CHOOSING THE CORRECT CONFIGURATION

Justin M. Ellrich, Black & Veatch Corporation, USA, discusses terminal configurations for LNG marine fuel supply.

The marine shipping and transportation sector is rapidly adopting LNG as a bunker fuel. Compared to the diesel and fuel oil traditionally used, LNG decreases carbon dioxide emissions and nearly eliminates nitrogen oxides (NOx) and sulfur emissions. LNG is therefore an ideal fuel to comply with IMO 2020 regulations and aid in the global energy transition to reduce carbon emissions. However, widespread use of LNG through global ports is limited by infrastructure to supply it where needed. Each port, and even each vessel, has different requirements for volumes, available space, draft, and transfer capability. No single solution is adequate for every locale and every ship; the optimal choice of LNG supply configuration depends on the constraints of each situation.

Transfer options

Multiple methods have successfully provided marine vessels with LNG bunker fuel: direct from a fixed onshore tank, from trucks or portable containers, and from small LNG carriers. These methods vary in terms of volumes, flexibility, and cost. The considerations for each major type of transfer scheme and their ideal applications are discussed in the following sections.

Tank-to-ship

LNG can be transferred from an onshore tank to a marine vessel in much the same fashion as traditional export terminals, albeit at much lower flowrate. Onshore tanks could be small, pressurised bullets or larger, low-pressure tanks. Because the tanks are affixed to a single location, the size range and number of vessels that can be served is limited as dedicated

berthing facilities are required. Tank-to-ship transfer also necessitates proximity to the shoreline and hazard exclusion zones, which may limit suitable real estate available in already crowded port locations. This method is best suited for a small, dedicated fleet with its own port facilities – such as a container yard or, if adequate property is available, along the shipping channel but away from congestion.

Truck-to-ship

Many LNG facilities, both large and small, have the ability to load trucks for small scale use. LNG trucks can reach many various ship sizes and locations and relieve a number of plot space issues that fixed tankage can create. LNG trucks are nearly interchangeable and can source LNG from different terminals in the vicinity, but not directly at the point of bunkering. A similar concept can also be employed using portable ISO containers. Instead of filling from the container to the bunker, the containers could be swapped out by crane and directly connected to a properly equipped fuel system.

Truck-to-ship transfer has so far been the predominant form of LNG bunkering because of the relative ease of the process and its limited requirements for dedicated infrastructure. LNG trucking and ISO containers will likely remain common bunkering options in the future, but their 40 m^3 volume per shipment is not expected to be logistically or economically advantageous in larger service areas – as the market continues to grow and more volume is demanded.

Ship-to-ship

LNG bunkering supply vessels are a rapidly growing segment. New-build LNG carriers scaled down to between 5000 - 10 000 m^3, or even other vessels retrofitted with LNG tanks, allow the greatest flexibility of supply. The vessels can be manoeuvred throughout a port to carry out a transfer operation with nearly any ship, sometimes conducting multiple transfers per trip. Furthermore, they are able to service deep draft vessels that may not be able to call on a fixed berth with onshore storage tanks. Dedicated bunker carriers can also alleviate a space constraint, having the ability to load LNG from a terminal not in proximity to the port then sail to the end users. This is the most expensive option from a purely transfer equipment standpoint, but it can unlock LNG fuelling for almost anyone, anywhere.

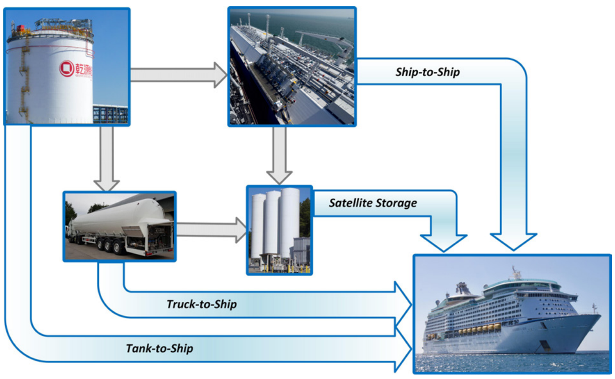

Figure 1. LNG bunkering transfer options.

