Summary

Introduction LNG

Liquefied Natural Gas is natural gas that is converted into its liquid state by cooling it at atmospheric pressure to approximately -160 °C. When it is cooled, it is around 600 times more compact than in its gaseous form and can be transported by vessel over long distances. The LNG supply chain is an alternative for pipelines transport on distances above 1500 kilometres and on routes without pipeline alternatives.

After gas exploration, the gas is treated and frozen to cryogenic conditions at a liquefaction plant. The LNG is loaded onto an LNG vessel. The vessel, which could use LNG as fuel, transports the LNG to an LNG receiving terminal. At an LNG receiving terminal, the LNG is stored in tanks before it is regasified and delivered to the gas network.

Vopak

Vopak is interested in operating LNG receiving terminals. With the multi-customer concept, Vopak delivers value to its customers by creating economies of scale. As with the other commodities for which Vopak provides storage facilities, Vopak acts as a custodian and never takes ownership of the LNG.

Gate Terminal

Gate Terminal B.V., a joint venture between Gasunie and Vopak, has decided to build an LNG receiving terminal at the Maasvlakte in Rotterdam, serving three customers with a contractual throughput of 3 billion cubic meters annually and a storage capacity of three 180,000 m^3 LNG tanks. Plans have already been made to expand the terminal capacity to 4 tanks in case more customers are interested in buying capacity rights.

Research objective

The research objective has been formulated as follows:

"to develop an easily applicable decision support tool with which Vopak can determine the main terminal dimensions and commercial contracts of a multi-customer LNG receiving terminal from a logistical and gas quality perspective for a large variety of business cases."

LNG receiving terminal demand

The LNG market has traditionally been divided into an Atlantic basin and a Pacific basin. The LNG market is currently maturing, including a small spot market. Because of the increased liquidity in the market, it is expected that customers will demand dedicated tanks and transhipment of LNG to back loading vessels and trucks. Vopak should find a balance between the terminal design and the customer contracts. It should be prevented that the capacity is oversold or that the terminal capacity is over dimensioned.

LNG quality indicators

The quality of LNG and natural gas is commonly expressed by the Gross Calorific Value, also called Higher Heating Value and the Wobbe index. The Gross Calorific Value corresponds to the quantity of heat which is produced by complete combustion of natural gas in air. The Wobbe index can be calculated by dividing the Gross Calorific Value by the square root of the relative density; the density of the gas mixture divided by the density of air. The gas-liquid ratio expresses the volumetric relation between the LNG at boiling point and 1 atm. and the natural gas under normal conditions. The higher the Gas-Liquid ratio, the more gas volume will be generated by regasifying one cubic meter of LNG. Gas networks have upper limitations on GCV, Wobbe index and nitrogen percentage. The LNG can be made leaner by adding nitrogen.

LNG weathering

Due to heat leakage in tanks and vessels, a part of the LNG boils off. This boil-off is used as fuel for propulsion, send to a waiting vessel or delivered to the gas network. Weathering is the phenomenon that LNG loses its lighter components and becomes heavier when lean boil-off gas leaves a vessel or tank. In vessels the influence of weathering on LNG quality and quantity is substantial, while it could be disregarded in tanks when the terminal has sufficient throughput. Due to the thermodynamic complexity, no generic formulas can be formulated to simulate the influence of weathering. A process simulation tool should be used to investigate the influence of weathering.

Multi-customer concept

The multi-customer concept with the Tier levels and the transitional quantity could easily be adapted for back loading vessels and dedicated tanks. The customer rights should be calculated per tank group and the unloading vessels should receive priority over back loading vessels. When LNG of different qualities is mixed inside the terminal, the customer inventory rights should not change. The customer inventory should be calculated from the LNG quality the customer itself has delivered to the terminal.

The key performance indicators of an LNG receiving terminal concern the ability to handle the expected demand and indicators on the utilisation of the terminal. The influence of the Tier system on customer behaviour is also believed to be an important performance indicator.

The decision support tool

The decision support tool has been made with the programmes Excel and Arena. Because the familiarity with Arena is low within Vopak, all in- and output is presented in Excel.

The decision support tool has been designed to simulate the logistic processes at the terminal. The decision support tool simulates the logistic processes during one year and has a warm up period of three months and runs one hundred replications, after which performance data is gathered.

The decision support tool simulates the logistic processes at the terminal under the assumption that the customers do not cooperate; it simulates the logistic processes which have been guaranteed to the customers.

The decision support tool could be used to:

- Balance the main terminal dimensions and the commercial contracts
- Test annual schedules which are designed in cooperation with the customers
- Convince stakeholders of the multi-customer concept to stakeholders

Case studies

Several case studies have been included in this report to demonstrate how the decision support tool could be used. The cases studies have been chosen in such a way that the influence of certain parameters is tested on the unloading capacity availability and the tank capacity availability. During the design phase it has been identified that these two factors are causing vessel delays for which the terminal is responsible.

Conclusions

The number of customers, the allowed vessel sizes and the amount of LNG that customers are allowed to retain in the terminal when a new vessel is expected are the factors which influence the required terminal capacity the most.

The quality of the vessel arrival schedule, the occurrence of bad weather and the number of berthing slots are the factors which influence the required unloading capacity the most.

The decision support tool could be used to investigate the logistic performance of a terminal design in combination with commercial contracts. The model user should select the cases in which the customers use their rights to a maximum; a combination of terminal design and commercial contracts should at least be tested for the maximum number of arrival vessels and for the maximum size of the arriving vessels.

Recommendations

It is recommended to have an owner within Vopak of the simulation tool, who also stores the performed simulation runs. The design of the annual unloading schedule should be done carefully, because a badly designed schedule could result in bad logistic performance.