Mid scale is SCALING OUT!

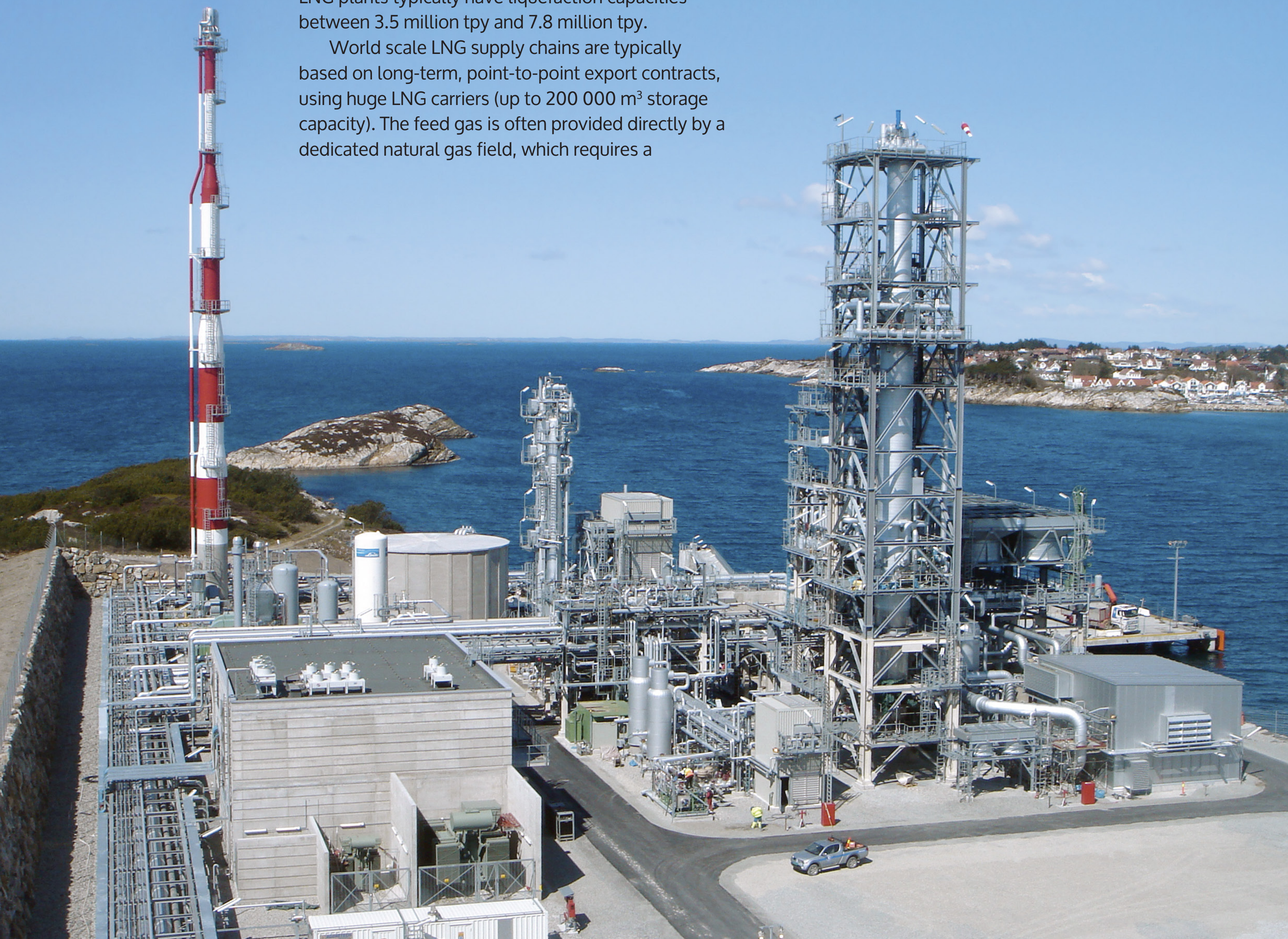
Dr Marc Schier and Maxim Schwarz, Linde Engineering Division, Linde AG, Germany, present a new mid scale LNG plant concept.

Natural gas accounts for approximately 30% of the world's energy consumption, and this figure is set to rise over the coming years. Figure 1 shows the development of global natural gas liquefaction capacity over the last 20 years, as well as a forecast for the coming years.

World scale vs small to mid scale plants

Although official definitions are vague, the LNG market can be approximately separated into small to mid scale and world scale production capacities, whereby the small to mid scale plants typically produce up to 0.5 million tpy, whereas world scale LNG plants typically have liquefaction capacities between 3.5 million tpy and 7.8 million tpy.