Terminal configurations

While multiple options are suitable for LNG bunkering transfer, the same can be said about the source of LNG supply. Infrastructure for bunkering ships and/or trucks can be added to terminals that import/export large volumes, or smaller dedicated facilities can be constructed to directly and exclusively serve the bunkering market. Similar to the transfer methods, the optimal terminal configuration depends on the specific scenario, taking into account volume, available land, and range of end-use ships.

Import terminals

For areas that lack gas resources, such as Europe and parts of Asia, considerable LNG infrastructure is already available at import terminals. Furthermore, while not exclusively, many facilities are within or nearby major ports and marine commerce centres with ideal proximity to the ships needing LNG bunker fuel. Generally, developing a dedicated small scale LNG terminal only to import bunker fuel is not economical, so integrating terminals to serve multiple LNG end-users is the prevalent model to achieve the desired economies-of-scale.

Any one of the transfer methods, or combinations thereof, is potentially feasible to add onto an import terminal. LNG carrier berths cannot accommodate safe mooring and loading of vessels outside of the design envelope, so modifications to the existing or a smaller, parallel berth would be needed in most instances.

Truck loading racks are a common and relatively simple addition. Another hybrid option is for the main terminal to supply a small scale satellite storage site nearby: a small marine carrier or trucks can deliver LNG in batches to onshore tankage, and vessels can fuel up away from the main terminal to avoid bottlenecking.

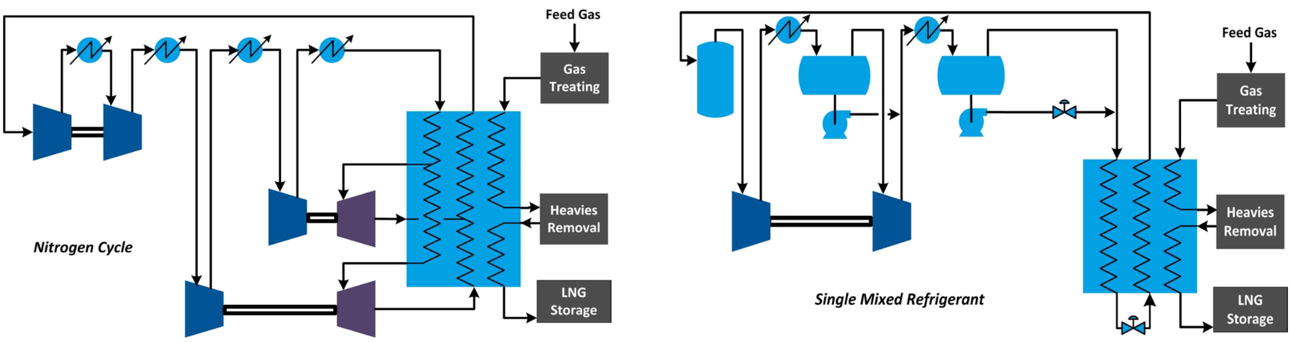

Figure 2. Liquefaction technologies for small scale LNG bunkering supply.

Export terminals

Existing or new-build export terminals can integrate bunkering in a similar fashion to import terminals. However, no significant projects have been announced that incorporate bunkering along with a baseload liquefaction plant. Along with the prevalence of large long-term contracts underpinning these project investments, the main reason for the lack of bunkering development at these plants is that the majority are not located within economical proximity to the major ports and shipping channels to supply a significant volume of LNG for bunkering. Because of the sizeable land area required for large scale export plants, small scale liquefaction has gained traction in gas-rich areas for the supply of LNG bunkering closer to the point where it is needed.

Figure 3. Example FLNG for bunkering supply capacity.

