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Decision-making tools for a LNG regasification plant siting

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ABSTRACT

The increasing energy demand in Argentina and the delayed development of local sources have forced the government to import natural gas from overseas. Nowadays, one of the most efficient energy carrier is the Liquefied Natural Gas (LNG). Following this trend, Argentina began to import LNG to be regasified and injected into the existing gas network. The conversion from liquid to gas can be done using onshore facilities or regasification ships moored at specially designed docks for this purpose. In this case, Floating Storage and Regasification Units (FSRU) were chosen to satisfy quickly the increasing demand. At this moment, Argentina has two injection sites, one located at Ing. White port (Bahía Blanca) and one at Escobar port (Escobar), both in Buenos Aires province. However, to satisfy the long term demand, new projects of onshore plants are being considered in Bahía Blanca. This paper considers different aspects included in the risk based land use planning. In order to determine the most appropriate place for the construction of LNG terminals, Quantitative Risk Analysis (QRA) techniques are used to complement social and environmental studies. Two alternative operation sites in the Bahía Blanca estuary are analyzed. The first one is located at Cuatreros port, near General Cerri city and the second at Rosales port, near Punta Alta city. Advantages and disadvantages such as the presence of other industrial facilities, distance to populated areas, evacuation routes, social and environmental factors and distance to be traveled by the regasified LNG in the ducts are discussed. As for the onshore accident risks, it can be concluded that both locations are possible if appropriate preventive measures should be taken in each location. However, other environmental considerations like the route of the ship into the estuary and the need for dredging identify Rosales port as the most suitable location.

1. Introduction

The primary energy matrix of Argentina is based on fossil fuels, being natural gas (NG) almost 50% of this quantity (41.71 billion m^3) (Secretaría de Energía de Argentina, 2014). The progressive decline in domestic natural gas production and the growing industrial and home consumption have created an imbalance between supply and demand for this fuel. To meet this increasing demand, the energy authorities began to import liquefied natural gas (LNG) to be regasified and injected to regional gas transmission pipelines. The conversion from liquid to gas can be done using onshore facilities or regasification ships moored at specially designed docks for this purpose. In the last case, the terminal is based on a Floating Storage and Regasification Unit (FSRU) permanently moored at the jetty and periodically supplied by a LNG carrier (Iribarren et al., 2010). This practice, called ship-to-ship operation (STS), allows a continuous operation of the LNG import facility. In Argentina, FSRUs were chosen as ways of quickly fulfilling the market expansion. At this moment, there are two injection sites located in the province of Buenos Aires: Ing. White port, Bahía Blanca and Escobar port, Escobar (Rodríguez, 2011). Each one provides about 10 $MMsm^3/d$ of NG to the national gas network.

However, to satisfy the long term demand, new projects of onshore plants are being considered in Bahía Blanca. In 2011, an important project to construct the first onshore LNG import terminal was launched. The terminal, with storage capacity of 125,000 m^3, would be designed to receive LNG from ships at a rate of 10,500 m^3/h with a pressure of 4.6 bar_g and a temperature of -162 °C. The plant would have a regasification capacity of 10 $MMsm^3/d$ (Consorcio de Gestión del Puerto de Bahía Blanca, 2011). In this type of operation, LNG tankers unload their cargo at dedicated marine terminals that store and regasify the LNG for distribution to domestic markets. Onshore terminals consist of docks, LNG handling equipment, storage tanks, and connections to

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gas network.

Although LNG has had a good safety record for the last 40 years (Alderman, 2005), experts are concerned about the LNG plants siting analysis and regulations, especially with issues related to safety zones, marine hazards, rivers and estuaries navigation, environmental impact, among others. On the other hand, since these terminals would be built onshore, relatively near populated areas, local communities are apprehensive about whether LNG terminals would expose them to unacceptable hazards. This concern was also observed previously in different facility location in other countries (Ártabra21, 2014; Manlove, 2008; Ártabra21, 2014; Huelva-Cateta, 2014; McIlraith et al., 2012; BCLNG-Info, 2014; Ikelegbe, 2013).

Several papers published in recent years are focused on the manner to take into account these aspects in siting LNG terminals. Some of them deal with regulatory compliance and approval processes for siting these facilities. For example, norms and codes like NFPA59A (NFPA59A, 2009; NFPA59A, 2013) and EN-1473 (ENS 1473, 2007) among others are extensively discussed (Raj and Lemoff, 2009; Williams, 2013; Taylor, 2007). In addition, the application of different risk evaluation techniques as an effective decision making tool is also found in many works (Taylor, 2007; Pitblado et al., 2006; Vinnem, 2010; Ramos et al., 2011; Aneziris et al., 2014; Vianello and Maschio, 2014). However, only a few articles consider simultaneously safety and environment issues (Manlove, 2008).

