LNG INFORMATION PAPER

#8

2022 Update

Retail LNG
(Small-Scale LNG)

CONTENTS

GIIGNL's Technical Study Group introduces a series of Information Papers that provide factual information about Liquefied Natural Gas (LNG). This paper describes the design and operation of Retail LNG. It also explains the measures the industry implements as standard practices to detect, control and minimize potential effects from a release of LNG.

INTRODUCTION

Retail LNG (Small-scale LNG) refers to a range of LNG production, transportation and consumption activities that take place at a smaller scale than in the traditional, "wholesale" value chain. Retail LNG has its own, distinct end users, infrastructure and market dynamics.

Retail LNG value chains typically follow the same "Hub and spoke" model as those of the conventional large-scale business, with a central facility serving multiple customers **(see Information Paper No.2)**. However, there is a much greater focus on end users. For Retail LNG, the "hub" is typically an LNG import terminal where traditional, large cargoes are broken down into smaller parcels or a domestic LNG production facility. In both cases, the "spokes" are supplied by loading relatively small amounts of LNG into trailers, iso-containers or bunker vessels for onward distribution.

As the Retail LNG segment has grown, it has attracted new participants and encouraged existing ones to expand their services into this emerging market. To maintain the LNG industry's excellent safety record, existing

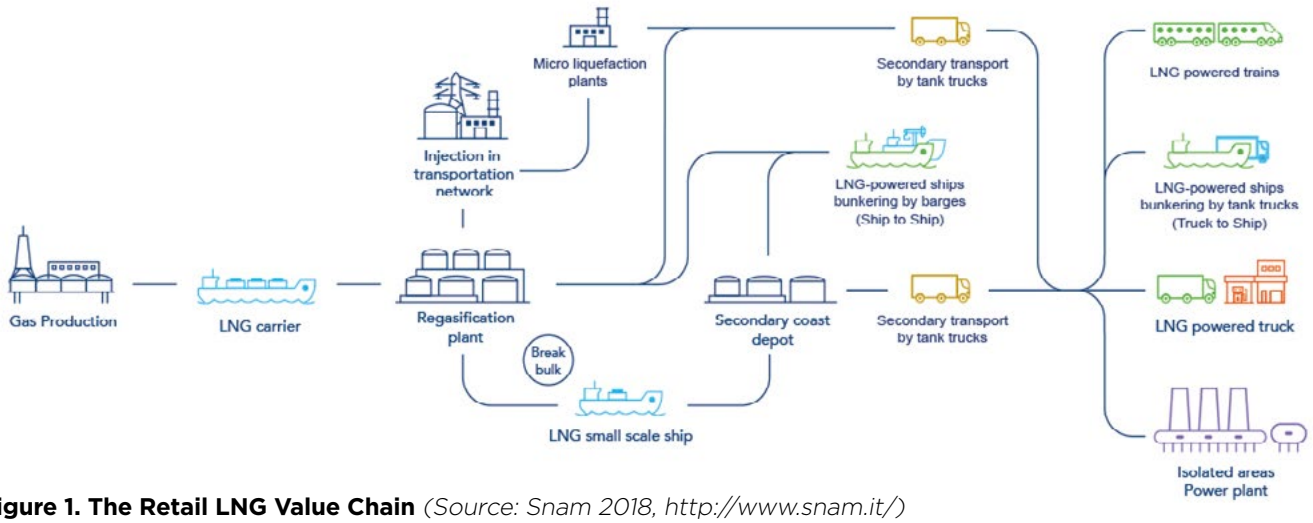


Figure 1. The Retail LNG Value Chain *(Source: Snam 2018, http://www.snam.it/)*

codes, standards and best practices have been adapted and applied to smaller scale operations and knowledge of the properties and hazards of LNG has been shared with new participants.

Similarly, although the smaller scale of Retail LNG results in technological and operational differences from traditional value chains, much of the equipment utilised has been in LNG service for many years. The optimisation of existing technologies represents a significant opportunity for the Retail LNG market, potentially opening the way for safer, more efficient and cost-effective offerings.

A more detailed overview of equipment utilised in the Retail LNG value chain is given in the **Retail LNG Handbook (1st Edition: 2015)**.

LNG STORAGE

Retail LNG requires only a small fraction of the LNG storage found in large-scale export and import terminals. In addition, operations typically involve the frequent transfer of small volumes of LNG, which creates relatively large amounts of boil-off gas (BOG). As a result, Retail LNG facilities often use pressurised storage vessels rather than the flat-bottomed atmospheric tanks used in larger plants. Operating at higher pressure suppresses the rate at which BOG is generated as well as enabling more boil-off gas to be retained inside the tanks. Routine venting and flaring can be eliminated by managing operations to minimise BOG generation and by using compression or re-liquefaction to capture any BOG removed from the storage system.

Pressurized LNG storage vessels are typically double-walled, vacuum-insulated bullets. They are designed and built to the requirements of recognized codes and standards (e.g. ASME Boiler and Pressure Vessel Code and EN 13458). The exact form of the vessel depends on its use, e.g. bulk storage, truck/trailer. ISO container, LNG bunker barge or small LNG carrier.