Greenfield developments

Where existing terminal infrastructure is not in place or integration is not feasible, new projects are needed to make LNG available to ships. The volume required to meet demand of the port must be weighed against the land available. Consideration must also be given to future market growth as more LNG-fuelled ships enter service, and whether it is economical to install excess capacity initially or to allow for parallel trains later to match demand.

Proximity to a reliable gas pipeline supply also factors into optimal siting of a bunkering supply facility. In some cases, building such a terminal some distance away from the end users or even off the waterfront may be necessary. Then, LNG bunker vessels or trucks can be used to traverse the short distance to the end users, which may ultimately give the project a more flexible supply capability.

Liquefaction

While significant growth in the number of LNG-fuelled vessels in operation and on order has been recorded, the volumes needed currently, along with the decentralised nature of the end users, are largely only suited for small scale LNG facilities (defined in this instance as between 0.1 - 1.0 million tpy). Significant experience exists in this size range with proven technology options, much coming from peak shaving units in the US, as well as road vehicle and remote industrial user supply, particularly in China. Small scale liquefaction does not require the high complexity and equipment count of dual loop processes to be economical – single loop systems with greater simplicity and lower initial cost are established as the better option for capacities in this range.

The two stalwarts of small scale liquefaction technologies are the nitrogen Brayton cycle and single mixed refrigerant (SMR). The costs of each technology are similar, with liquid hold-up vessels and pumps for SMR replaced by turboexpander-compressor units for nitrogen cycles. The differentiator for SMR is a greater than 30% efficiency boost over nitrogen cycles, which will incur lower operating expense. However, this efficiency advantage does not always make SMR the top choice. The magnitude of expense for the low end of capacities with cheap available power, and in some cases an intermittent operating profile that may be needed because of variable bunkering demand, offsets the liquid refrigerant import and handling considerations and favours nitrogen cycles. Nonetheless, as production rate increases, SMR efficiency can translate to more significant operating expense savings and has thus become the prevalent choice for larger small scale capacities.

Gas turbines as refrigeration compressor drivers are common in the industry, but motors on this scale can be cheaper with significantly reduced maintenance requirements conducive to the simplified approach for small scale LNG. Motor drives are particularly attractive if power is sourced from renewables, as this results in a significant reduction of the facility's carbon footprint. A typical simple cycle drive and on-site power generation approach, common for LNG in the past, would combust approximately 10% of the incoming gas; electrification from renewables would reduce that to below 1% with use only for some process heating services. Even if not fully renewable, the electrical infrastructure required for small scale LNG typically enables full grid connection instead of on-site power generation, which increases both costs and emissions.

Execution approach

Project developers and contractors have worked extensively to standardise and modularise small scale LNG units. The size of equipment allows extensive pre-fabrication and minimisation of on-site labour while still utilising normal means of transport to the site, such as trucking or barges. Pre-engineered items that leverage the repeat experience of contractors for this capacity range can also decrease the development schedule and provide performance certainty. LNG tanks as pressurised bullets can be installed in less than half the time of a field fabricated option, and even modularised API 625 low pressure types, up to 20 000 m^3 capacity, are in development.

FLNG solutions are also a viable approach for the scale of LNG bunkering supply. The combination of minimal land use, ship-to-ship transfer, modularisation, and proven technology afloat may offer an ideal option for certain projects. Due to the smaller capacity, barge-based hulls and smaller Type C storage can be efficiently integrated with Black & Veatch's topside design, akin to Exmar's FLNG vessel.

Conclusion

Geographical and logistical constraints for utilising LNG as a bunkering fuel have generated multiple innovative methods to supply and transfer the cryogenic liquid. The distribution infrastructure needed to meet the growing demand must integrate existing terminals to their greatest extent, as well as develop new sources of supply. The existence of multiple proven transfer methods will help project developers alleviate siting constraints in busy ports and be flexible suppliers to any customer no matter the size. In order to enable the lowest cost and risk option, and to swiftly deploy additional capacity, projects will look to standardised small scale technology and modularisation. LNG