BIGGER

IS NOT ALWAYS BETTER

Warren R. Miller and Fei Chen, Air Products and Chemicals Inc., USA, explain why smaller plant capacities can sometimes equate to bigger opportunities.

Smaller scale LNG projects are a growing trend in the LNG industry. In the past, most LNG plants possessed similar attributes – all were land-based and most were designed to enjoy economy of scale by employing the largest equipment that was proven at the time. These factors are no longer the sole consideration, as evidenced by a number of developing projects. It is a fact that most large, easily accessible gas fields are already being produced. Many of the new gas finds are smaller, offshore or more remote. Additionally, energy price volatility has made traditional, large volume, long-term contracts increasingly difficult to secure. Finally, niche requirements for transportation fuel and energy peak shaving require smaller volumes, which fluctuate in their demand. As a result, the challenges of justifying the financial viability of new projects have increased, and the market is looking for innovative solutions to meet these requirements.

Consequently, there is a renewed focus on small (0.03 million tpy to 0.5 million tpy) and mid scale (0.5 million tpy to 2.5 million tpy) plants as a way to monetise stranded reserves and meet these new market demands. As smaller plants do not benefit from the same economies of scale as larger plants, many project developers focus on reducing capital.[1] In addition, they are also focusing on execution strategies that facilitate shorter project schedules, accelerating time to on-stream and monetisation of stranded gas. However, in order to be economically viable, a small/mid scale LNG plant must minimise downtime, maintenance intervals and lost production, just like a large plant.

Simple nitrogen expander cycle

Where low capital investment becomes much more important than a high efficiency process, simple nitrogen expander cycles are sometimes considered for smaller plants because they are perceived to be easier to operate (Figure 1). The natural gas is simply cooled and condensed against a single component fluid, which can be easily compressed and upon expansion reaches a temperature that is colder than the liquefaction temperature of the natural gas feed. This is the basis of the simplest liquefaction process.

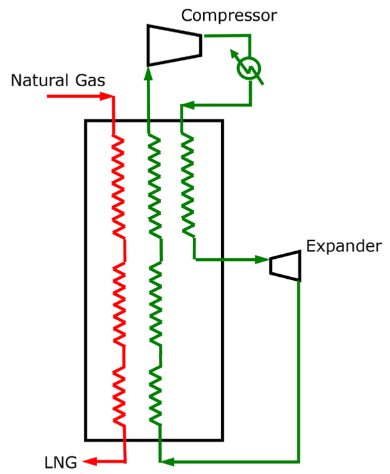

Figure 1. N2 recycle process.

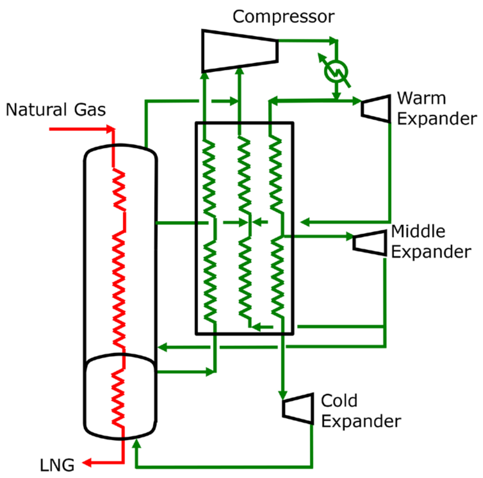

Figure 2. Three-stage N2 expander LNG process.

Quick turndown of a simple nitrogen expander cycle is easily achievable. The nitrogen refrigerant is nonflammable and environmentally friendly. The use of nitrogen also eliminates the need to store hydrocarbon refrigerants, as required by mixed refrigerant (MR) systems. Most nitrogen expander LNG trains operating today are less than 0.1 million tpy, used in peak shaving or interruptible service, and usually consist of one compressor, one compressor loaded expander (compander), and one cold box with a maximum of two brazed aluminium heat exchanger (BAHX) cores. In addition, the nitrogen expander cycle can be highly modularised to minimise field construction cost.

To make up for inefficiencies of a simple nitrogen expander cycle and the limited size of proven equipment, more expander refrigeration is required. To produce more LNG, duplicate parallel companders and BAHX cold boxes can be used. However, increasing the amount of rotating equipment can result in a more complicated plant, which is less reliable and more difficult to operate. Additionally, the BAHX cores must handle the thermal stresses inherent with liquefying the multi-component natural gas. Nevertheless, a small nitrogen expander cycle system may be suitable for small requirements, or where low capital is the main goal rather than efficiency.[2]

As an alternative to the small nitrogen cycle, Figure 2 shows a nitrogen expander cycle that utilises three levels of expanders in a process with efficiency comparable to the single mixed refrigerant (SMR) process. It uses commercially available companders to produce 0.5 million tpy to 1.0 million tpy of LNG. This more efficient nitrogen expander cycle will reduce footprint and the amount of equipment over multiple parallel trains.

