration sequences as well as LNG Carrier specificities (interfaces).

CASE STUDY

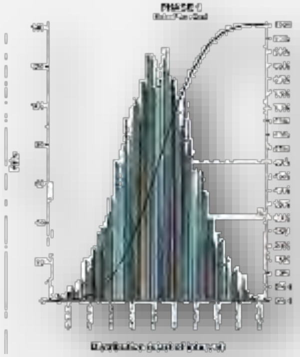
The main assumptions and functions of the LNG Small Scale Terminal used for this case study consist in:

- Scalable Development: Four (4) phases.
- LNG Supply from FSRU located less than 10 km from terminal.
- Unload LNG Carrier (max 25 000 m^3).
- LNG Storage of 10 000 m^3, scalable capacity from 3 000 m^3 to 10 000 m^3
- Send-out fuel gas to adjacent oil terminal (boilers)
- Bunkering – Supply LNG Fuel to ships, either atmospheric or pressurized tanks.
- LNG Truck Loading – 2 bays - LNG Truck simultaneously.

PHASING OF THE ENGINEERING ACTIVITIES

Engineering Services provided by SOFREGAZ were:

- Conceptual Study
  - Explore different Configurations (functions)
  - Explore different technologies (Linked with functions and ROI)
  - Preliminary time schedule for EPC implementation
  - Preliminary budget for investment CAPEX / OPEX
  - Assist Owner in Technology Selection



- FEED
  - Development based on Selected configuration
  - Scope of Work for EPC contractor
  - Preliminary time schedule for EPC implementation
  - Preliminary budget for investment CAPEX / OPEX (Monte Carlo simulation)

- QRA – Quantitative Risk Assessment
  - Evaluation of risk exposure

TYPICAL PLOT PLAN

Functions:

- To safely operate the facility
- A scalable development.
- To store the LNG
- To load the LNG onshore tank(s)
- To manage BOG
- To deliver fuel gas to customers
- To load the LNG ship tank(s)
- To load the LNG trucks
- Ship mooring
- Ensure the Commercial business (Metering)

LNG SUPPLY

On this case study, LNG is sourced from nearby location.

Different configuration have been explored:

- LNG Barge with atmospheric LNG Storage (2 000 m^3)
- LNG Barge with Pressurized LNG Storage (7 500 m^3)
- Small LNG Carrier with LNG Storage (25 000 m^3)

Main aspects to consider:

- Size of the Jetty
- Frequency of ships
- Possibility of ship bunkering outside reloading station (Ship to Ship)

Decision from Owner:

- LNG Barge with Pressurized LNG Storage

LNG TRANSFER FROM SHIP TO LNG RELOADING STATION

Different configuration explored:

- LNG Flexible Hoses
- LNG Rigid Arms
- Possibility of direct bunkering (ship to ship)

Main aspects to consider:

- Footprint
- LNG Flow
- Operating envelop
- Unloading duration
- Pressure
- OPEX

Decision from Owner:

- Decision mainly based on safety aspect
- LNG Rigid Arms 8” (1 Liquid + 1 Gas)
- Design flow: 1 000 m^3/h

NG SEND-OUT & BOG MANAGEMENT

Natural Gas send-out:

- BOG generated during operation shall be considered to avoid flaring
- Local consumer
- Power plant
- Boiler

Main aspects to consider:

- Operating pressure (need of compressor)
- Continuity in production (need of vaporizer for make up)
- Footprint / Metering

Decision from Owner:

- BOG is used as pilot gas for flare and nearby already installed oil terminal flare
- BOG is sent as a fuel gas to the nearby already installed boiler
- BOG is used to maintain pressure in bullet tanks
- Ambient air vaporizer used for make up

LNG STORAGE

Different configuration explored:

- Atmospheric Tanks (single / full containment) (9% Nickel / membrane type)
- Pressurized Cryogenic Vessels (Vertical or horizontal)

Main aspects to consider:

- Investment flexibility
- Overall capacity
- BOG Management
- Footprint / Visual Impact
- Constructability (built in situ or in workshop) / Time schedule

LNG STORAGE

Decision from Owner:

- Pressurized horizontal vessels with external pump
- 10 x 1 000 m^3 with sequential investment.

Design Specific:

- The decision for the external pump instead to rely upon the internal tank pressure for the unloading tank function was based on the bunkering function.

- A retention dyke has been designed around the manifold.

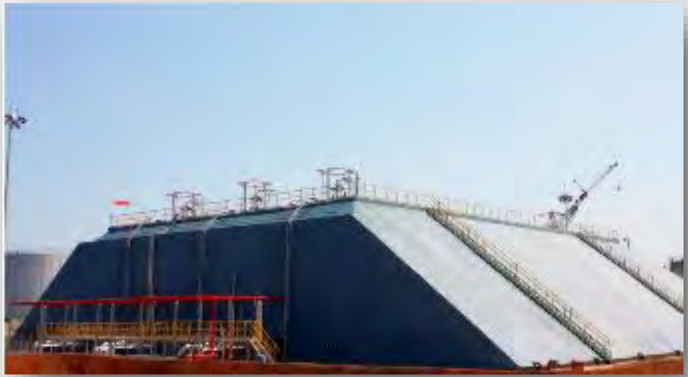
PRESSURIZED STORAGE TANKS – BLEVE

Pressurized tanks may have to be designed assuming the BLEVE* phenomenon, as a credible event. Local law may impose to mitigate this potential scenario by designing the pressurized tanks as mounded tank or others equivalent protection.