World scale LNG supply chains are typically based on long-term, point-to-point export contracts, using huge LNG carriers (up to 200 000 m^3 storage capacity). The feed gas is often provided directly by a dedicated natural gas field, which requires a



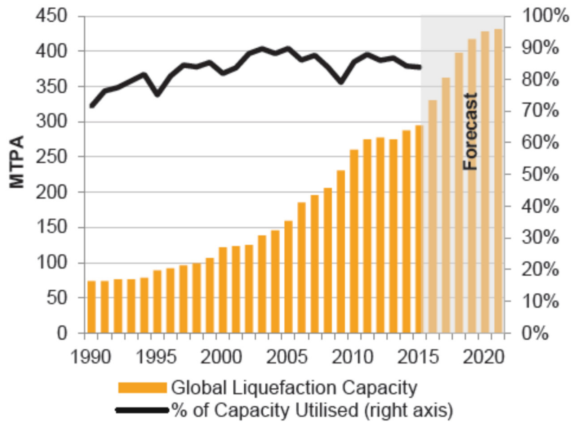


Figure 1. Global liquefaction capacity built-out 1990 – 2021 (sources: IHS, public announcements).

Figure 2. LNG plant in Shan Shan, China.

complex and costly treatment of the gas prior to liquefaction. At the point of import, the LNG is transferred to huge LNG storage tanks, regasified and fed into the local pipeline grid.

Small to mid scale LNG facilities usually use pretreated pipeline gas and supply LNG in much smaller parcels (often standardised containers with a storage volume of 40 m^3) to multiple offtakers. The small LNG parcels are typically used for applications such as heavy vehicle and marine fuelling, as well as small scale power generation, especially where break-bulk supplies from world scale LNG terminals are not available or are difficult to access.

According to a study carried out by the Engineering Division of The Linde Group, approximately 10 – 15% of global liquefaction capacity is currently produced by small and mid scale LNG plants, the vast majority of that in China.

New class of mid scale liquefaction plants

Recently, a new trend of mid scale LNG plants producing between 1 million tpy and 2 million tpy can be seen in the market. These plants combine features of both plant types described previously, as, on the one side, they use pretreated feed gas coming from a pipeline, but, on the other side, the produced LNG is exported to high value markets in large parcels.

Today, such mid scale LNG plants can be constructed using standardised machines, equipment and instrumentation that are already used for smaller plants. Prefabricated modules can significantly reduce on-site construction effort, especially in remote areas, or in environments where construction work is difficult or costly.

Figure 3. LNG reference plant in Jimunai, China.

This greater level of standardisation and modularisation, together with well-referenced equipment sizes, means that contractors can draw on a much larger pool of vendors and offer more competitive pricing. In addition, by using frame agreements for long lead items and design blueprints as far as possible, the lead times from tendering to commercial production can be significantly reduced for mid scale plants compared to world scale projects.

Figure 4. LNG reference plant in Beinichuan, China.

Bridging the technology gap between mid scale and world scale plants

Although the liquefaction principle for mid and world scale facilities is essentially the same, the technologies used in world scale plants – by virtue of their sheer size – are more complex than those in the mid scale sector. They usually use two or three independent refrigeration cycles to liquefy the gas and are typically approximately 10 – 20% more efficient than the mid scale liquefaction processes that tend to use single mixed refrigerant (SMR) cycles.

The cooling process takes place in either coil-wound heat exchangers (CWHEs) or plate-fin heat exchangers (PFHEs). In general, CWHEs are used in world scale LNG facilities and larger mid scale LNG plants, while PFHEs are used in small and mid scale LNG plants. Most cryogenic equipment manufacturers specialise in either CWHEs or PFHEs, but the Engineering Division of The Linde Group has the technologies and expertise in-house to manufacture both.

Starting from train sizes of approximately 0.5 million tpy, Linde strongly recommends using CWHEs, which are extremely robust and safe as the pipes in bundles are wound, and not welded or joined. This design provides the flexibility to contract and expand as the temperature changes. For smaller installations, PFHEs have the advantage of lower capital investment costs, but are more sensitive and less resistant to thermal shocks during start-up or malfunctions, for instance.

Innovative offering tailored to mid scale plants

Linde originally developed a standardised plant concept for small scale LNG plants known as StarLNG™. This modularised technology was tailored specifically to the flexibility demands and cost pressures of the respective small scale LNG market. It is designed as a process toolbox with configuration variations supporting approximately 90% of real-life LNG projects and uses either an SMR process applying PFHE (LIMUM®1), or a double N2 expander process.

This concept was adjusted for larger mid scale LNG plants. It is also based on the company's proprietary SMR process technology, but applies CWHE (LIMUM®3), which enables liquefaction capacities of up to 1.25 million tpy per train.