LNG TRANSFER

Although the Retail LNG distribution chain involves smaller volumes, many valuable lessons from the wider LNG industry can be applied to minimise the risks of spills during LNG transfer operations and to avoid the overfilling of containers.

LNG can be transferred from storage to vessels, trailers, rail cars, etc. using either differential pressure (when the pressure of the LNG storage is higher than that of the receiving vessel) or cryogenic transfer pumps (when storage pressures are lower than the pressures of the receiving vessel). The transfer can be accomplished using either dedicated transfer arms (sometimes known as hard arms) or cryogenic hoses.

LNG bunkering to a tugboat *(Source: MOL)*

Transfer Arms have an extensive track record of safe and reliable operation. They are usually fitted with an emergency disconnection system (commonly referred to as a Powered Emergency Release Coupling or PERC) that can quickly and safely shut off the flow of LNG flow and decouple the arms from the vessel with almost no release of product to the atmosphere. The design and operation of transfer arms are covered by well-established international standards.

The increased use of cryogenic hoses has coincided with the emergence of offshore liquefaction and regasification facilities. However, they are also being used in Retail LNG applications such as bunkering. Hoses for LNG are available in various sizes and configurations. As with transfer arms, hoses can be fitted with emergency release systems and quick connect/disconnect couplers that provide similar operational safety levels to fixed loading systems.

Loading LNG into road trailers is already commonplace. Loading bays employ multiple safety and security systems, such as breakaway couplers, overpressure protection, crash barriers, gas detectors, remote isolation and emergency shutdown systems to manage the arrival, processing and departure of LNG vehicles. The design and operation of loading facilities for ISO-containers and rail cars is based on a similar approach.

LNG TRANSPORTATION

Road Transportation

The Retail LNG market supplies smaller, more scattered end-users than traditional value chains and therefore requires a more extensive and flexible transportation network. The design and operation of equipment used to transport LNG from production and/or storage facilities are focused on ensuring public safety. Aspects such as crashworthiness, resistance to fire, compliance to codes and regulations, training and emergency response plans are all intended to manage the risks associated with the transportation of LNG.

Road trailers are the most common transportation means for Retail LNG and are widely used to refill storage tanks at refuelling stations, to supply satellite stations and for bunkering ships directly at a quayside. Advances in anti-roll technology and "active" vehicle monitoring systems that check vehicle conditions (speed, turning radius, etc.) and can apply breaking or other measures are improving the safety of LNG trailers. Trailers are also decreasing in weight and increasing in capacity while advances in insulation technologies are providing better performance and operational flexibility.

Vacuum-insulated ISO-containers, designed for thermal performance, ease of operation and safety, are widely available. Using ISO-Containers rather than road tankers allows LNG to be transported via a combination of road, rail and container ship, potentially allowing supply to islands or other users where a single means of transportation is not feasible.

Truck loading at Montoir-de-Bretagne LNG terminal *(Credit: Elengy/Cyrille Dupont)*

Marine Transportation

Up until recently, the waterborne transport of LNG has been carried out almost exclusively in LNG carriers. These vessels must comply with all relevant local and international regulatory requirements, including those of the International Maritime Organization (IMO), International Gas Carriers Code (IGC) and US Coast Guard (USCG), as well as any additional requirements imposed by the government administration of the vessels' country of registry. More details are provided in GIIGNL's **Information Paper No. 3** for more details.

LNG Bunkering Vessel alongside a large container vessel *(Source: Rotterdam port)*

END USERS

Marine Users

The technologies required to use LNG as a marine fuel, including fuel storage systems and a range of engines that meet the needs of coastal and deep-sea vessels, are proven and commercially available.

LNG has a lower energy density than traditional liquid fuels (about 65% that of Heavy Fuel Oil and 60% that of Marine Gas Oil) and larger storage volumes are needed to provide the equivalent fuel capacities. Space considerations are therefore important for ship-owners and operators who must consider the impact of storage tanks' location on bunkering operations, the relationship to crew and passenger accommodation, the ability to simultaneously bunker and transfer cargo and/or passengers at the same time and the need for spill containment and/or secondary barriers to mitigate the effects of any potential leak or release. To date, onboard storage of LNG has largely been in IMO Type C tanks (spherical or cylindrical vessels with a design pressure higher than 2 barg) either integrated within the ship's structure or mounted above or below deck. Type C tanks allow the gradual increase in pressure due to LNG boil-off to be managed to a point, but ultimately the boil-off must be used as fuel or reliquefied.

Road Users
Road users are typically served via an LNG Fuelling Station, which will itself generally be supplied by an LNG road trailer discharging into the Fuelling Station's storage system. LNG is generally stored in a pressurised bullet tank from where it is pumped to the LNG Dispenser and into the storage tanks of the end user.

Commercial and Industrial Users
LNG can be a low-cost, more sustainable alternative to liquid fuels for commercial and industrial (C&I) users in remote areas, islands or other locations not well served by traditional pipeline gas supply.

C&I facilities will usually have an equipment package which is used to offload LNG from transport trailers into LNG storage vessels. The offloading package will have as many offload connections as needed to match the volume/logistical requirements of the end user.