SMR process

For larger capacity requirements, the SMR LNG process is well suited (Figure 3). SMR processes are more efficient than simple nitrogen expander cycles, require fewer rotating equipment items and are well proven in the mid scale range. The refrigerant consists of a mixture of hydrocarbons and nitrogen optimised to match the natural gas cooling curve as closely as practically achievable. SMR processes are still less efficient than precooled mixed refrigerant (PCMR) cycles, limiting the practical size of a single train before parallel equipment is required. Nevertheless, for mid scale applications, the SMR LNG

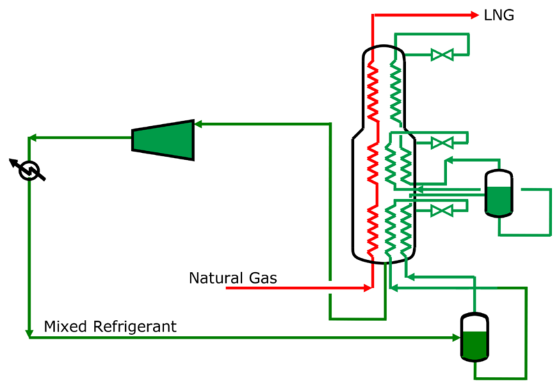

Figure 3. Single mixed refrigerant (SMR) LNG process.

process (Figure 3) can provide proven performance and reliability.[3] Almost all SMR LNG plants operating today are in the under 1.0 million tpy size range. Either BAHX cores or coil-wound heat exchangers (CWHEs) may be employed in liquefaction plants using SMR cycles. However, CWHEs have several advantages in this service, including superior resistance to thermal stress, improved operability with two-phase flow, and the ability to handle greater capacities without having to resort to parallel units.

PCMR process

Many plants producing LNG in the range of 1.0 million tpy to 2.5 million tpy utilise the well proven propane precooled mixed refrigerant (PCMR) process, where MR is still used for liquefaction and subcooling in a single CWHE, but propane is used for precooling. Over the past 30 years, precooling has become the norm for plants that approach capacities in excess of 1 million tpy because of its flexibility and efficiency. When a plant is designed for continuous operation, downtime is costly and reliability commands a premium. A mid scale LNG plant must minimise downtime, maintenance and lost production just like a large plant.[4] The PCMR plants in service in this size range achieve excellent efficiency with high on-stream factors using single compressor trains. There is no need for parallel compression trains or parallel liquefaction heat exchangers to achieve high reliability. This process is well suited for this size range.

Case study

The Ningxia Hanas LNG plant (Figure 4) is one of the largest LNG facilities of its kind in China and was engineered by Technip using Air Products' AP-SMR™ process. It is a mid scale LNG plant located in Yinchuan. It has two trains with a total capacity of 800 000 tpy. The plant is well engineered to have high efficiency and high reliability. The feed gas is compressed to reduce the overall liquefaction power requirement. The MR composition is composed of components readily available at the plant site. Electrically-driven two-stage centrifugal machines with cost-effective fixed speed motors are used for the MR compressor, while the compressor speed variation is achieved using hydraulic coupling. As fuel gas demand is low, all boil-off gas (BOG) from the storage tanks and truck loading stations is recycled for reliquefaction, thus avoiding wasteful flaring.

Extensive dynamic simulations of the plant were done during the engineering phase of the project to verify the ability of the plant design to handle start-up and other transient states. As an example, the models enabled the response of the process controls to changes in weather condition and feed gas to be evaluated. The LNG is ultimately distributed to the Chinese market in order to meet the growing demand for clean energy.

Conclusion

In designing any facility, there are trade-offs between initial CAPEX and efficiency, which are highly dependent on specific site conditions. The underlying justification for many projects is often the opportunity presented by the difference between the cost of the natural gas source and LNG price, but efficiency is important when producing LNG from any gas resource. Poor efficiency is the lost opportunity to produce more LNG. High efficiency can be a significant factor that makes a project economically attractive, and the resulting incremental capacity will almost always justify the additional costs. Furthermore, because the liquefier tends to be a smaller part of the investment for a greenfield project, an LNG project developer should carefully consider the risk of saving capital at the expense of operability and reliability. Low reliability translates into a higher amount of downtime, which directly affects the revenue stream. **LNG**

References

1. SOLOMON, J., 'Meeting Technical Challenges in a Changing Market', *The Petroleum Economist Ltd*, (2010).
2. SOLOMON, J. 'Scaling it Down', *LNG Industry*, (Spring 2012), pp. 85 – 88.
3. BRONFENBRENNER, J. C. and MILLER, W., 'On a Smaller Scale', *LNG Industry*, (Winter 2008), pp. 64 – 70.
4. BROFENBRENNER, J. C., PILLARELLA, M. and SOLOMON, J., 'Selecting a Suitable Process', *LNG Industry*, (Summer 2009), pp. 17 – 25.

For more information, please contact Air Products at 1-610-481-4861 or email, info@airproducts.com

Figure 4. The Ningxia Hanas mid scale LNG plant in China utilises Air Products' AP-SMR™ process.