

Natural gas – stepping stone to a sustainable future:

## Secure source of energy for the world

Establishing an eco-friendly and sustainable energy chain is one of the greatest challenges of our time. Most urgently, this means finding ways to drastically reduce emissions of greenhouse gases such as carbon dioxide. One solution is to switch to natural gas – an effective alternative to other established energy sources. Natural gas is a key stepping stone on the pathway towards more climate-friendly choices. From private households through industry to transport, The Linde Group is playing a major role in unlocking the benefits of this primary energy carrier at all key stages of the value chain beyond exploration and drilling operating, from the source to the point of use through a combination of technologies, engineering and operational capabilities. Harnessing innovative cryogenic technologies, we turn it into liquefied natural gas (LNG) not only for transport all over the world but also smaller scale to be used on local markets. Similarly, liquefied biogas is making a valuable and lasting contribution to the goals of climate and environmental protection and here the availability of LNG is the key to be able to grow the use of biogas.

While greenhouse gas emissions cannot be stopped overnight, we can already make radical reductions. Opting for natural gas, for instance, can significantly lower CO<sub>2</sub> levels. Burning methane, the principle component of natural gas, generates almost a third less carbon dioxide than crude oil and nearly 45 percent less than coal. And yet natural gas is similar to oil in terms of its versatility. Furthermore, the world's gas deposits are set to last several hundreds years and reserves are more geographically spread than our crude oil reserves. And since natural gas and biogas can be mixed without difficulty, biogas sources can easily be connected to existing natural gas networks, paving the way for more sustainable use of natural resources.

Natural gas already covers around 25 percent of global energy demand and is therefore one of our most important sources of energy today. Experts anticipate that rising crude oil prices will continue to drive the both the global as well as the developing local small scale LNG market – particularly as oil and gas prices seems to becoming increasingly decoupled. Emissions regulations are also growing more stringent, particularly in the transport sector (shipping being a case in point), injecting additional urgency into the search for viable alternatives. Natural gas is a promising part of the answer to these challenges.

However, as with oil, most natural gas deposits are located far away from the actual point of use. At present, over 90 percent of natural gas is fed through long pipelines to power plants, industrial facilities and homes. But once the distances involved in relation to the volume of gas to be transported are high, this ceases to be economical. The costs for pipelaying, materials and compressor stations are just too high. Instead, to transport gas efficiently it is liquefied. When cooled to minus 162 degrees Celsius, natural gas liquefies. This liquefied gas is to 1/600th of its original gaseous volume, which means it takes up a great deal less space. The cryogenic technology required for this purpose is one of Linde's core areas of expertise. The company has been able to adapt its liquefaction systems to perform in even the toughest of climates, as seen at the world's most northerly large-scale LNG plant – Hammerfest in Norway.

There are around 70 of these world-scale facilities in operation across the globe, with a combined capacity of approximately ten million tonnes per year. They are directly connected to large natural gas reserves and produce LNG for export. This is then shipped around the world in the holds of special LNG tankers. Around 200 billion cubic metres of natural gas is now transported in this way each year – or around ten percent of the global gas market.

And demand is constantly growing. Once the tankers reach shore, the LNG can be transferred to trucks at coastline LNG terminals and transported to the point of use, or it can be re-evaporated and continue its journey by pipeline. Linde offers innovative technologies and complete solutions for the entire LNG infrastructure from natural gas clean-up and liquefaction through storage and vaporisation in tanks in ports and on ships, for instance, to transport local distribution and customer applications.

In cooler regions, 60 percent of natural gas is used for heating. However, thanks to cutting-edge tankers and Linde's efficient liquefaction technology, this gas is playing a greater role in today's global energy mix across an increasingly wide application spectrum. This climate-friendly energy carrier can now be used to generate electricity or fuel trucks and ships, for example. Linde offers a broad portfolio of energy-efficient, tailored liquefaction systems to meet diverse market needs. Solutions range from world-scale plants down to smaller LNG terminals, for instance to supply truck refuelling stations. In Australia, Linde also operates these LNG microplants itself.

The liquefaction technology is continually evolving to enable viable access to more remote natural gas reserves. Many natural gas deposits are located offshore and can only be accessed via floating platforms or extraction ships. Linde is collaborating with partners on floating production, storage and offloading (FPSO) units so that LNG can be generated far out at sea. Linde engineers are also developing special plant modules to boost yields from natural gas deposits through nitrogen injection, in a process called enhanced gas recovery (EGR).



**LNG trade routes:** Shipping is the only economically viable way of transporting natural gas once the distances run into thousands of kilometres. Before it can start its journey, however, the gas has to be liquefied. In this state, it can then be loaded onto special LNG tankers. Around 200 of these vessels are currently in service, transporting LNG around the globe. Once the tankers reach the shore, the LNG can be transferred to trucks at coastline stations and transported to the point of use, or it can be re-evaporated and continue its journey by pipeline.