SUCCESS THROUGH PLANNING AND RISK MITIGATION

Mark Butts and Yogesh Meher, CB&I, outline how identifying key risks can help optimise and de-risk projects from the very beginning.

In today's LNG industry, safety considerations are paramount, as underscored by the degree to which related regulations, industry design codes, equipment, procedures, and systems permeate the entire LNG value chain. Modern LNG tank designs have many built-in features which act as safeguards and provide layers of protection against the identified risks.

There is more than one means to contain liquid and vapour in an LNG tank. In fact, the industry has standardised several configurations, such as single

containment and full containment. Operational integrity of LNG facilities relies on the foundation set in codes and standards that dictate engineering designs and material specifications for constructing storage tanks and related equipment. These guidelines serve as a crucial layer of protection, ensuring facilities maintain safe containment of LNG, thus allowing companies to mitigate risks, safeguard personnel, and uphold reliable operations. In the full containment configuration, the secondary containment serves as an additional layer of protection against potential leaks or spills, providing a safeguard in the event of primary liquid containment failure. The secondary container is engineered to prevent the spread of LNG beyond the primary area, either by installing a barrier (such as a dike or berm), or alternatively by utilising an outer tank surrounding the inner tank, which can also be designed to contain the vapour and the liquid.

The selection of a tank system's configuration has a significant impact on the facility siting. Facility codes such as NFPA 59A (Standard for the Production, Storage, and Handling of Liquefied Natural Gas) have siting requirements, including separation distances from the storage tank to the facility property lines, that are dependent on the selected tank system concept, e.g. single, double, or full containment system. A full containment tank system allows the most compact facility siting and land utilisation, since the secondary container serves as an impoundment for both LNG liquid and vapours in case of a primary liquid container leak.

Plot size available for construction and siting of the facility are important factors for engineering design and constructability. Process design requirements (such as flow rates, operating pressures, etc.) must also be considered, as well as local regulations established by the Authority Having Jurisdiction (AHJ), community, state, or country. Finally, industry codes and standards establish important requirements for any project.

CB&I's project delivery model ensures high-quality and cost-effective solutions for projects. Many customers draw on the company's deep knowledge and extensive LNG experience early in a project's development, allowing us to provide input, recommendations, and project-specific solutions that enhance the long-term value of the facility. Its integrated EPC resources enable us to self-perform all aspects of the project, from conceptual design to tank commissioning. This translates into low-risk and high-value LNG storage solutions for the company's customers.

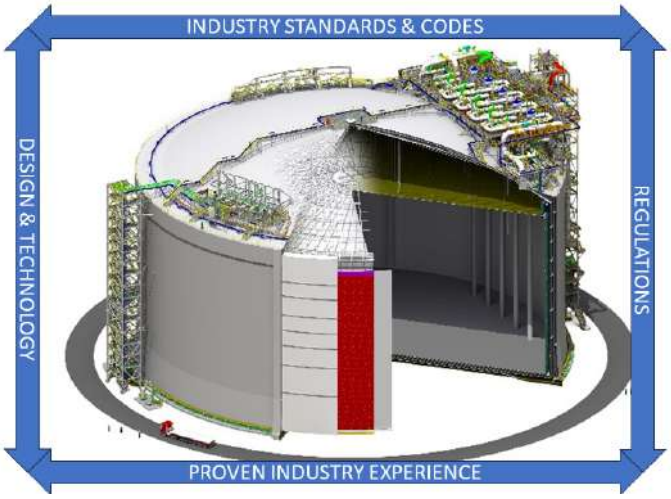

Figure 1. Continuous improvement of LNG storage safety.

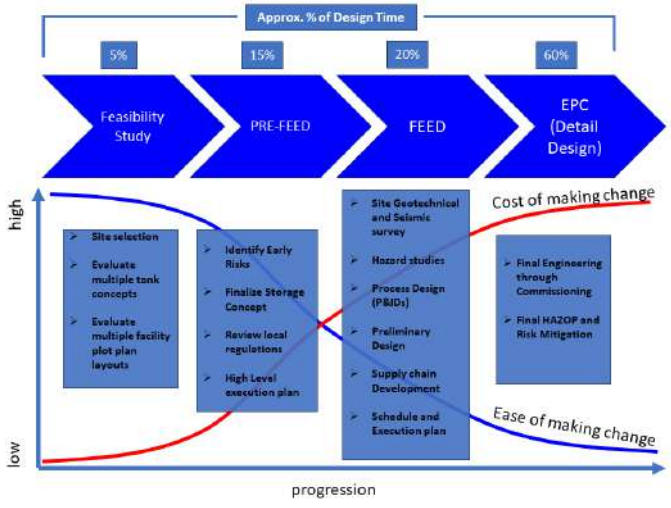

Figure 2. Early engagement is a key to success.