For liquefied gas, the thermal gradient, between tank and soil, shall be carefully investigated for avoiding soil freezing.

Mounded spheres

Mounded bullets



(*) A BLEVE (Boiling Liquid Expanding Vapour Explosion) is caused by the complete ruin of a pressurized tank containing a liquid whose temperature is much higher than its boiling temperature at the atmospheric pressure.

LNG TRUCK LOADING

Different configuration explored:

- LNG Flexible Hoses
- LNG Rigid Arms

Main aspects to consider:

- Truck capacity / LNG flow
- Truck access / traffic / waiting area
- Investment flexibility
- Footprint
- Truck connection (side, top, back)
- Number of weighbridge
- Fiscal Metering

Decision from Owner:

- LNG Rigid Arms
- Truck bays with 2 weighbridges
  (5 x 100 m^3/h with sequential investment)

LNG BUNKERING - ASSUMPTIONS

LNG onshore storage is provided using pressurized LNG bullet tank technology.

The bunkering function has to take into account the loading of either pressurized or atmospheric (Membrane) LNG ship tanks.

Therefore the process design imposes to be able to operate, during the bunkering operation, the onshore bullet tanks at either pressurized pressure or atmospheric pressure.

The BOG coming back from the atmospheric ship tank shall be managed.

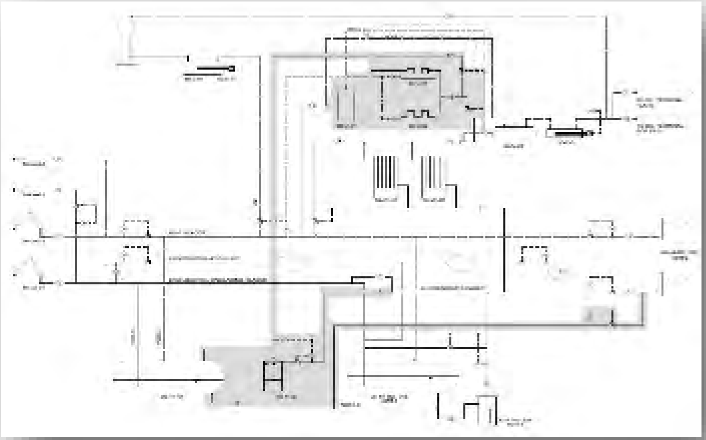
BOG MANAGEMENT – BUNKERING

- Option with BOG Compressor and Recondenser for low pressure storage (BOG Management).

- Sofregaz developed the option to allow bunkering operation whatever the LNG driven ship tank technology is. Meaning that bunkering operation can be done for both pressurized and atmospheric tanks, even if the onshore tank are only pressurized type.

- Only one tank is maintained under pressure, all other tanks are operated at atmospheric pressure when atmospheric ship tank is loaded.

- The pressurised tank is used to manage the BOG coming from the ship.



LNG BUNKERING

Different configuration explored:

- LNG Rigid Arms
- LNG Flexible Hoses

Main aspects to consider:

- Footprint
- LNG Flow
- Operating envelop (sea water level)
- Loading duration (ship immobilization)
- Pressure & BOG management
- Fiscal metering

LNG BUNKERING

Decision from Owner:

- Optional investment
- LNG Flexible Hose technology
- 1 Liquid + 1 Gas
- Flow: 500 m^3/h

- Decision based on:
  - Operational flexibility according to the position of manifold on ship
  - Investment

SOFREGAZ EXPERTISE

Oil & Gas Treatment

- Oil/Gas gathering and separation plants
- Central processing plant
- Sweetening
- HC & water dew point adjustment
- Extraction & fractionation of NGL (C2, LPG, C5+)
- Gas lift & gas injection
- Flare gas recovery

Pipeline Transmission

- All fluids (natural gas, crude oil, chemicals, …)
- Pipeline routing and design
- Basic & detail engineering
- Compressor station
- Pumping station
- SCADA systems

Liquefied Natural Gas

- Small scale liquefaction
- Peak-shaving plants
- LNG Import terminals (Onshore & FSRU)
- General plant optimisation
- Cold recovery & utilisation
- BOG Recondenser
- Heating value adjustment
- Bunkering /Truck loading
- Inner Tank Design and Interface with outer tank
- Gas to power

SOFREGAZ HIGHLIGHTS

96 LNG REGASIFICATION TERMINAL REFERENCES

20 FEED Studies

9 LNG Regasification terminals designed and built (11 LNG tanks with a cumulated capacity of 1,450,000 m3)

67 References in feasibility studies, PMC, basic engineering, Value Engineering, and process design

ENGINEERING SERVICES

- Financial Study
- Conceptual to FEED phase
- Detailed design
- Pre-Comm / Commissioning

STUDIED THE FOLLOWING CONFIGURATIONS

- Onshore terminal
- FSRU
- FSU + onshore vaporization
- Regasification on GBS.
- Bunkering stations

SUPPLIED THE FOLLOWING VAPORIZER TECHNOLOGIES

- Open Rack Vaporizer (ORV)
- Submerged Combustion Vaporizer (SCV)
- Intermediate Fluid Vaporizer (IFV)
- Shell and Tubes Exchanger (STE)
- Ambient Air Vaporizers (AAV and AFV)

DESIGNED THE FOLLOWING TANK TECHNOLOGY

- 9% Ni single, double, and full containment
- Stainless steel membrane containment

- Specifying pressurized tanks

SOFREGAZ

THANK YOU

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