In Argentina, facing with the real need to increase imports of LNG and the public concerns about LNG facilities safety, it is necessary to reach an appropriate balance within local public safety and national energy requirements.

Following these ideas, in this work, the actual risks are evaluated realistically based on the knowledge of potential LNG's hazards, risk control, mitigation measures and environmental protection. It is described the QRA methodology to assess risks and apply the results for land use planning, complemented with social and environmental factors. Two alternative siting areas in Bahía Blanca estuary are analyzed. Risk and environment aspects are used as a decision making tool for determining the best location.

2. Bahía Blanca LNG project

2.1. Description of the onshore LNG regasification terminal

The onshore facility receives LNG from a carrier and stores it in cryogenic liquid state. LNG is further pressurized and vaporized to obtain NG as final product. The terminal can deliver a specified gas rate into the network and maintain a reserve of LNG. Fig. 1 (Lemmers, 2005) shows a schematic flow-sheet of the process to be used in Bahía Blanca project.

2.1.1. Jetty structure

The jetty structure, with a berth to moor the carriers, is a steel construction with a concrete deck. On the pier, articulated piping (unloading arms) is installed to connect the ship to the onshore terminal. The unloading arms can move to allow LNG carrier displacement due to environmental factors while they are connected.

2.1.2. LNG storage tanks

A double containment tank is used for storing LNG at cryogenic temperature. The inner tank meets the low temperature ductility requirements for storage of the product. The outer container serves primarily to keep the insulation and retain vapors.

2.1.3. LNG vaporizers

The LNG is vaporized using open rack vaporizers (ORV). ORVs use seawater in an open falling film type arrangement to vaporize LNG passing through the tubes. The seawater passes through a series of screens to remove debris before entering the intake basin. Then, after being used in the vaporizers, the water falls over aluminum panels and it is collected before discharging back into the sea. The vaporized gas is injected into the 80 bar_g national distribution system.

2.1.4. Vapor handling system

In normal operation, heat transfer from the surroundings produces boil-off gas (BOG) in the tanks and liquid-filled lines. This vapor is collected in the boil-off header and sent to the boil-off compressor suction drum. A BOG recondenser is used to recover the BOG as a product.

During ship unloading, the quantity of vapor in the tank outlet increases significantly. Moreover, in extreme turndown or emergency conditions, vapors generated within the terminal can exceed the capacity of the BOG compressor. If this occurs, the excess vapors are sent to a flare for safe disposal.

2.2. Alternative locations of LNG terminals

Energy companies as well as national authorities agree that the ports in the south of the Buenos Aires province are convenient to place LNG import terminal. Two alternative operation sites in the Bahía Blanca estuary are considered (Fig. 2). The first one is located at Cuatreros port, near General Cerri, a community placed 15 km to the south of Bahía Blanca city. The second option is Rosales port, near Punta Alta city, which lies 30 km northeast of Bahía Blanca.

3. Risk analysis and land use planning

In recent years, local communities have manifested a growing concern regarding the hazards derived from industrial sites, especially when residential areas are neighboring these facilities. To protect the population against the high risks of the production, storage and transport of hazardous materials, separation distances between the hazard source and the population have to be considered (Papazoglou et al., 1998, 2000).

In this sense, land use planning (LUP) is an important tool in government policies (Licari and Weimer, 2011). To introduce safety considerations, two different ways of dealing with risk assessment can be adopted: a 'consequence based' approach and a 'risk based' approach. The first focuses on the calculation of consequences of possible accident scenarios. The second considers the assessment of both, consequences and expected occurrence frequency of the selected scenarios (Christou et al., 1999).

The results presented in this work are based on risk levels estimations obtained using the quantitative risk analysis (QRA) methodology for an LNG terminal (Aneziris et al., 2014). In particular, the individual risk, defined as the annual frequency of death of a person affected by the consequences of an accident, is calculated.

There are several standard levels of acceptable risk to determine the appropriate distance between the population and the industries. Even though in Argentina there is no specific regulation in this matter, it is generally accepted worldwide that the individual risk to third parties should not exceed the annual frequency of death of a person of $1 \cdot 10^{-6}\ y^{-1}$ in the facility limits.

4. QRA of the regasification LNG terminals

This study consists of the hazardous zones definition, evaluating the distances at which effects caused by a Loss of Conteinment