Early engagement: A key to success

Early involvement of a storage EPC contractor and open collaboration between the contractor and owner opens more opportunities to explore innovative approaches and select the optimal design and in-built safeguards. Late engagement of the contractor often results in additional cost and longer schedules due to missed opportunities to influence early decisions that shape the project development and execution.

Early engagement also offers more opportunities to explore innovative approaches to material selection, supply chain, construction methodologies, and commercial models in partnership with customers. This is more important than ever with the recent rising global costs impacting all aspects of the EPC project lifecycle. By prioritising early engagement, CB&I supports customers by providing lower cost and shorter time to market on storage solutions.

Terms like engineering study, FEED, pre-project planning (PPP), front end loading (FEL), feasibility analysis, and early project planning are often used interchangeably, reflecting various stages of project development. An engineering study typically involves an analysis of project requirements, feasibility, and preliminary design options. FEED, on the other hand, goes deeper into the engineering phase, refining concepts and providing detailed designs and cost estimates. PPP encompasses the initial stages of project development, focusing on defining project scope, objectives, and requirements. While FEL emphasises early project planning, aiming to minimise risks and uncertainties before full scale project execution. These terms collectively represent the iterative process of project development, from initial concept to detailed design and planning. The LNG storage tank capacity, configuration and containment

type are typically finalised during these phases of early engagement. Some key activities include finalisation of the facility layout and plot plan, thorough geotechnical investigation, a preliminary process design, and facility hazard risk assessment.

Early risk assessment helps with de-risking

Today's LNG storage design has many built-in safeguards to handle a variety of loadings, hazards, and upset conditions during its operating life. These built-in design features are often identified as safeguards during a facility hazard assessment (HAZOP and HAZID). Early and detailed planning provides definition of key design inputs, which are then implemented to optimise the design and maximise the safeguards required to build a more robust structure, facilitating many years of successful operation.

Industry codes for LNG tanks require the purchaser to conduct a risk assessment and consider it in the selection of the storage concept and configuration. All credible release events and the potential for event escalation need to be considered during the risk assessment.

A Hazard Risk Assessment is typically part of the FEED design and begins with identifying the internal (inside-out) and external (outside-in) hazards which have a direct impact on the design of the LNG tank. Internal hazards are typically tank overfill, thermal shock, leaks, overpressure, vacuum, and rollover. These are often mitigated using additional layers of protection in the form of redundancy and early detection.

External hazards play a significant role in the selection of the tank containment system and materials of construction. The various external hazards can affect a tank system and may require consideration in the facility risk assessment. Major external hazards – such as external fire, external explosion, and projectile impact – should always be included in the facility risk assessment performed by the facility owner. Seismic (earthquake) loading, while being considered as an external hazard, is more applicable to the primary tank due to the greater mass of the stored liquid.

The risk assessment helps determine the credibility of these hazards and magnitude of external loads and effects these hazards apply to tank systems. While the storage system's outer tank is often constructed of pre-stressed concrete to mitigate these external hazards, in some cases an outer steel tank may be adequate.

An overall outline of risk assessment includes the following:

- Identifying the hazards.
- Identifying potential release events and scenarios.
- Evaluating probability of occurrence of events.
- Estimating consequences (impacts to people, property and environment).
- Evaluating resulting risks.

A Project-Specific Hazard Assessment includes assessing the probability of occurrence of the hazard and evaluating the degree of damage from the hazard loading.

Conclusions

A comprehensive storage EPC execution plan, coupled with early engagement between the EPC contractor and the owner during project development, allows for the identification of key inputs and risks, thereby optimising and de-risking the project from its outset. This proactive approach enhances project efficiency, minimises uncertainties, and ultimately improves the likelihood of successful project delivery.

Since constructing its first LNG tank in the 1950s, CB&I has focused on delivering LNG storage solutions safely, on time, and with the highest quality standards. The industry draws on CB&I's deep knowledge and extensive LNG experience early in a project's development, allowing the company to provide input, recommendations, and project-specific solutions that deliver greater long-term value. The ability to self-perform all aspects of the project, from conceptual design to tank commissioning, translates into low-risk and high-value LNG storage solutions for the company's customers.

The second part of this two-part article series in the June 2024 edition of *LNG Industry* will address key early inputs and their impact on the selection of the optimal tank configuration. The company will also address risk detection and mitigation measures which help provide additional safeguards. **LNG**