LNG is usually stored in vertical or horizontal pressure vessels with capacities typically ranging from 5,000 to 400,000 litres. Most designs utilise connections and piping which allow for top or bottom filling of the vessel.

The use of ambient vaporisers coupled with a smaller electric or gas-fired trim-heater is becoming increasingly common in smaller Retail LNG applications. "Fired" vaporisers, such as water bath vaporisers and fully electric vaporisers, are also widely used.

Normally, all equipment, including the LNG transfer area, is contained within an impoundment area. Vapour fencing can also be employed around the periphery of the installation to help mitigate vapor propagation within the facility or offsite. A detailed fire detection/protection evaluation, identifying the appropriate type, quantity and physical siting of equipment necessary for the detection and control of fires, leaks and spills of LNG, is required by code in many jurisdictions.

KEY POINTS AND CONCLUSIONS

In closing, the key points of this information paper are:

1. The inherent risks associated with LNG that have been observed and carefully mitigated for many decades also exist in the Retail LNG market. Although there are differences in scale and scope between the markets, the lessons learned and practices employed by LNG import terminal operators provide the Retail LNG market with demonstrative guidance on what prudent operations can look like. Understanding the hazards of LNG, managing the associated risks and maintaining operational protocols and operator knowledge are imperative for all participants of the Retail LNG market. Basic Properties of LNG are described in more detail in **Information Paper No. 1.**

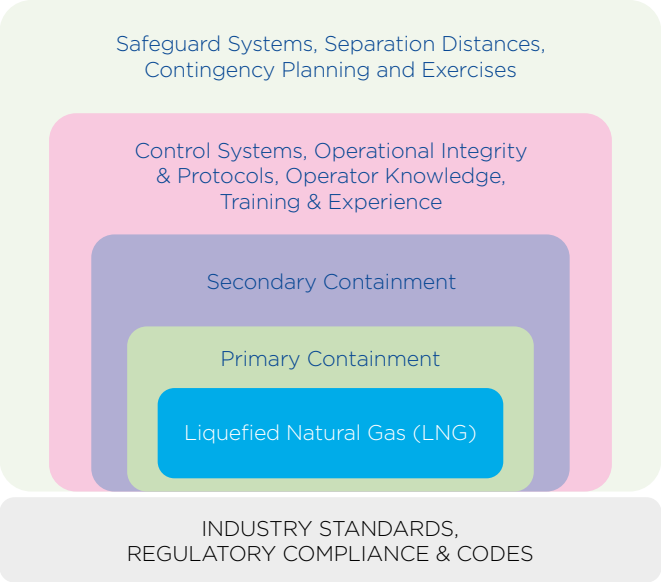
2. Industries involved in LNG trade, governments, class societies and other interested parties have worked together for many years to create codes, standards, rules and regulations that represent the collective knowledge of the participants and the current best practices within the industry. These documents can reflect the "state-of-the-art" in terms of technologies and capture the operational best practices that have been gained through actual technical design processes, operational experience, research and development and testing. While the current operation of LNG import terminals is viewed as having a robust and well proven set of codes and standards, it has been recognized that the scale and scope differences that exist with Retail LNG have produced "gaps" in coverage that should be addressed with the drafting of focused codes and standards. **Information Papers No. 4 and 5** describe ways in which the industry maintains operational integrity through regulations, codes, standards and best practices.

3. Extensive industry experience of managing safety, security, staffing, equipment siting, and transfer operations at LNG import terminals provides an excellent reference for developing Retail LNG facilities and for conducting safe and efficient Retail operations.

4. As the supply of LNG to Retail market grows, it is imperative that the level of care and custody that the historical LNG industry has provided be maintained by all Retail LNG market participants. Industry knowledge, and the collective lessons learned of the broader LNG industry is being shared with new entries including for example by:
   - Supporting the development of focused and standardized procedures for operational activities, such as bunkering and tank filling.
   - Developing commercially feasible and operationally effective measures to manage the boil-off within the LNG process chain.
   - Standardization of Retail LNG equipment and transfer interfaces to minimize the chance of releases along the Retail LNG process chain by promoting compatibility between suppliers, transporters and end users.
   - Supporting the dissemination of LNG knowledge and experience throughout the LNG value chain, focusing on operational safety and the maintaining of the high safety standard of the LNG Industry.
   - Supporting standardization authorities and governments in the development of technical standards necessary for the Retail LNG market.

As reflected in the illustration below, the Multiple Safety Layers for LNG are all firmly based on a foundation of solid Industry Standards, Regulatory Compliance and Codes, many of which are developed by the foregoing associa-tions and regulatory bodies. These "safety layers" include several key components of the industry's Risk Management framework. Included among them are Primary and Secondary Containment, Control Systems which promote Operational Integrity; Protocols, Operator Knowledge and Experience (which are reinforced by comprehensive and ongoing training). A protective umbrella of Safeguard Systems, Separation Distances, and Contingency Planning further enhances the safe management of LNG.

MULTIPLE SAFETY LAYERS MANAGE LNG RISK



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