The plants are suitable for high feed gas pressures and come with three individual refrigerant fractions that provide separate refrigeration power for the precooling, liquefaction and subcooling cycles. The plants enable part load capability of 30% or less, and can be individually tailored to most pipeline gas specifications with options for heavy hydrocarbon (HH) or nitrogen removal. StarLNG plants are assembled on site with minimum installation effort (the CWHEs and associated pipes and equipment are mounted in a steel structure), and their robust design allows for easy start-up. They also come with modularised pretreatment and process units, as well as main pipe racks.

In addition, by using frame agreements for long lead items and design blueprints as far as possible, the lead times from tendering to commercial production can be significantly reduced for mid scale plants compared to world scale projects. For this purpose, The Linde Group's Engineering Division and The Elliott Group have developed a highly standardised and modularised concept for the main refrigerant cycle compression section of small to mid scale LNG plants. A respective cooperation agreement was signed in March 2016, which enables Linde Engineering to significantly increase the speed to market.

References for mid scale LNG plants

Linde has a number of references for mid scale LNG plants using the LIMUM®3 process technology (Figures 2 – 6). For all of these units, the company has also been involved as an engineering and procurement (EP) or engineering, procurement and construction (EPC) contractor.

Special attention should be directed to Linde's plant reference in Stavanger, Norway (Figure 5). At first, this plant was built using a CWHE made of stainless steel (SS) instead of aluminium in order for the SS-CWHE to gain manufacturing and operating experience in LNG service. This is especially important for floating applications, due to the fact that stainless steel is the preferred material offshore due to fatigue. Furthermore, the CWHE is equipped with a fibre optic temperature measurement system, which enables the creation of complete 3D temperature profiles inside of the CWHE.

Figure 5. LNG reference plant in Stavanger, Norway.

Figure 6. Boil-off gas (BOG) re-liquefaction plant in Bintulu, Malaysia.

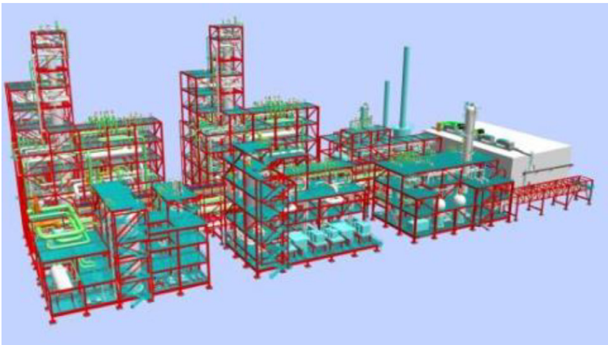


Figure 7. CAD model view of reference project (FEED) in British Columbia (B.C.), Canada.

Development of a new mid scale LNG plant concept based on existing references

Based on its existing smaller mid scale references with capacities of up to 0.7 million tpy, Linde has developed an optimised concept with regard to cost and schedule for an LNG production capacity of 2.1 million tpy, i.e. a new class of larger mid scale plants. The main criteria for this new plant concept were high safety standards and the efficiency of a world scale facility, combined with the simplicity and robustness of typical mid scale LNG plants.

Based on the key objectives mentioned above, a number of concept studies have been performed including liquefaction technology and refrigerant compressor driver selection, cooling concept, train configuration and construction concept. Figure 7 shows the 3D CAD model view of the modularised liquefaction and pretreatment modules of the LNG reference plant in Squamish, British Columbia (B.C.), Canada, following intensive concept studies.

For the natural gas pretreatment (e.g. acid gas removal or dehydration unit) a 1 x 100% train configuration was selected to maximise economy of scale, whereas a 2 x 50% train configuration has been selected for the liquefaction and refrigeration, due to the following reasons:

- The key equipment (compressors, motors, CWHE) stays within proven sizes without jeopardising the technical limits.
- The size of the rotating key equipment ensures a competitive procurement environment and avoids single sourcing situations.
- A 2 x 50% train configuration provides improved availability during scheduled maintenance or trips of the main rotating equipment.
- Turn-down behaviour is improved.
- Functional units with many interfaces can be located in one module, reducing the amount of hook-up work on-site in B.C.

Conclusion

Based on its StarLNG technology, Linde has developed a concept for a new class of mid scale LNG production plants with 1 – 2 million tpy liquefaction capacity. It is assumed that such plants will become increasingly attractive for the international LNG market, combining the strengths of both mid scale and world scale plant types and markets. The concept reduces the processing effort for already pretreated feed gas and offers economy of scale benefits compared to small scale LNG plants. It also uses components of well proven size without stretching the technical limits and reduces the construction cost by applying a fully modularised concept that can be realised in a competitive environment. Furthermore, it significantly reduces overall project risk and complexity compared to world scale LNG projects (shorter time to market and reduced complexity of financing). Finally, the concept enables new players apart from the big oil and gas majors to enter the LNG export market. **LNG**